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preliminary studies were conducted to optimize design and sampling heights. The passive samplers were prepared and pre-weighed in Riverside CA, USA, transported to LBL in Kentucky, USA for the study, and returned to Riverside for post-weight analysis. Both the laboratory controls and the field controls experienced a small but consistent loss of mass (mean 0.002 g, SEM 0.0003 g) from the initial weights to the final weights. The weights of the field deployed collectors were adjusted to compensate for loses.

At each of the two test sites a grid pattern consisting of three rows, 50 m apart, with four or five poles in each row, also 50 m apart, was established on each side of the trail. One grid was on the north side of the main trail (woods side, A in Fig. 1) and another grid was established on the south side of the same trail in the front field. A second pair of grids was established roughly 1 km from the entrance station along a trail nearly completely enclosed by vegetation (the tunnel site, B in Fig. 1).

All passive dust collectors were deployed and removed, within 30 minutes of one another, beginning at 8:00 A.M. and ending at 6:00 P.M., respectively. Following exposure, the collectors were covered and sealed for transport back to Riverside. Each sampler was inspected for insects and other debris not typical of road dust using a 4× hand lens. Small insects were noted in four of the samplers, but their contribution to the dust calculations was within the variability of the balance and considered insignificant. The difference between the weights before and after deployment was assumed to be accumulated dust. Both laboratory controls (those that did not leave Riverside) and field controls (those that traveled to the site and back but were not opened), were used to evaluate environmental effects on weight. Ten percent of the collectors were controls. Data was calculated as milligram dust per square centimeter, and adjusted to square meter where appropriate.

In addition to the dust monitoring techniques, weather data and the number of vehicles passing the sites were recorded. A portable weather station (Onset computers, Pocasset, MA, USA) was deployed at the A site in the front field to measure wind speed and direction, temperature, and relative humidity. Small HOBO (Onset computers, Pocasset, MA, USA) temperature and relative humidity sensors were used at the tunnel site to check for differences between the two test sites. Traffic counters were installed across the trails at both locations to determine the number of passes through the test sites.

Experimental results and discussion

Particulate PM 2.5 load

Two DataRam 2000 real time particulate monitors were deployed to determine ambient dust concentrations of particles less that 2.5 μm. The front field site maintained a consistent low ambient concentration of approximately 2-μg m^{-3} throughout the day (Fig. 3). Spikes in concentrations occurred as vehicles passed. The average concentration for most of the spikes was less than 10 μg m^{-3}.

Wind conditions had a significant effect on the monitoring data (Fig. 4). Overall wind speeds were light, averaging between 1 and 2 ms^{-1}. Gust speeds up to 6 ms^{-1} were observed with average gust speeds of 4 ms^{-1}. The wind direction was predominately from the east with gusts tending to be southeasterly. Both the wind direction and speed tended to blow dust away from the active monitor contributing to low ambient concentrations. This was confirmed by the passive monitors described below. While the wind direction tended to blow dust from the trail away from the monitor, a steady wind maintained a constant background concentration of particulates delivered to the monitor from other locations.

The DataRam set-up in the tunnel site was a 1 m off the trail, 0.5 m off the ground and surrounded by dense vegetation. Ambient concentrations were negligible until a vehicle passed (Fig. 5). Average concentrations due to vehicles ranged between 50 and 300 μg m^{-3} (Fig. 5a) with maximum concentrations 1.5 to two times higher (Fig. 5b). In contrast to the front field site, wind conditions were still at the monitor resulting in virtually no background dust until a vehicle passed.

The day the study was conducted rider numbers were low as compared to many weekends. In the tunnel site (B, Fig. 1) 126 vehicles were counted and in the front field location (A, Fig. 1) 149 vehicles passed. Each of the spikes corresponds to a single passage by an individual or group. If one vehicle generated average ambient loads of 150 to 250 μg m^{-3}, DOC 50 -327- 98

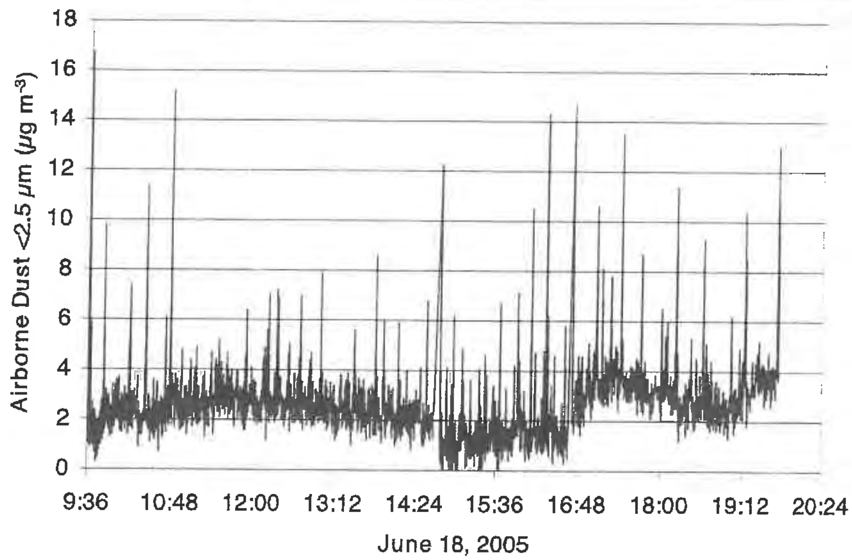

Fig. 3 Active monitoring data for ambient concentration of particle measuring less than 2.5 μm from the Front Field site

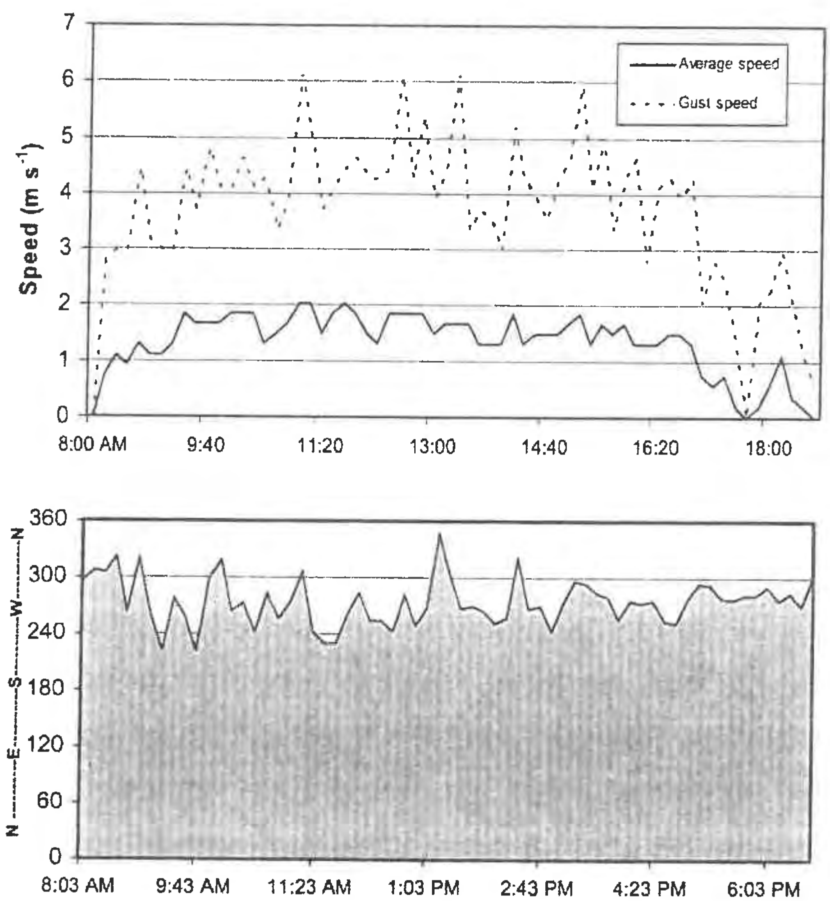

Fig. 4 Wind speed (top) and wind direction (bottom) measured in the front field

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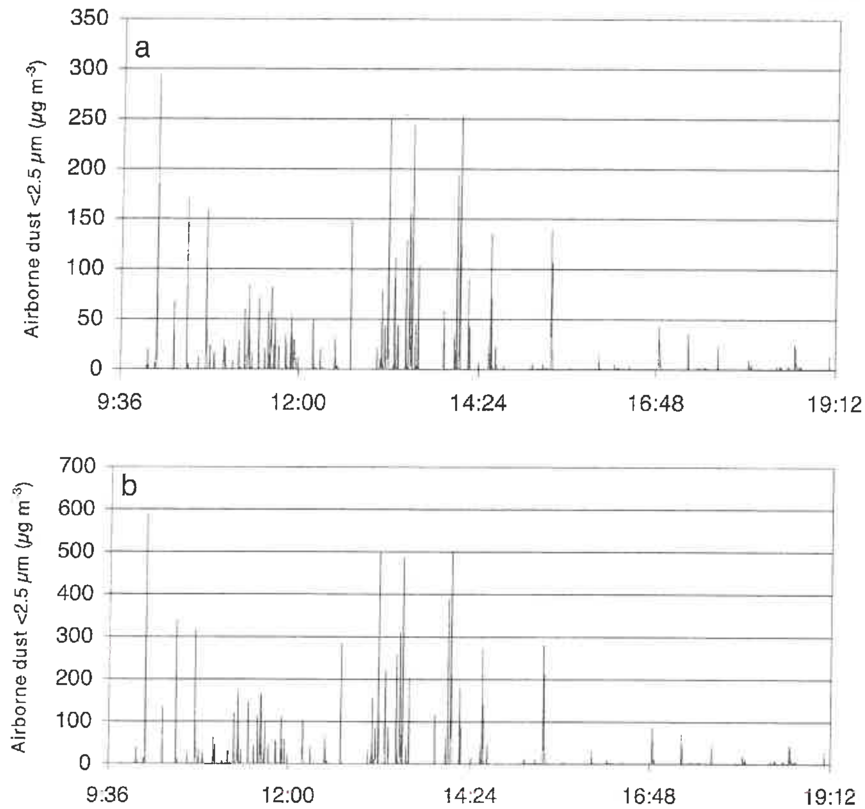
Fig. 5 Ambient concentrations of particle measuring less than 2.5 μm. a Average concentrations, b peak concentrations



on days where rider numbers are much higher, the ambient concentration would be well into the unhealthful range for continuous exposure at this test site. There were many different types of vehicles on the trails from small 150 cc motorcycles to large four-wheel drive pickup trucks – undoubtedly, the larger vehicle generated more dust (Gillies et al. 2005).

Although dust was visible for longer periods than were recorded by the particulate monitors, based on images of particulates accumulating on leaf surfaces, most of the dust particles generated by OHVs are larger than 2.5 μm (Fig. 6). Based on this limited information and the current EPA interpretation, particles sent airborne by OHV traffic do not pose any long-term health concerns at the rider densities encountered on June 18, 2005.

Vegetation

Leaf samples from autumn olive (Eleaganus umbellata), staghorn sumac (Rhus typhina), sycamore (Platanus occidentalis), and wild grape (Virtis spp) were collected next to the main trail and 25 m away from the trail road and prepared for SEM. The sampling day followed several days of heavy rain so only small amounts of dust was visible to the naked eye. Images were assessed for:

1. Physical damage such as abrasions, broken trichomes and punctures
2. Percent surface area occupied by dust particles
3. Blocked stomata
4. Estimated size of particles

In comparing samples on and off the trail, the leaves collected along the trail did have a higher number of particles on the surface, but there was no observed difference in lesions or superficial damage. Particles were observed on both sides of the leaves (Fig. 6). All four of the species examined had stomata on the underside of the leaves exclusively, which is common for temperate zone plants. A few examples of particles blocking stomata were observed and captured in images, but there were no consistent patterns of stomatal blockage due to dust deposition (Fig. 6).

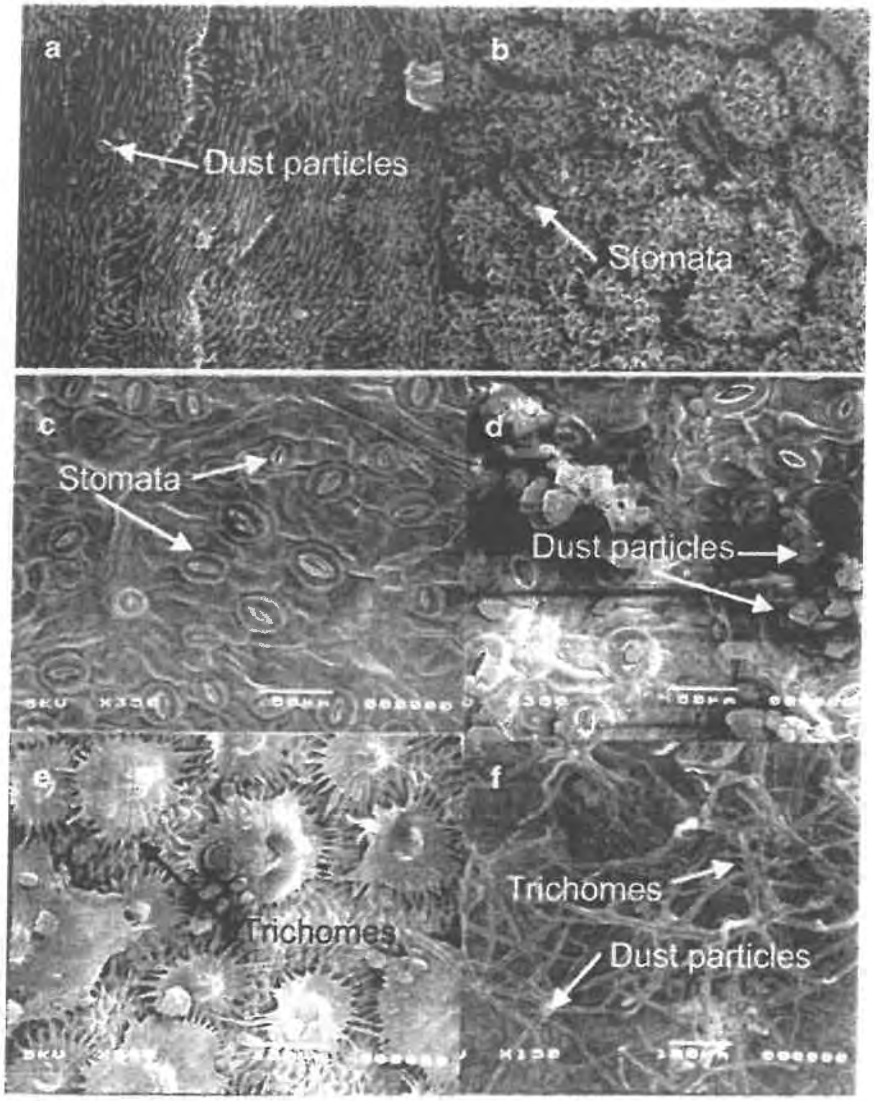


Fig. 6 Scanning electron micrographs. a Upper surface of wild grape. b Lower surface of wild grape. c Lower surface of sycamore collected away from the trail. d Lower surface of sycamore collected on the trail. e Upper surface of autumn olive collected on the trail. f Upper surface of sycamore collected on the trail

Based on a visual assessment, it does not appear that plants growing along the roads and trails were severely impacted by dust generated by OHVs, as long as heavy traffic is followed by rain. Physiological assessment of photosynthesis and respiration were not conducted, but outside of a biochemical assimilation of nutrient elements from dust, it seems unlikely that a physiological assessment would change the conclusion.

The scanning electron microscope images allow an estimate of typical dust size – at least particles that remained after rain. For the most part, particles were larger that 2.5 μm, but examples of fine particles were captured at higher magnification (Fig. 6).

Passive dust collectors

For purposes of describing the heterogeneity of the dust plume, all data from all the samplers are shown in Figs. 7 and 8. Averages and integrations of averages are shown in Table 1. The collectors deployed at the edges of the trails captured the majority of the dust in the lower 2 m (Fig. 7), suggesting larger particles with greater influence by gravity. The fugitive road dust collected by the sticky traps varied widely from sampling pole to sampling pole, as expected, with variances between samplers on adjacent poles up to ±50%. The variance among the samplers is an important indicator of the variance

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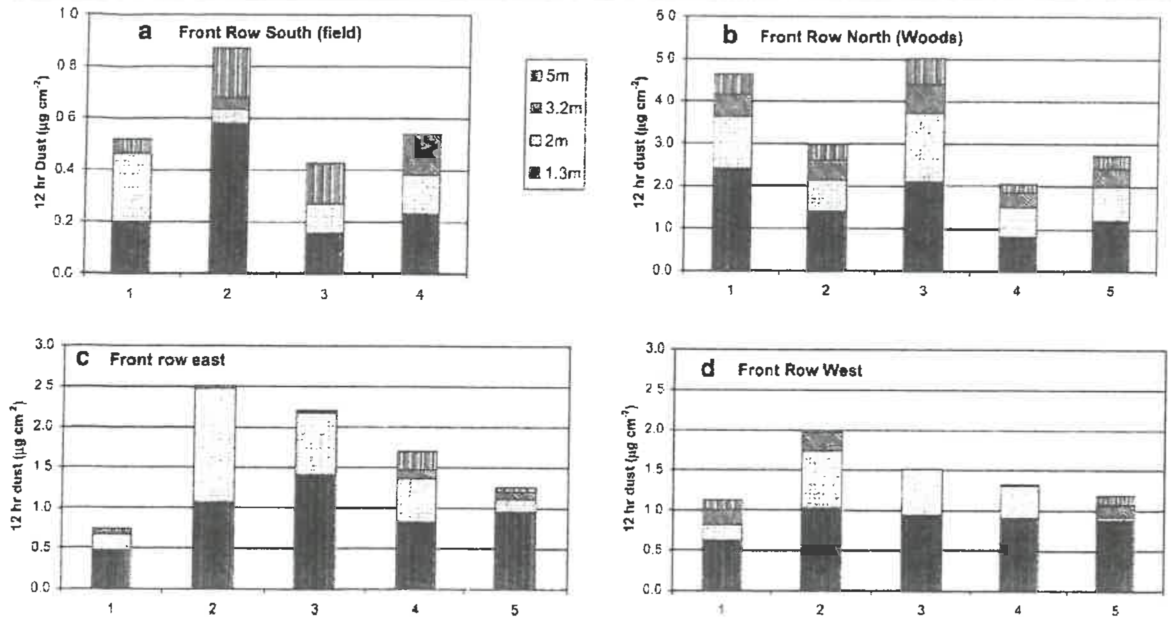

Fig. 7 Dust accumulation on passive samplers after 10 h (a–d). Each bar indicates one sampling pole and the divisions indicate the quantity for dust collected at each sampling height. Note the change in units on y-axis

in particulate load in the dust plumes themselves. A combination of the variability in roadbed conditions (even in a 250 m span), vehicle and rider characteristics, and wind patterns made for major differences in how dust was transported off the trail. In the tunnel site (B on Fig. 1) dust loads were heaviest at the middle 3 samplers, where vegetation was heaviest and the trail fully enclosed.

At the front field location (A on Fig. 1), dust collected on the north side of the trail was 5 to 6 times greater than the dust collected on the south side of the trail. Clearly wind direction had a significant effect on dust collection in the front field and woods sites. Wind direction was generally from the east-southeast, and the collectors on the north side (Fig. 7b) of the road accumulated significantly more mass than did the samplers on the south side of the trail (Fig. 7a). Along the tunnel site where winds were generally calmer, deposition to the east and west side collectors was similar (Fig. 7c and d).

At 50 m and 100 m away from the trails, a higher percentage of particulates were captured at the 2.3 m and 3 m heights (Fig. 8). Although particle sizes on the collectors were not determined, the pattern of capture is consistent with larger particles traveling shorter distances and at lower elevation while smaller particles were launched higher and tended to travel further. Along the tunnel transects, dust movement back into the woods was inhibited by the dense vegetation along the trail, particularly on the west side of the trail where collection rates were very close to zero (data not shown). Dust movement to the 50 and 100 m distances was similar regardless of wind directions (Fig. 8c vs d and e vs f) suggesting that the dust captured by these samplers was more representative of the ambient conditions than the periodic heavy dust conditions generated by moving vehicles.

Estimating aeolian transport

Soil erosion was calculated by integration of the average dust mass for each row at the four heights over the 5-m collection pole (Table 1). The underlying assumption is that the samples taken at four heights are representative of the gradient in dust concentration moving past the poles. An integrated vertical value of 0.25 g m^{-2} was calculated for the woods transect (north of the road) in comparison to 0.13 g m^{-2} for the field transect (south side of the road). The two tunnel transects had similar values of soil displacement at 0.10 (west side) and 0.11 (east side) g m^{-2}. When this value is calculated for both sides of the trail, total erosion for the front field was

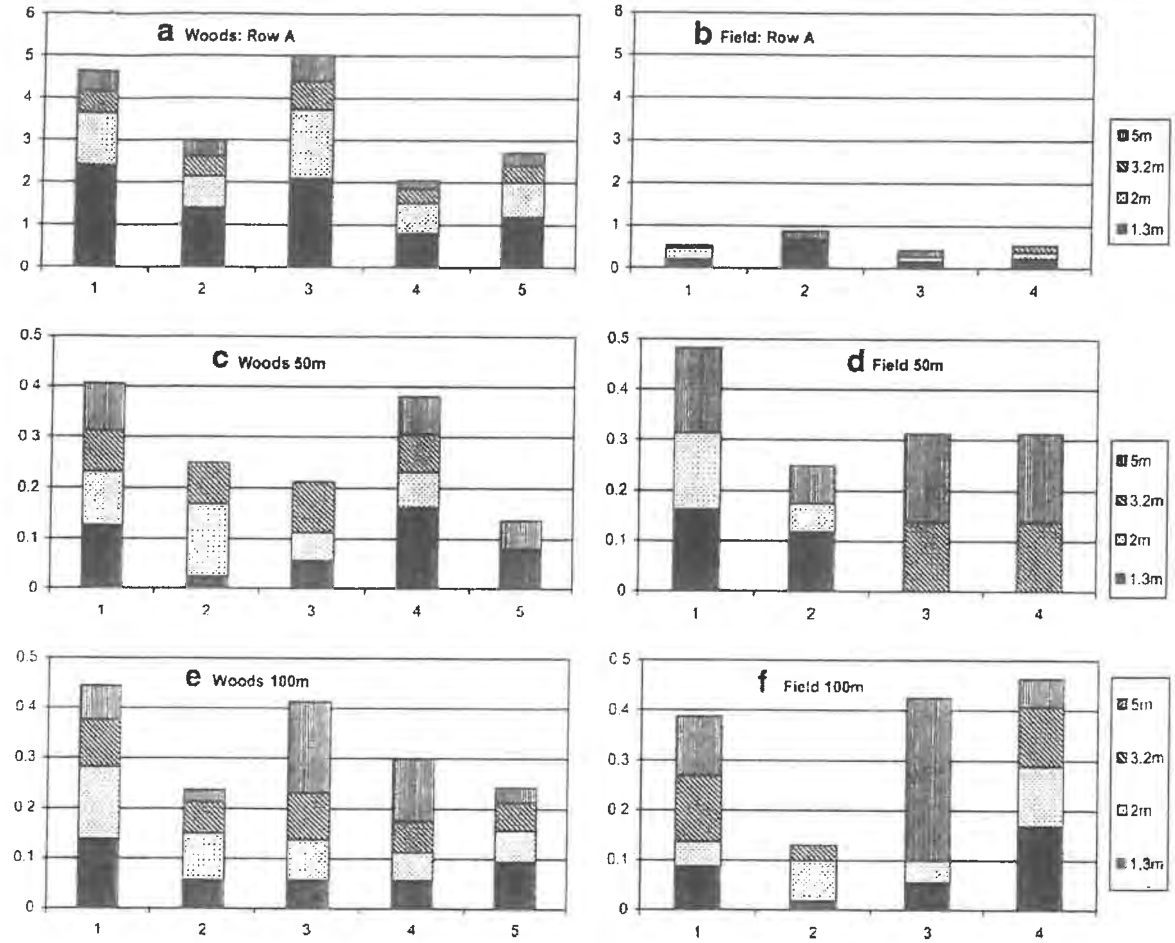

Fig. 8 Dust accumulation on passive samplers after 10 h at the Front field location. Left column, north side of trail (a, woods) and right column is the south side of the trail (b, field). Data shown is for the entire grid. c and d 50 m away from the trail; e and f 100 m away

Table 1 Displacement of soils particles due to vehicle traffic

	Collector Height (m)	Woods	Field	Tunnel west	Tunnel east
		Average dust collected mean mg/cm^2 (SEM)			
	1.3	1.57 (0.27)	1.60 (0.12)	0.88 (0.07)	0.95 (0.15)
	2	1.03 (0.18)	0.15 (0.04)	0.38 (0.12)	0.61 (0.23)
	3.2	0.48 (0.06)	0.04 (0.05)	0.12 (0.05)	0.06 (0.21)
	5	0.40 (0.07)	0.08 (0.06)	0.05 (0.03)	0.07 (0.40)
Displacement	Unit	Integration			
Particle mass per pole	Milligram per 450 cm^2	10.98	5.62	4.42	5.11
Particle mass crossing front row	g m^2	0.24	0.12	0.10	0.11
Soil displacement along transect	Gram per 5×200 m	244	125	98	113
Linear soil displacement	g/km trail	1219	624	497	567
Number of vehicle trips		126	126	149	149
Soil displaced per trip in 1 km	Gram per trip per kilometer	8.19	4.19	3.90	4.50
Erosion	Kilogram per trip per hectare	4.1	2.1	2.0	2.2

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1,844 g km^{-1} of trail, and 1,058 g km^{-1} in the tunnel area for what was a light day of trail traffic. These data only account for aerial dust collected within 10 m of the trail. A small percent of the dust was collected 50 m further away from the road in three out of the four transects, suggesting that the calculations slightly underestimate the quantity displaced. Using the numbers of trips counted as a basis for soil erosion, on average vehicles displaced 8.2 and 4.2 g of soil per trip along 1 km of the road by the entrance station and 3.9 and 4.5 g of soil per trip along a 1 km of trail in the tunnel locations. Assuming the trails were 5 m wide these values equate to between 4 and 6 kg of soil per lost trip per hectare (Table 1). At one trip a day (365 a year) this rate of erosion is very close to the Forest Service estimate of an annual loss of 2,000 kg/ha (1 ton/acre) quoted by Frazer (2003). Given that these trails may experience 365 trips in a day, soil loss from aeolian erosion may exceed losses due to runoff.

Conclusions

Off-highway vehicles caused a significant amount of soil erosion by aeolian displacement at the Land Between the Lakes OHV area. Most of the soil particles collected during the study period were in size classes greater than 2.5 μm, which tended to travel less than 50 m away from the trails. The grid pattern used for the passive sampling enabled a three-dimensional visualization of the plumes. Larger particles remained lower in the plume and did not travel far, while smaller particles traveled higher in the plume and moved further away from the source.

Most of the dust mass captured by the passive sampler was of sizes not considered a threat to human health. However, spikes in average particulate loads greater than 150 μg m^{-3} were common when vehicles passed the active monitor in the tunnel test site. Given the relatively light ridership during the experiment, when the numbers of riders are substantially higher, air concentrations would be expected well into the unhealthful range where the forested edges of the trails inhibit air circulation. Where the trails are open with adequate air circulation, such as along the main trail by the entrance station, the particulate loads have lower impacts on human health.

The evaluation of dust effects on vegetation suggests that OHVs cause only minor perturbations at LBL. Some stomatal blockage was observed, and surface accumulations of dust may periodically inhibit photosynthesis and respiration, but little superficial damage to the cuticle was evident in the images captured by SEM.

The results of this study demonstrate the success of using a low-tech particulate trap for estimating aeolian soil erosion and atmospheric loading due to vehicle traffic on unpaved roads. Little quantitative data has been published to demonstrate aeolian erosion due to vehicle traffic. The sticky traps provided a useful tool for land managers to determine erosion losses during the dryer parts of the year.

Acknowledgements We thank Karla Johnson at the Hancock Biological Station, Murray State University for access and technical assistance with the Scanning Electron Microscope, Lowell Christensen, Administrator at the American Honda Rider Education Center for providing us test site for development of the passive samplers and we are indebted to Chad Ingle, Kyle Varel, Jared Nance and Angee Kelley at the Land Between the Lakes National Recreation Area for their help in preparing the passive samplers, setting them up and taking them down during the field monitoring campaign.

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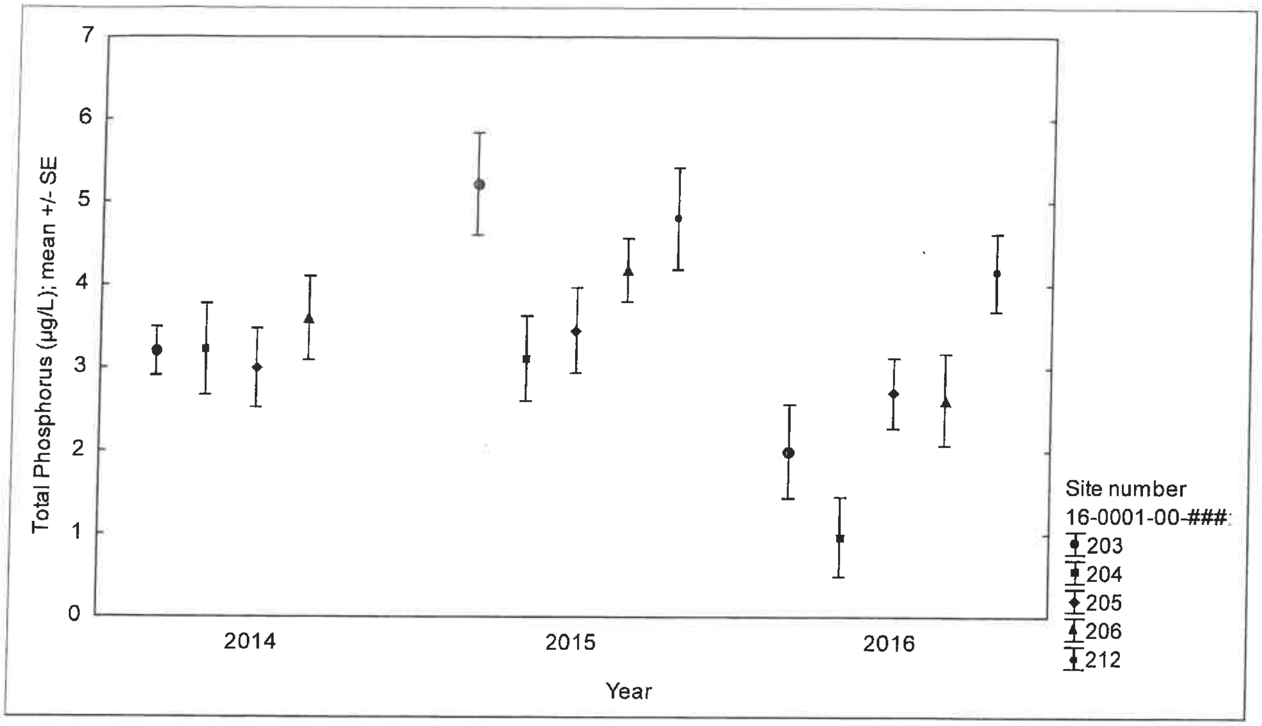

Figure 10. Total phosphorus concentrations by year at Lake Superior near shore monitoring sites near Grand Marais.

2.3 Stressors and Sources

In order to develop appropriate strategies for restoring or protecting waterbodies, the stressors and/or sources impacting or threatening them must be identified and evaluated. The *Lake Superior North Watershed Stressor Identification* (MPCA 2018) report provides results of stressor identification monitoring completed in select LSN Subwatersheds. Additionally, investigations into loss of connectivity were completed for several subwatersheds in which localized impacts can be addressed with feasible strategies. The Core Team also provided additional input on stressors and sources that were present in the watershed. The primary stressors and pollutant sources impacting the LSN Watershed include the following:

- **High water temperatures** that do not support sensitive coldwater species such as brook trout. Causes of high water temperatures may include beaver dams, turbid water, loss of riparian vegetation and shade, low flows, low groundwater input, and climate change.
- **Physical habitat degradation and loss of habitat diversity** that reduces spawning areas, cover or pools for fish, and critical habitat for aquatic macroinvertebrates. Habitat loss can be due to bank erosion (caused by channel incision and widening), sediment deposition, beaver dams, road and ditch runoff, major flooding events, sediment transport issues related to road culverts, and invasive species (e.g., Emerald Ash Borer) that have the potential to affect watershed hydrology and aquatic organisms.
- **Aquatic organism passage barriers** created by road culverts or natural barriers, both of which can reduce or eliminate fish passage and serve as a migratory barrier to other aquatic life. Road culverts can be undersized, perched, and/or improperly set. Natural barriers include bedrock

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and boulder waterfalls that are usually permanent barriers, and beaver dams that create temporary or periodic barriers. Barriers contribute to spawning stress since fish may need to migrate to find suitable spawning habitat. Fish also need to seek temperature refuge during periods of thermal stress (summer heat, winter ice).

- **High sediment and associated nutrient concentrations** that are a result of high magnitude, low frequency snowmelt and precipitation events. Sediment and nutrient sources are varied:
  - Streambank and valley wall erosion
  - Watershed runoff from open lands, gravel or dirt roads, and development and impervious surfaces (e.g., roads and driveways, ditches/conveyances, culvert crossings, other land management activities)
  - Beaver activities (e.g., failed dams, ponds)
  - Historic and current land clearing and timber harvest in the watershed and riparian areas
  - Septic systems (non-compliant/non-functional systems under all conditions)
- **Altered hydrology associated with flashy, high stream power and low flows associated with lack of groundwater influence.** Flashy hydrology combined with erodible soils contributes to high sediment loads during snowmelt and rain events, and can cause excess sediment transport and deposition further degrading physical habitat (e.g., in the Woods Creek Watershed). Ditched channels and deforested land increase the hydrologic flashiness of the system, leading to stream bed and bank erosion. Impoundments, including private dams and beaver dams, can also alter streamflow. Finally, groundwater discharge to some streams is low during the summer, leading to low baseflow conditions.
- **Altered food webs** affect fish assemblages. Climate change, aquatic invasive species (AIS), and fisheries management can alter a species' food base and predation pressures, and therefore affect growth and survival rates.

2.4 TMDL Summary

The Clean Water Act and EPA regulations require that TMDLs be developed for waters that do not support their designated uses (fishable, swimmable, consumable). A TMDL is a plan to restore and maintain water quality standards in waters that are not currently meeting them. TSS TMDLs have been developed for the Poplar River (MPCA 2013) and Flute Reed River Watersheds (MPCA n.d.). Appendix A provides the current loading, load reductions needed, and load and wasteload allocations from the TMDLs. The Poplar River was proposed for delisting in the 2018 draft 303(d) list because it meets the applicable water quality standard due to restoration activities. Some of the waterbodies in the LSN Watershed are also impaired due to mercury; however, this report does not cover toxic pollutants. Mercury impaired lakes are addressed by a statewide TMDL study approved in 2007, and supporting

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Cumulative and Universal: ATV Impacts on the Landscape and Wildlife

A Review of the Literature on the Subject

Prepared by: Backcountry Hunters and Anglers

Summer, 2011

MT site resulted in increased surface runoff and suspended sediment concentrations. Suspended sediment concentrations in the runoff increased 50% over pre-disturbance levels after 40 ATV passes. Ricker et al. (2008) reported increases in suspended stream sediments resulting from ATV trail surface runoff in a paired watershed study in Stafford County, Virginia. Suspended stream sediments rose approximately 94X downstream of an ATV trail crossing relative to sediment concentrations above the ATV trail crossing. The results of the paired watershed study led the authors to conclude that increases in suspended stream sediment were a result of a combination of highly erodible silt loam soils (common in the Inland Northwest of the United Sates) and ATV trails acting as conduits for suspended sediment (Ricker et al. 2008). Iverson et al. (1981) reported a five-fold increase in surface runoff and increased sediment yields of 10-20 times in areas affected by OHV use in the Mojave Desert.

Impacts of ATV traffic on water quality and aquatic systems are not limited to increases in suspended stream sediments. ATV trails funnel water that dislodges contaminants which end up in streams, rivers and lakes (Ouren et al. 2007). Contaminants can also be directly introduced into aquatic systems through oil and fuel spills and wind deposition of emission particulates that are transported in dust migration, settle onto vegetation, and subsequently washed off leaf surfaces by rain and snow and moved by surface water run-off. All-terrain vehicle operation in or near streams and waterways poses a serious water pollution threat (Havlick 2002). This can have detrimental impacts on populations of aquatic animals. Garrett (2001) (as cited in Taylor 2006) reported that environmentally sensitive aquatic species (including fish) were absent from OHV impacted sites on the Nueces River in Texas, while unimpacted sites hosted numerous environmentally sensitive species. The magnitude of the effect ATV use has on water quality is influenced by trail features including trail curvature and slope percentage.

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Cumulative and Universal: ATV Impacts on the Landscape and Wildlife
Prepared by Hunters and Anglers, Summer 2011

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One of the principal concerns identified by County SWCDs for the Lake Superior North – Watershed is groundwater protection, for both quality and quantity. Groundwater withdrawals have increased nearly 30% over the last 20 years, partly due to the rising demand for water supply for private consumption and recreational water related needs. It is estimated that the development pressure is moderate in some parts of the watershed where land is converted from timberland, resorts and lakeshore into home and recreation development (USDA-NRCS). This increase in recreational development can be seen with a significant increase ($p=0.001$) from 1994 to 2013 in non-crop irrigation for golf courses and special categories. At this time, aquifer drawdown is now a concern; however, if water usage and land use conversion continue to increase, the probability of the water table being drawn downwards also increases. It is for this reason that the MNDNR monitors and takes precautions when permitting water use appropriations.

Groundwater quality is based on the sensitivity of the aquifers and the effects of naturally occurring and anthropogenic influences for constituents found in the water. Special consideration should be practiced in areas of high groundwater contamination susceptibility, which are sparsely located throughout the watershed. Overall, the groundwater quality of the watershed appears to be healthy, despite some exceedances of constituents, including arsenic. However, the primary source of contamination for this watershed is geology. Additional and continued monitoring will increase the understanding of the health of the watershed and its groundwater resources and aid in identifying the extent of the issues present and risk associated. Increased localized monitoring efforts will help accurately define the risks and extent of any issues within the watershed. Adoption of BMPs will benefit both surface and groundwater.

While land management, riparian and shoreland development, and road-stream intersections may represent acute threats to aquatic health in the Lake Superior – North Watershed, longer-term and more nebulous threats may be posed by climate change, and the interaction of climate change with other stressors. Many of the watershed's streams support sensitive, stenothermic organisms that depend on perennial, coldwater streams carrying low concentrations of sediment and nutrients. These habitat and water quality conditions are the result of interacting factors of climate, hydrogeology, and land cover, and may be degraded by changes in any of these factors. Predictive models incorporating climate and land use changes suggest that aquatic resources of the Lake Superior – North Watershed are likely to experience higher temperatures, reduced dissolved oxygen, increased erosion, and other associated stress in the near future (Johnson et al. 2013, Herb et al. 2014). These changes are likely to have negative effects on the health of aquatic systems, though planning and BMP implementation may mitigate some impacts. For example, understanding the importance of small, cold tributaries to the ecological integrity of larger river systems may be of critical importance in protection planning efforts. Tributaries often spawning and nursery habitat for trout and other fishes, and may serve as critical refugia for fish and other aquatic organisms during periods of thermal stress. A watershed-based focus that recognizes the connection between landscapes, riverscapes, and the condition of aquatic resources will be essential to protection and restoration efforts.

In general, aquatic habitats in the Lake Superior – North Watershed are in very good condition; streams, lakes, and wetlands rank among the highest-quality in the state, and some represent near-reference quality examples at a national scale. Stream biological monitoring surveys suggest that sensitive indicator taxa are widespread and abundant, and several rare species of fish and macroinvertebrates were observed. Many streams were designated as exceptional aquatic resources, which should provide a higher level of protection from degradation. From a protection and restoration standpoint, the watershed possesses several favorable characteristics. A relatively high proportion of its lands are already under some form of protective management (e.g., state parks, federal wilderness designation, AMAs), and much of the remainder is administered by public agencies charged with incorporating water quality considerations in their management and planning efforts. The watershed's aquatic resources are

Executive summary

DOC 53A -340-

In 2013 and 2014, the Minnesota Pollution Control Agency (MPCA) conducted intensive watershed monitoring (IWM) of surface waters in the Lake Superior – North Watershed. Eighty-nine lakes and 64 streams were monitored by MPCA and local partners, collecting water chemistry and biological data that was used to assess the quality and use support of these waters. Water quality was generally good throughout the watershed; in many cases, lakes and streams ranked among the least polluted in the state of Minnesota.

No aquatic recreation impairments were identified, indicating that the streams and beaches of the Lake Superior – North Watershed are generally safe for swimming, boating, and other forms of body-contact recreation. The watershed's lakes were found to harbor low levels of nutrients and algae. However, a small number of lakes appear to be experiencing a declining trend in transparency. Although these lakes are still meeting water quality standards, the declines in transparency may be related to lakeshore development. Protection strategies should be developed for these lakes in order to prevent future impairments.

Exceptional biological communities (fish and aquatic macroinvertebrates) were documented in many streams; most streams supported brook trout and other cold-adapted fishes, and highly sensitive aquatic macroinvertebrates were widespread and abundant. These high quality streams are excellent candidates for protection efforts. Two streams were determined to carry excess loads of suspended sediment, which negatively impacts aquatic life; restoration efforts are already underway on each of these impaired streams.

Although water quality is generally good in the Lake Superior – North Watershed, and few impairments have been identified, some potential threats to aquatic resources should be mentioned. Poor land management is perhaps the most obvious source of potential stress. The watershed is dominated by forest, much of which is managed for timber products. Logging is common within the watershed, and poor harvest practices may have negative impacts on aquatic systems. The watershed's extensive road network includes many intersections with streams and rivers; these crossings may disrupt ecological connectivity and cause localized impacts to aquatic habitat. Residential development and agriculture may also contribute stress to aquatic systems, though these land uses comprise relatively small proportions of the landscape. Lakeshore development, in particular, may be of concern to many of the high quality lakes found in the watershed. Groundwater withdrawals have increased nearly 30% over the last 20 years, partly due to the rising demand for water supply for private consumption and recreational water related needs. Finally, climate change is perhaps the most relevant potential stressor for the watershed's aquatic resources. Although it is difficult to explicitly isolate its effects from that of other stressors and natural variation, evidence suggests that the region's rivers and streams will be affected by a changing climate to some extent. Land managers, community leaders, and other stakeholders should consider the best available information regarding climate change and other potential stressors when developing restoration and protection strategies for the watershed.

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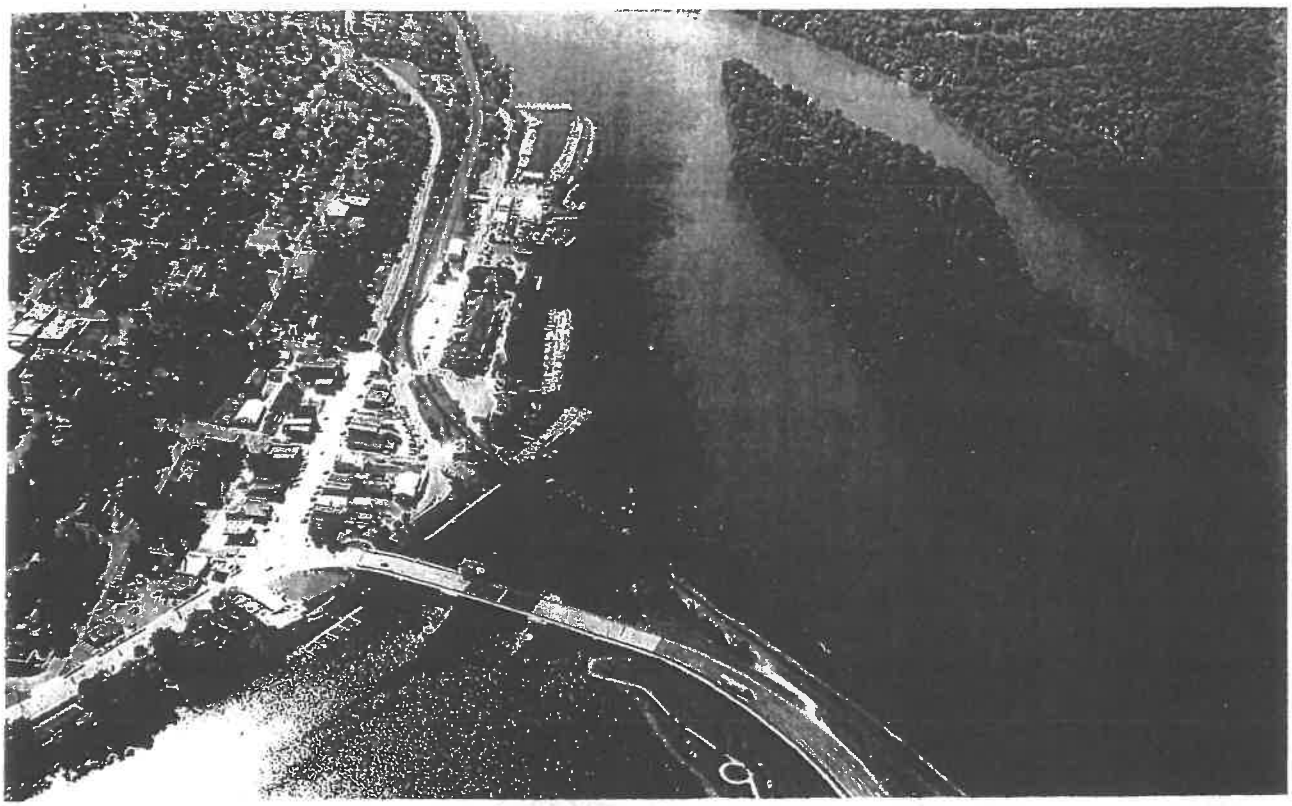
Swimmable, fishable, fixable?

What we've learned so far about Minnesota waters

April 2015



Minnesota Pollution Control Agency

CLEAN WATER LAND & LEGACY AMENDMENT

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Swimmable?

To date, the MPCA and its partners have systematically monitored and assessed a large number of the streams, rivers, and lakes in half of Minnesota's 81 major watersheds.

When the MPCA and partners **monitor** a lake or stream, it means we study:

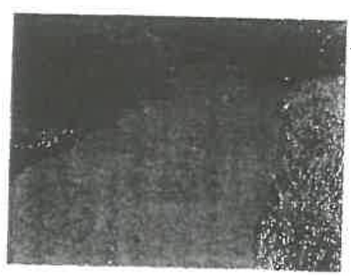
- Levels of nutrients, sediment, and bacteria
- Communities of fish and macroinvertebrates such as aquatic bugs
- Flow of rivers and streams
- Contaminants in fish

In the second part of this step, **assessment,** we take a look at what the data is telling us. Then we determine whether the condition of water bodies meet water quality standards. Water quality standards are the benchmarks used to determine the suitability of waters for swimming and fishing, and their overall biological health. Water quality standards are not "one size fits all." In many cases they are regionalized for different parts of the state, and tailored to different types of water bodies.

The maps on the following pages show where the MPCA and partners have studied watersheds and the results so far.

Why are nutrients a pollutant?

Excess nutrients cause blooms of algae that hurt aquatic life and recreation.



Why is sediment a pollutant?

Sediment – particles of soil and other matter – clouds the water, making it hard for fish and other aquatic life to find food, breathe, and reproduce.

Why are bacteria a pollutant?

Bacteria may make a lake or stream unsafe for swimming and other recreation.

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Summaries and recommendations

Water quality in the Lake Superior – North Watershed is generally good, and consistently met state standards, reflecting its lightly-developed, heavily-forested landscape. Many exceptional streams were identified and outstanding water quality was noted in a number of lakes. However, a small number of streams were identified as impaired due to high levels of suspended sediment, and, although no lake water quality impairments were identified, transparency in some lakes appears to be declining.

Approximately 40% of the streams monitored in the course of this study were found to support "exceptional" biological communities. These streams typically contain Brook Trout and other fishes that require clean, cold water, including species that are rarely found outside of the Lake Superior – North Watershed (e.g., Longnose Sucker). Lake Chub, a state-listed Species of Special Concern, was found in several streams in the far northeast corner of the watershed. The macroinvertebrate communities of these exceptional streams are typically diverse, include high densities of sensitive insects, and are particularly rich in stonefly and caddisfly genera. The larval dragonfly *Boyeria grafiana*, a state-listed Species of Special Concern, was found in 22 streams and several other rare macroinvertebrates were observed in various streams across the watershed.

Exceptional streams were found throughout the Lake Superior – North Watershed, but were more concentrated in certain subwatersheds (e.g., the Devil Track River and Temperance River subwatersheds). The lowest proportions of exceptional streams were found in the two subwatersheds that include aquatic life use impairments due to high levels of suspended sediment (Poplar River subwatershed, Flute Reed River subwatershed).

Essentially all of the Lake Superior – North's exceptional streams drain minimally-developed, lightly-disturbed catchments. However, a few may be threatened by ongoing and future land use. For example, the catchment of Irish Creek contains a significant proportion of private land and is adjacent to an area that has experienced relatively rapid development in recent decades. Similarly, the Little Devil Track River drains the outskirts of the watershed's largest developed area (Grand Marais), and the river's lower reaches are completely surrounded by private land. Poor land use practices in developing areas may contribute to water quality degradation, and should be an ongoing concern in the Lake Superior – North Watershed.

Shoreland protection is an important means for maintaining water quality in lakes. Although no lake water quality impairments were identified in the Lake Superior – North Watershed, transparency appears to be declining on four lakes (Poplar, Deer Yard, Devil Track, Tom). The causes of these declines are uncertain, but it's notable that each of these lakes' shorelines ranks among the most-developed in the watershed. Efforts are underway to identify and address potential threats to lake water quality (i.e., non-compliant septic systems) on some of these lakes.

A multi-agency effort has recently been undertaken to systematically identify and prioritize watershed protection opportunities in Minnesota. The purpose of this approach is to provide state agencies and their partners with a consistent method and rationale for how to identify water bodies at risk, set reasonable goals for protection, incorporate locally held water quality values and considerations, and provide recommendations for specific protection methods. In this process, lake monitoring data is subjected to a multi-step analysis that forms a preliminary ranking of protection priorities. A combination of factors are reviewed to determine priority ranking. Among these factors are a lake's sensitivity to an increase in phosphorus, a documented decline in water quality or monitored phosphorus concentrations close to the water quality standard, and the percentage of developed land use in the area. In the Lake Superior – North Watershed, highest protection priority is suggested for six

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Salmon & Trout Conservation

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Salmon & Trout Conservation
The impact of excess fine sediment on invertebrates and fish in riverine systems

Literature Review

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I Introduction

At a global scale, suspended solid (SS) concentrations in many rivers have dramatically changed in recent years (Walling, 2006). Existing evidence indicates that natural sediment loadings have been substantially exceeded in many catchments in the UK, particularly since World War II (Evans, 2006). Sediment loadings delivered to watercourses originate from a number of upstream primary and secondary sediment sources, the main anthropogenic activities increasing sediment supply to watercourses include:

- Changes in agricultural practices; for example, increased areas of arable cultivation, leading to greater areas of bare exposed soil susceptible to erosion by winter rainfall (Greig, *et al.*, 2005), and mechanised farm practises which compact the soil and increase runoff and soil erosion (McMellin *et al.*, 2002: Bilotta, *et al.*, 2007). For instance, sediment-fingerprinting research indicated 61% of the sediment load of the River Tweed in Scotland was derived from arable and pasture top soils (Owen *et al.*, 2000).
- Intensification of agricultural practices; for example, increasing stock density (Heaney *et al.*, 2001) and multiple cropping on arable land.
- Increased bank erosion due to loss of natural hydrology.

Erosion processes and sediment delivery form an integral part of aquatic systems, influencing their geomorphology, habitat distribution and water quality. Aquatic communities are adapted, and hence able to cope with, natural 'baseline' sediment inputs. Healthy freshwater ecosystems require sediment inputs to maintain habitat and nutrient fluxes, but excessive loading can have catastrophic effects on river ecosystem function. The main direct physical effects are reduction in habitat availability and modification of habitat biogeochemical conditions through reduction of oxygen and increased concentrations of toxic compounds (Kemp *et al.* 2011; Jones *et al.* 2012). Sediment suspended in the water column can also cause sublethal effects from turbidity and direct physical damage, particularly to fish species (Wilber & Clarke, 2001).

Sediment in the water column can be measured in three main ways 1) turbidity; the optical (light scattering) property of the water, 2) total SS; direct measurement of particulate weight present in a volume of water and 3) water clarity; also an optical property of water. Deposited sediment can also be measured using sediment traps. Despite this, there is a distinct lack of SS monitoring data from around the UK, mainly due to cost implications but also a historic perception that other water quality parameters were of greater importance.

II. Effects on Invertebrates

The negative impacts of high and persistent sediment loads on invertebrate assemblages and abundances are well documented with Ephemeroptera, Plecoptera, Trichoptera (EPT) taxa exhibiting the greatest negative response to increased sediment. Sediment can trigger invertebrate decline in various ways including; scour damage, burial of heavy or immobile species, the clogging of gills or feeding structures, and reduction in interstitial habitat and primary production (Newcombe and MacDonald, 1991) (Fig. 1). Much of the recent literature has explored the effects of excessive sediment deposition on invertebrates from physical and biological perspectives, looking beyond the focus on reduced total abundance and taxonomic richness

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found in older papers (Richards & Bacon, 1994; Shaw & Richardson, 2001; Zweig & Rabeni, 2001). Changes in invertebrate life has trophic implications for fish species, particularly juvenile salmonids, so understanding and controlling the impacts of sedimentation is crucial to maintain ecological fitness of river systems.

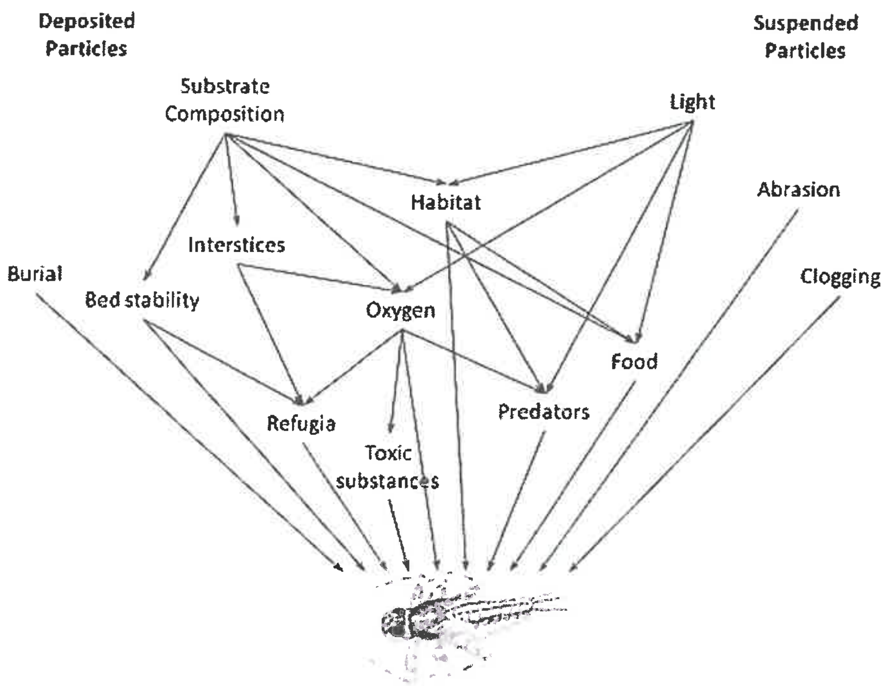

Figure 1: Summary diagram illustrating the direct and indirect mechanisms by which fine sediments impact upon macro-invertebrates (Jones *et al.* 2012)

Biological changes

A study by Buendia *et al.* (2013) assessed evidence of patterns in assemblage structure and functional traits of benthic invertebrates in response to excessive fine sediment deposition. Invertebrate groupings in high sediment areas were only a subset of the groups found in locations with minimal fine sediment and these invertebrates had biological traits that favoured resistance and resilience to fine sediment, such as shorter life cycles and smaller body sizes. Descloux *et al.* (2014) similarly examined changes in biological characteristics caused by colmation in benthic and hyporheic invertebrate assemblages. In the benthic zone colmation significantly modified eight invertebrate trait profiles and in the hyporheic zone it significantly modified five. As found in the previous paper, trait selection in benthic invertebrates leaned more towards resistance or resilience capacities of species and features related to physiological and trophic functions. As only morphological traits were modified in hyporheic zone invertebrates, it was concluded that colmation is biologically more selective on benthic than hyporheic assemblages as benthic invertebrates have less adaptations to cope with excessive sedimentation.

Behavioural/Habitat changes

Vadher *et al.* (2015) demonstrated via lab experiments that the addition of fine sediment inhibited movement of *Gammarus pulex* into sediment refuges during exposure to water column disturbances. In the control 93% of the individuals moved into subsurface sediments when the water level was reduced. This was reduced to

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0% when as little as 20% fine sediment was added. This physical barrier means larger macroinvertebrates cannot protect themselves from stressors such as floods and streambed drying. Reduced availability of refuges caused by fine sediment can also increase the density of invertebrate drift, as invertebrates have nowhere to hide and become forced to leave the river substrate to prevent smothering. Benthic invertebrate drift rates have shown to increase in SS concentration as little as 8mg/l (Rosenberg and Wiens, 1978) and population size has been shown to reduce by 77% when exposed to 62 mg/l of SS for 100 days (Wagener and LaPerriere, 1985). A 40% reduction in stream invertebrate species diversity has been recorded in response to prolonged SS concentrations of 133 mg/l over the period of a year (Nuttall and Bielby, 1973). Molinos & Donohue (2009) examined the response of 4 common macroinvertebrate taxa to different doses and exposures of sedimentation. They found that invertebrate drift was strongly affected by exposure time and all taxa exhibited statistically significant responses within the first day under all exposure concentrations. Larsen & Ormerod (2010) similarly found that even very small, short-term increases in fine sediment reduce benthic density by promoting invertebrate drift. When sediment was added drift density overall increased by 45% with the strongest contributors being mayflies (*Baetis rhodani*, *B. muticus* and *Ecdyonurus* spp.), helodid beetles and simuliid/chironomid dipterans.

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iii. Effects on Fish

Excessive fine sediment, in suspension or deposited, can have damaging impacts on all life stages of fish, particularly salmonids. This has been worsened for salmonids by a shift in the timings of arable cultivation in the UK, from spring to autumn sown cereals, which now coincides with their egg incubation times (Collins and Walling, 2007; Collins *et al.,* 2008). The effect on ecosystems will, however, depend on several key factors, including: the concentration of fine sediment in suspension; the duration of exposure to fine sediment; and the sediment chemical composition and particle size (Bilotta and Brazier, 2008). This makes determining the impact of SS on fauna and flora difficult to generalise, quantify and compare. However, generic consequences of increased SS concentrations in the water column for fish can include:

Mortality

The relationship between SS concentration and direct mortality is highly complex. The effect of sediment on fish will vary depending on life stage, time of year, size of fish, composition of sediment and the availability of off-channel habitat (Bash *et al.*, 2001), as well as the exposure magnitude, duration and frequency (Servizi and Martens, 1992). For example, in a review of published critical SS concentration thresholds based on dose-response experiments examining impaired growth, reduced feeding and mortality, Berry *et al.* (2003) reported ranges of 27-80,000 mg l^{-1} for mollusca and 4-330,000 mg l^{-1} for various fish species. Such ranges in the severity of effect of SS concentration are a function of associated stressors including sediment particle size, species life history stage, temperature, the presence of sediment-associated contaminants and sediment load duration (Swietlik *et al.*, 2003). Due to the complex interaction of such stressors, it is unlikely that a comprehensive list of genus-based critical SS concentration targets can be developed in the short-term (USEPA, 2003).

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Reduction in suitable spawning habitat and declines in egg/early life stage success

Effects of excessive deposition of fine sediment on salmonid spawning success and egg survival have been well documented over the years. It has been proved in a vast plethora of literature that infiltration of fine sediment limits success of eggs hatching through the reduction of gravel permeability and oxygen availability (Ingendahl, 2001; Greig *et al.* 2007; Schindler Wildhaber *et al.* 2014). Salmonid eggs (as well as many cyprinid fish and lamprey eggs) require a well-oxygenated environment during the embryonic development stage, so eggs are laid in permeable gravel beds with interstitial pore spaces, which allow the passage of oxygenated water. Excess fine sediment in the water, when deposited, can clog these interstitial pores, obstructing the circulation of oxygenated water, which reduces egg survival (Carling, 1984; Magee *et al.* 1996). Salmonid egg mortality of between 98-100% has been recorded within spawning gravels experiencing high siltation loads (Turnpenny and Williams, 1980). The effect is particularly damaging when sediments contain a high organic component, as its subsequent decomposition also reduces oxygen from the water (Rubin, 1998). Excess deposited sediment can also reduce interstitial and hyporheic (region beneath streambed) flow velocities (Chapman, 1988; Acornley and Sear, 1999). This decreases the natural flushing process, which removes the harmful metabolic waste excreted by the embryos (Burkhalter and Kaya, 1975). SS can also be damaging to fish species, such as perch and roach, depositing eggs on macrophytes, as silt particles can adhere to the eggs and reduce oxygen and carbon dioxide exchange (Stuart, 1953).

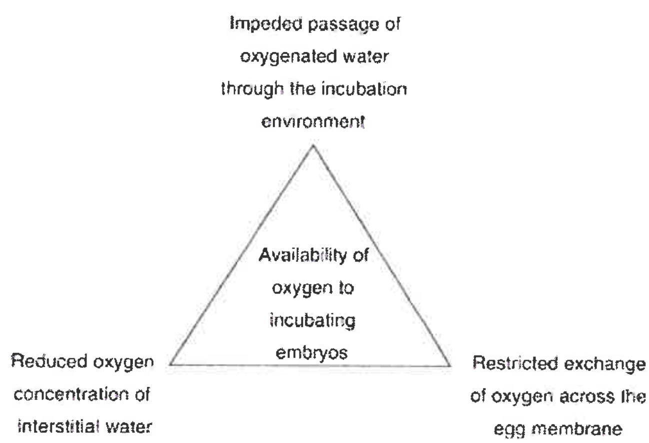

Figure 2: The three specific mechanisms by which fine sediment accumulation restricts O2 availability to incubating salmonid embryos (Greig *et al.* 2005)

Fine sediment can also exert sub-lethal effects on fish fry including: delaying emergence by trapping fry in interstitial pores (Phillips *et al.*, 1975); and premature hatching of smaller and poorer quality fry, due to exposure to low dissolved oxygen concentrations (Alderdice *et al.*, 1958: Mason, 1969). Researchers have found a relationship between fine sediment (less than 0.850 mm) and fry survival, with decreasing survival of up to 3.4% for each 1% increase in fine sediment (Cederholm *et al.*, 1981). Louhi *et al.* (2011) showed that brown trout (*Salmo trutta*) fry experienced predator-masking effects associated with high sedimentation. Control fish tended to postpone fry emergence when exposed to predator odour, whereas fish in the high-sedimentation treatment showed no response to predators. This indicates that in high sediment environments predation is a bigger risk to fry survival. The study also confirmed that in high sediment environments trout fry were emerging earlier with larger yolk sacs. As these fry emerged prematurely to

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escape the suboptimal conditions associated with increased sedimentation it is highly probable that they will be poor swimmers and thus more vulnerable to predation and downstream displacement than fully developed fry. Bowerman *et al.* (2014) found the same phenomenon occurred in bull trout (*Salvelinus confluentus*) fry; they too were emerging from the incubation environment at much earlier development stages when sediment percentages were higher. This work also highlighted later life implications for premature fry that do survive to adulthood, as early emergence can lead to fitness reduction in later life stages. The deposition of sediment on the riverbed also changes and degrades physical habitat for bottom dwelling fish and fry, leading to lower fry and parr density (Lisle and Lewis, 1992). The sediment fills in the spaces between substrate particles, creating a smoother riverbed (Diplas and Parker, 1992). This, not only reduces the available habitat complexity and availability, but also increases water velocity and the need for shelter from the water current (Richardson and Jowett, 2002). Sedimentation also decreases habitat connectivity (Cohen, 1995) and heterogeneity (Boles, 1981).

Gill irritation/trauma

Fish gills are delicate and easily damaged by abrasive sediment particles. Fish species have been found with increasing levels of deformities, eroded fins, lesions, tumours, gill flaring and 'coughing', all related to increasing SS in the water column (Berg, 1982; Schleiger, 2000).

Altered blood physiology

Research has show increases in plasma glucose (Servizi and Martens, 1987), blood sugar levels (Servizi and Martens, 1992) and plasma cortisol (Redding *et al.*, 1987) in fish species exposed to fine sediment. These are all indicators of stress, and can impact physiological systems, reduce growth and decrease immunological competence against other stressors, such as disease. In a study by Sutherland & Meyer (2007) all three life stages of the spotfin chub (*Erimonax monachus*) and whitetail shiner (*Cyprinella galactura*) showed increases in immunoreactive corticosteroid (stress) levels when exposed to moderate sediment concentrations. This study showed that fish species experience physiological stress as a result of suspended sediment regardless of their life stage. Respiratory impairment caused by sediment in the gills was suggested to be the main factor instigating the stress response in the spotfin chubs. Stress to salmonids can also affect the smoltication process, leading to decreased osmoregulatory ability, impaired migrations and a reduction in early marine survival (Wedemeyer and McLeay, 1981).

Altered movement/swimming performance

Migrating fish species, such as salmonids, are commonly known to migrate through high SS concentrations in estuaries. However, like other containments, exposure time is a key element in the impact of SS as well as concentration (Newcombe and MacDonald, 1991). This means high exposure rates to sediment loads can halt fish migration, particularly upstream. Fish are known to exhibit avoidance reactions and move away from the vicinity of adverse sediment conditions, if refuge conditions are present (Sigler *et al.*, 1984; Bash *et al.*, 2001). The effects of suspended sediment on swimming ability on juvenile brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) were explored by Berli *et al.* (2014). Both species experienced a decrease in swimming performance as turbidity increased, but rainbow trout were impaired to a greater extent. This was attributed to impairment in the ability of the fish to utilise anaerobic metabolic pathways in high sediment environments. The authors concluded that the ability of salmonids to maintain swimming

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performance is hindered when fish are exposed to environmentally relevant, suspended sediment-generated turbidities.

Changed foraging behaviour and reduced territoriality

Turbidity can reduce feeding rates, and affect prey selection and prey abundance. This is particularly significant for visual feeders, such as salmonids, where SS can reduce the effectiveness of them obtaining food (Berg, 1982). However, research also suggests the turbid-clear water interface may sometimes assist feeding, by offering concealment and protection within the turbid water (Scullion and Edwards, 1980). Robertson *et al.* (2007) showed that during autumn initial introduction of sediment increased foraging activity in juvenile Atlantic salmon (*Salmo salar*). It was suggested that the small increase in turbidity provided visual isolation from predators. As sediment levels were raised to over 180 mg/L this foraging activity declined along with a rapid reduction in territorial behaviour. Such responses to increased water turbidity have been shown to instigate increased emigration from preferred habitats as excess sediment makes habitats unsuitable. Although salmon were less responsive to increases in suspended sediment levels in colder water temperatures (winter months) this work highlighted the importance of not assuming salmon are more sediment tolerant at these times. Pulses of turbid water have also been shown to breakdown normal social organisation and territoriality, which can decrease feeding rates and may affect overall growth rates (Berg, 1982).

IV. Ecosystem-scale effects

Community homogenisation

Sedimentation can affect aquatic biota at both a population and community level, and result in homogenisation. This means regionally distinct faunas may be replaced with few invasive and disturbance tolerant species (Walters *et al.*, 2003). This could be a serious threat to biodiversity, both now and in the future, by reducing species' resilience to climate change. Sedimentation can also increase the susceptibility of invasive species such as Canadian pondweed and the common carp, which potentially have major disruptive effects on aquatic ecosystems.

Transfer of pollutants

Fine sediment exerts an important control on the transfer and fate of a wide range of agricultural and industrial contaminants (Warren *et al.*, 2003; Collins *et al.*, 2005). Sediment therefore represents an important vector for contaminants such as phosphorus (Haygarth *et al*, 2005); heavy metals (Neal *et al.*, 1999) and organic pollutants like sheep dip substances (Long *et al.*, 1998). These associated pollutants can alter species assemblages by poisoning the water system, and accelerating eutrophication. The capacity of fine sediment to bind contaminants can also lead to an increase in the resident times of the pollutants in aquatic systems (Foster and Charlesworth, 1996), thereby increasing exposure times and the opportunity for pollutant remobilisation.

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Reduced primary productivity

Suspended solids reduce water clarity and increase turbidity, exerting a negative effect upon primary production. Research suggests in subarctic Alaskan steams concentrations of SS as little as 8mg/l can reduce primary production by 3-13% (Lloyd, 1987), and above 2100 mg/l no primary production can occur (Van Nieuwenhuyse and LaPerriere, 1986).

Depressed oxygen levels in the water

Suspended solids can contribute towards raising the Biological Oxygen Demand (BOD; Petts *et al*., 2002), and hence lowered oxygen levels potentially to stressful or lethal levels for vulnerable species and life stages.

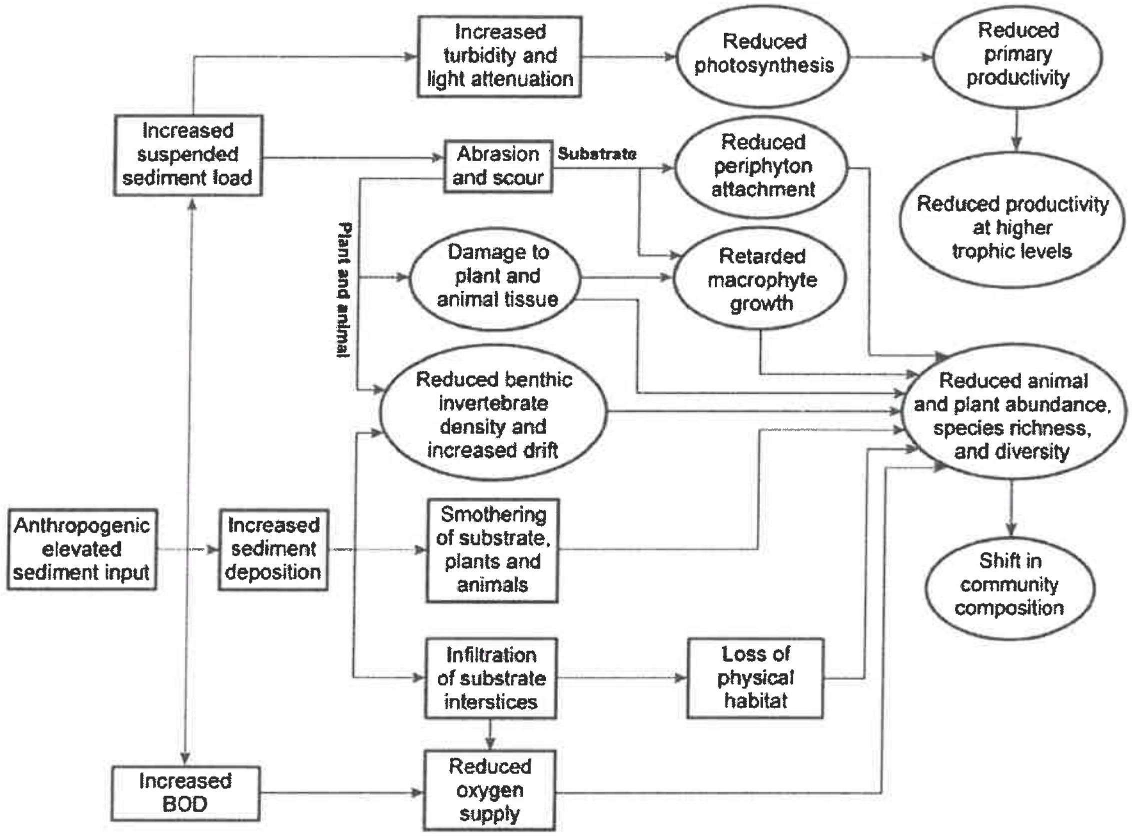

Figure 3: Effects of high sediment loads on aquatic ecosystems. Rectangles = Physicochemical effects. Ovals = Direct/long-term biological and ecological responses. (Kemp *et al.* 2011)

V. Current Management

Until it was revoked, the Freshwater Fish Directive (FFD) stipulated that suspended solid concentrations should not exceed an annual mean of 25mg/l. However, this standard was not imperative and the recommended figure was simply a guideline. In 2009 the FFD and Shellfish Waters Directive were both revoked, with their key requirements being transferred to the Water Framework Directive (WFD). In 2010,

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UKTAG published a note detailing recommendations that should be considered in the transfer, including an environmentally protective solids standard. Application of a standard was deemed necessary to protect shellfish against potential smothering, release of sediment associated pollutants and dissolved oxygen sags related particularly to dredging activity. It was also recommended that suspended solids continue to be monitored due to their ecological significance (UKTAG, 2010). Since the repeal of both Directives, the initial FFD guideline target was lost and no standards for suspended solids under the Water Framework Directive currently exist (Cascade Consulting, Thames Water Utilities, 2011).

In the scientific community attempts have been made to identify target values for both deposited fine sediment and sediment loading, yet the relationship between deposited fine sediment and agricultural sediment pressure is still poorly understood. Collins *et al.* (2007) used a structured modelling methodology to predict the impact of projected structural evolution in agriculture (land use change) and the uptake of sediment mitigation methods due to programmes like the England Catchment Sensitive Farming Delivery Initiative (ECSFDI) on annual mean suspended sediment concentrations across England and Wales by 2015. This work suggested that structural and mitigation work could potentially reduce the national sediment loss from the agricultural sector by 9% by 2015.

Collins and Anthony (2008a) also modelled catchment compliance across England and Wales using the previous FFD guideline standard. The study provided the first national scale assessment of sediment sources for England and Wales under current environmental conditions (year 2000), suggesting that source contributions are in the order: agricultural sector (1929 kt = 76%) eroding channel banks (394 kt = 15%), diffuse urban sources (147 kt = 6%) and point source discharges (76 kt = 3%). A structured regression model was used to convert the predicted total sediment loadings into time-averaged suspended sediment concentrations at national scale. The findings suggested that approximately 83% of the total catchment area of England and Wales appears to require no further reductions in sediment loss to rivers from diffuse agricultural sources for the purpose of meeting 'Good Ecological Status' (GES) as defined by the Water Framework Directive (WFD). It is important to note, however, that the use of the FFD sediment threshold failed to identify catchments across England and Wales where the detrimental impacts of sediment are widely reported e.g. the chalk catchments of southern and eastern England. Chalk catchments are particularly vulnerable to sedimentation due to the lack of any significant flushing effect owing to their baseflow-dominated hydrology.

Naden *et al.* (2016) took these concepts further and analysed instantaneous measurements of deposited fine sediment in 230 agricultural streams across England and Wales in relation to 20 potential explanatory catchment and channel variables. Two main practical recommendations were made from this work regarding fine sediment load targets: 1) the ability of streams to transport/retain fine sediment needs to be taken into account, 2) where agricultural mitigation measures are implemented to reduce delivery of sediment, river management to mobilise/remove fines may also be needed in order to effect an improvement in ecological status in cases where streams are already saturated with fines and unlikely to self-cleanse.

There are, however, serious concerns regarding the use of a single global threshold concentration for suspended sediment. This is because of the large variability of effects caused by sediment, the diversity of

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habitat and conditions within catchments, the existence of sub-threshold effects on both fish and their supporting ecosystems, and the failure of an annual mean to capture the highly episodic nature of sediment pressures which are focused during flood events. To address this alternative sediment targets were proposed for England and Wales using an alternative sediment target scheme (Cooper *et al.*, 2008). This was based on nationally extrapolated suspended sediment yields and uses the lower quartile of the measured ranges for catchment types to represent potential targets and the upper quartiles as critical thresholds. These tentative targets were intended for use in the identification of thresholds from a local perspective. Collins and Anthony (2008b) used a structured modelling framework taking explicit account of sediment sources derived from different societal sectors to assess catchment compliance at national scale across England and Wales using these alternative sediment targets. This work successfully identified catchments where negative sediment impacts on fish are being reported.

The use of sediment yields to represent sediment targets is undermined by a number of problems. Since suspended sediment fluxes represent the aggregate of sediment delivery, their utility is best found in helping to define overall catchment response to environmental pressures as opposed to ecological impacts. Reliable coupling of sediment loadings to ecological impacts requires understanding of additional metrics such as sediment deposition and flushing and sediment grain size characteristics. It also important to highlight that all modelling data is based by common consensus on inadequate knowledge of all pathways and adequate monitoring data assumptions and therefore should not be used in isolation, but as part of an integrated modelling and monitoring approach, to help mange uncertainty and ground truth results. Anecdotal evidence from stakeholders on the impacts of fine sediments upon ecosystem can also provide important insight, and therefore should not be ignored.

VI Concluding Remarks

Understanding and monitoring sedimentation pressure is key to ensuring the delicate ecological mechanisms of riverine ecosystems are preserved. Natural sediment pressures within river systems vary dramatically depending on catchment topography, geology, vegetation, local climate and land use (Hicks and Griffiths, 1992). It is now accepted that excess sediment can cause deterioration in water quality and aquatic biodiversity (Collins *et al.*, 2008). The evidence here highlights the threats our aquatic fauna and flora face because of excess fine sediment pressures. The WFD objective of GES cannot be achieved without addressing this important pressure. Given the problems associated with using the FFD threshold or the alternative sediment yield based target scheme, urgent action is required to identify more meaningful revised sediment targets for England and Wales. Revised targets must take more explicit account of the impacts of sediment on aquatic ecology and should be developed in a catchment-specific manner (Collins and McGonigle, 2008). A generic measurement of sedimentation is not reliable; therefore management should focus on the river basin scale to ensure source control, taking more account of observed impacts rather than modelled inputs. Preventing further damage to river habitats and associated species requires catchment-scale, holistic management, involving the cooperation and regulation of all land users. Managing excess sediment requires prevention and restoration measures, all of which require sound understanding of the key sources (Collins and Walling, 2004) and appropriate monitoring to gauge catchment compliance against revised and improved catchment-specific sediment targets. In order for sediment management to progress in

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England and Wales, better-informed sediment targets, and replicable monitoring methods are urgently required for compliance testing.

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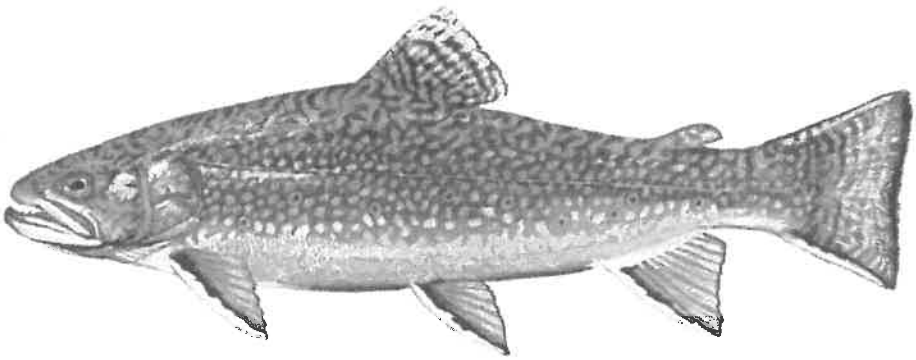

Figure 32. Brook Trout (Salvelinus fontinalis) require clear, cool, and well-oxygenated waterbodies (Becker, 1983).

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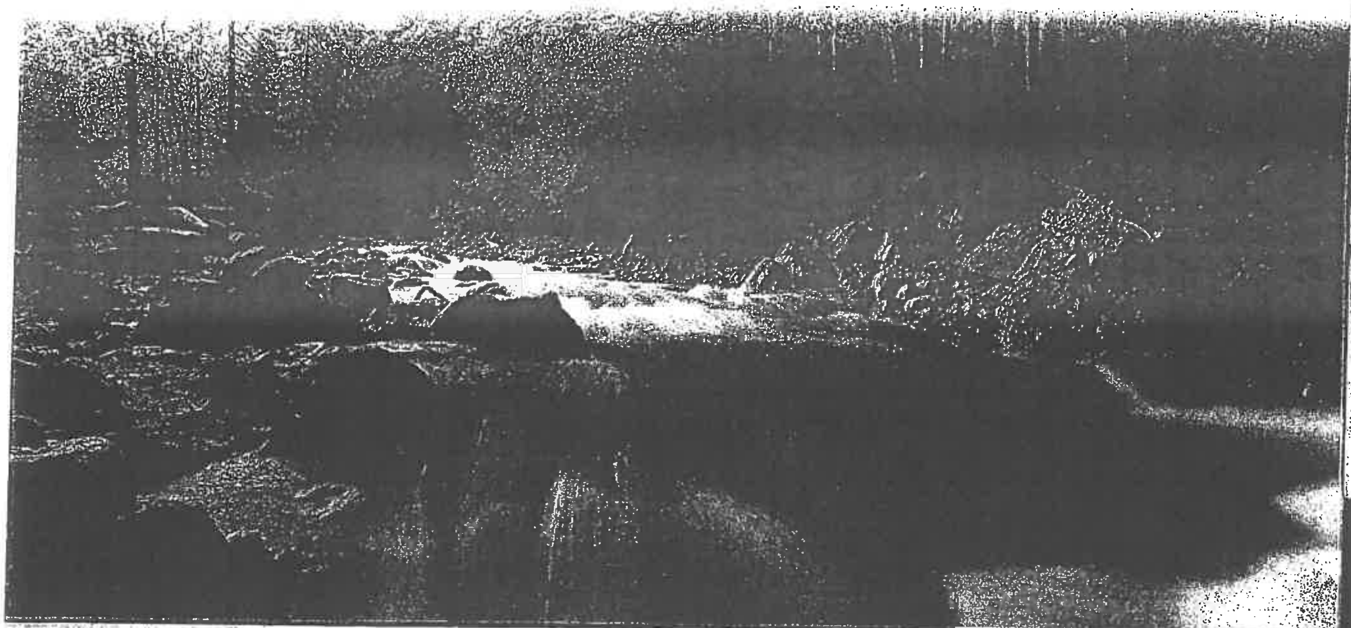
PRINCIPLES OF WATER RESOURCES



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pesticides, fertilizers, lawn clippings, heavy metals, and bacterial loadings from dust can all be generated from street refuse. Highway salting, though reduced in some areas, often migrates to rivers or into groundwater after snow and ice begin to melt.[9]

Construction Activities Soil erosion at construction sites can cause increased sedimentation in local water bodies. Improperly stored construction materials, chemicals, and fuels can also become sources of pollution due to construction site runoff. Proper construction site management can greatly reduce nonpoint source pollution runoff into local water bodies.

Stormwater Runoff Surface water runoff from precipitation events flush large amounts of pollutants—including chemicals, fertilizer, trash, and other waste—from streets, construction sites, agricultural fields, golf courses, and factories, along with sediment from erosion. All of these pollutants enter water bodies at a variety of locations, such as sewer systems, overland flow, and drainage ways.

Dredging Activities Dredging activities in rivers and lakes can also cause water quality problems. Pollutants often become sequestered, or bonded, to bottom sediments and can reside there for decades. Dredging can stir up these materials and often causes them to be transported downstream or to be ingested by fish. Deposition of suspended sediments in reservoirs and temperature changes of deeper waters created by dredging can also affect water quality.[10]

BASIC PARAMETERS OF WATER

The basic chemical and biochemical processes that affect water quality are the result of nature. Long before humans settled along the banks of rivers such as the Yangtze in China and the Nile in Egypt, sediment-laden floods carried metals and minerals that contributed to poor quality of water. Ancient floods of the Mississippi River filled adjacent oxbow lakes and marshes with organic materials such as decaying plants and animals. The aridity of the Colorado River watershed caused salt from alkaline soils to enter the river for thousands of years before human cultivation began in Mexico and the United States. Groundwater in certain regions, or at great depths, contained dissolved minerals that rendered it unfit for human consumption. These natural processes greatly affected water quality around the world long before the negative influences of humans.

TEMPERATURE

Many physical, biological, and chemical characteristics of surface water are dependent on temperature. Excessive temperature changes can accelerate chemical processes and can be detrimental to aquatic plants and wildlife. Increased heat in water can reduce its ability to hold dissolved oxygen, while sudden temperature "shocks" (often caused by heated industrial water released into a lake or stream) can be deadly to many aquatic species. Another example of temperature shock can occur when cold water from the bottom of a reservoir is released through a dam outlet facility and into warmer river water flows downstream. Removal of shade trees and shrubs along a shoreline can also affect the temperature of a water body, particularly during warmer seasons of the year. Fish respond to water temperature variations and often move to new locations when temperature changes vary by little more than 1 to 4°F (1 to 2°C).[11] This occurs because temperatures are outside a tolerable range for various species such as trout.

Water temperature is greatly affected by depth. Surface water is generally much colder at greater depths than shallow water, since it requires more time to absorb heat. Such temperature variations can cause lakes to "turn over" in the spring and fall (see Chapter 3), creating variable water quality characteristics. By contrast, groundwater at depths less than 300 feet (91 m) generally maintains a constant temperature of

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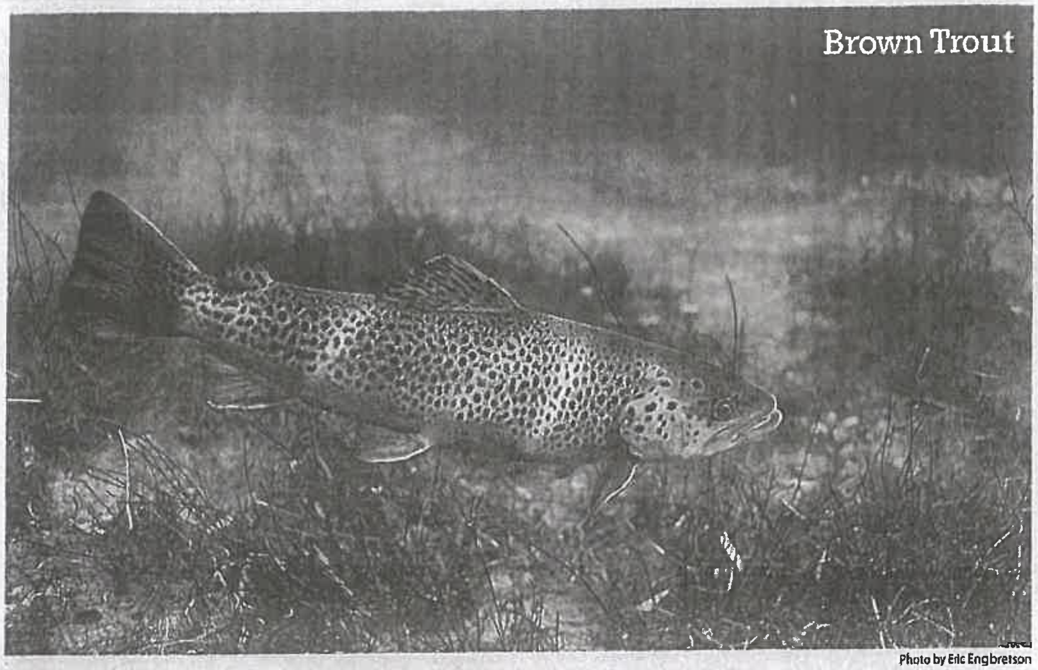

Photo by Eric Engbretson

Brook Trout and Brown Trout

Both brook trout and brown trout are found in many streams in Wisconsin, and require cold, clean water to survive. Both species are sensitive to pollution and low oxygen conditions. A study conducted on 33 coldwater streams in Wisconsin and Minnesota found that when impervious surfaces covered more than 11% of a watershed, trout were eliminated from streams.[8]

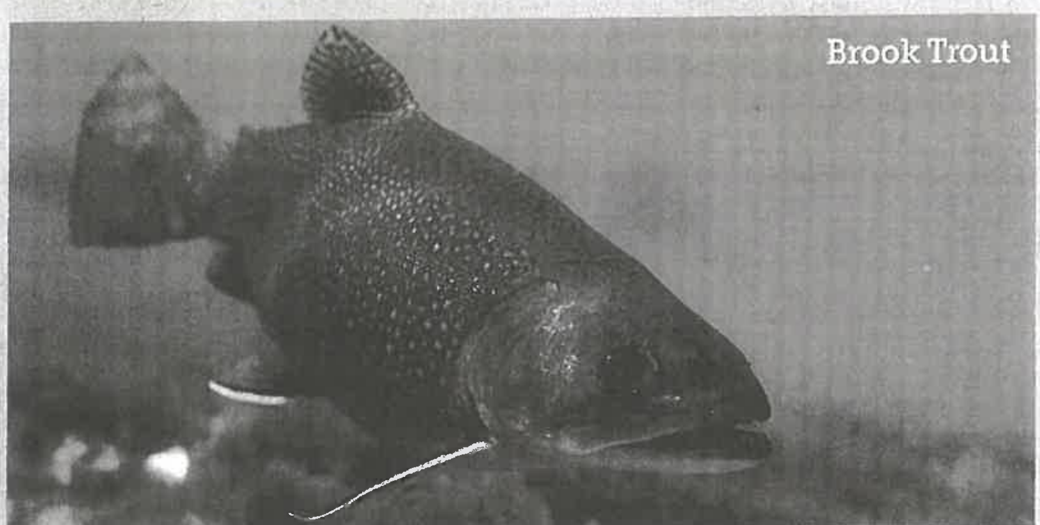

Photo by Eric Engbretson

The brook trout is the only trout species native to Wisconsin's waters. Part of their diet consists of aquatic insects and small fish, whose populations are negatively impacted by increased runoff and sedimentation.

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Surface water hydrology

The Rainy River-Headwaters Watershed contains 32 intermediate watersheds (12-digit Aggregated HUC) and 136 minor watersheds (14-digit HUC). Major rivers include the Ash, Bear Island, Black Duck, Burntside, Cross, Dumbbell, Dunka, Greenwood, Horse, Isabella, Island, Kawishiwi, Little Indian Sioux, Little Isabella, Mitawan, Moose, Nina Moose, Sea Gull, Shagawa, and Stony rivers. In addition, many smaller tributaries flow directly into lakes and into other major tributaries. This entire watershed is comprised of the Canadian Shield, which is a broad plain of eroded ancient rock covering much of central Canada and portions of northern Minnesota. Most of this bedrock is extremely hard, with the exception of some weak spots where glaciers have scared the landscape. The majority of this excavation is westward trending and now holds the lakes of the region and many of the streams that connect those lakes (Waters, 1977). This pattern is evident throughout the border lakes region of Minnesota and Ontario. The Canadian Shield, although locally rugged, is a vast area that is regionally flat. This regional attribute produces a great maze of navigable waterways that permitted relatively easy access by Native Americans, Voyageurs, and present day recreational use.

The Kawishiwi River is the largest river system in the Rainy River-Headwaters Watershed and begins it journey downstream from Kawishiwi Lake. It continues to flow to the north through Square, Kawasachong, Polly, Koma, and Malberg Lake before turning to the west. The Kawishiwi River passes through a lake-dominated landscape, with Alice, Insula, Hudson, Four, Three, Two and Lake One connecting directly to the river. After flowing 46.9 miles from its headwater, the South Kawishiwi River splits off to the southwest towards Birch Lake. On its path, it receives additional water from the Isabella River, which connects to the South Kawishiwi through Little Gabbro, Gabbro, and Bald Eagle Lake. The Isabella River is a stream-dominated system, with many cold-water stream resources that produce a vibrant brook trout population. Several other stream systems contribute their waters to Birch Lake directly before the South Kawishiwi River exits along its northern shoreline. The South Kawishiwi River rejoins the mainstem in Farm Lake after flowing through White Iron Lake. Waters of the Kawishiwi River continues to flow north from Farm Lake through another series of lakes and rapids before contributing its waters to Pipestone Bay of Basswood Lake. The Kawishiwi Falls, between Garden and Fall Lake, is a 60-foot waterfall that attracts numerous tourist each year. The river drops approximately 340 feet from its headwaters to its mouth at Basswood Lake. Most of this change in elevation occurs at the occasional rapids and falls between lakes, resulting in a less than five feet of elevation change per river mile. Major tributaries within this drainage are the Isabella, Dunka, Stony, Bear Island, and Dumbbell River. The majority of this drainage is within the BWCAW. This catchment contain 45.7% (863,998 acres) of the entire land mass of the Rainy River-Headwaters and has an average discharge near Ely of 1,000 cubic feet per second.

Many of the large lakes (Gunflint, Saganaga, Basswood, Crooked, Lac la Croix) that are located along the border are treasured by canoeists, campers, and fishermen as nearly pristine remnants of the "North Woods". A few short rivers along the international border exist, including the 12-mile long Granite River between Gunflint and Saganaga Lake. This river consists of small-interconnected lakes that are shallow in depth and can have some rough rapids with sufficient water. The majority of the water exiting Saganaga Lake flows to the north into Canada along the voyageurs' Kaministikwia route (Waters, 1977). This water later rejoins the United States portion of this watershed through the Maligne River that contributes its flow to Lac la Croix. A small tributary stream also connects Saganaga to Swamp Lake, where it continues to the west through Ottertrack, Little Knife, Knife, Birch, Basswood, & many more lakes and small connector streams. The land mass between these two major flowages is better known as Hunter's Island. This island is solely contained in Ontario, Canada, with the majority of it within the Quetico Provincial Park. The Basswood River starts at the outlet of Basswood Lake and flows 5.3 miles before connecting with Crooked Lake. The Horse River contributes its flow to the Basswood River

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portion of this stream within its boundaries. Waters from this area eventually enter the Rainy River before flowing 85.1 miles to Lake of the Woods, where it continues down the Winnipeg River to Lake Winnipeg, and finally, by way of Canada's Nelson River, to Hudson Bay.

Select drainages within this watershed provide excellent brook trout habitat near the middle and upper reaches but usually lack them near the pour point where habitat is limiting (thermal, substrate, and gradient). Tributary streams to the Island River are generally cooler, with brook trout as the principal game fish. Four-hundred and eight stream reaches totaling 894.26 stream miles exist throughout this major watershed, of which 373.11 stream miles are designated as cold-water (CW) in 227 stream reaches. Some of the streams that are designated cold-water include Arrowhead, Ash, Black Duck, Dunka, Dumbell, Inga, Little Isabella, Kinmount, Mitawan, and Snake River/Creek.

There are 12 dams located on various sized tributaries and outlets of major lakes, including the Kawishiwi, South Kawishiwi, and Stony River (USACE, 2013). Most of these dams were originally created for hydroelectric production or to control water levels. A limited amount of stream channels have been altered, with many natural meandering streams present throughout this watershed (Figure 10). The majority of the streams within this watershed are colored to some degree, with low alkalinity (10-50 parts per million as a result of igneous rock and bogs (Waters, 1977). There is five long-term and continuous USGS stream flow monitoring station located in this watershed near the mouth of the Gold Portage, Kawishiwi, South Kawishiwi (2), and Basswood River. Stream discharge in this watershed is relatively stable due to the moderating effect that the abundant lakes and wetlands have on stream flows.

A total of 1,273 lakes greater than 10 acres and 401,146 acres of wetlands exist within this watershed. The majority of the lakes and wetlands are found along the international border and function as water storage for continued stream flow throughout the seasons. Carved from hard igneous rock by the glaciers, these lakes are typically cold, deep, rocky, clear, and well-oxygenated (Waters, 1977). Many of these lakes are narrow, long and straight, oriented in the way glaciers proceeded through the landscape. This topography is a canoeist paradise, with many islands and rocky points. Many of these lakes are interconnected by water routes and short streams, with relatively easy portages between waters that are not navigable.

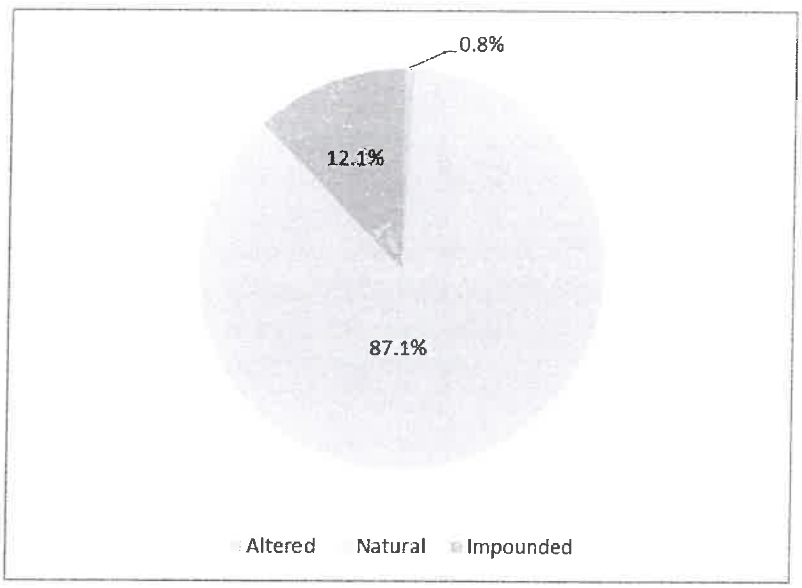

Figure 10. Comparison of natural to altered streams in the Rainy River-Headwaters Watershed.

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Sources:

1) Minnesota Pollution Control Agency Surface Water Data Access ((Online map);https://mpca.maps.arcgis.com/apps/webappviewer/index.html?id=c3ad23220f60416fadcc117f82ba05e3)

2) Map of the Superior National Forest (2018)

3) MN Legislature Office of Revisor Statutes List of MN Trout streams (by county) (https://www.revisor.mn.gov/rules/6264.0050/)

4) MN DNR Trout Angling-North Shore Inland Maps (https://files.dnr.state.mn.us/maps/trout_streams/northeast/maps9-20.pdf)

5) Objective Maintenance Levels (OML) for Superior National Forest Roads (Forest-Wide Travel Management Project https://www.fs.usda.gov/nfs/11558/www/nepa/38755_FSPLT1_024887.pdf (pg. 3))

6) MN DNR Parks and Trails map of the Proposed Border to Border Route for Licensed Off Highway Vehicles.

Note: The MN State Parks & Trails Map and the 2018 Map of the Superior National Forest include most but not all of the stream crossings on the Proposed Border to Border Route for Licensed Off Highway Vehicles. The Minnesota Pollution Control Agency Surface Water Data Access Online map (https://mpca.maps.arcgis.com/apps/webappviewer/index.html?id=c3ad23220f60416fadcc117f82ba05e3) more comprehensively details the streams and Rivers in the Superior National Forest and is the Source for the List below of MN DNR Designated Trout Streams and Rivers crossed by the Proposed Border to Border Route.

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Summary

The Little Isabella River Subwatershed had three assessable stream segments, containing three biological monitoring stations, and two lakes assessed for aquatic recreation (Table 18 and Table 19). All of the streams and lakes met the applicable standards or criteria and fully support aquatic life and/or aquatic recreation (Figure 34). In-stream habitat was in good condition with the highest overall habitat score (84.08 out of 100) in the Rainy River-Headwaters Watershed (Appendix 5). As a result of quality in-stream habitat and good water quality, a relatively diverse fish and macroinvertebrate community was surveyed during monitoring. The low amount of disturbance within this subwatershed almost assures excellent biological integrity. A portion of this subwatershed had exceptional performing biological, chemical, and physical parameters and are worthy of additional protection in order to preserve them.

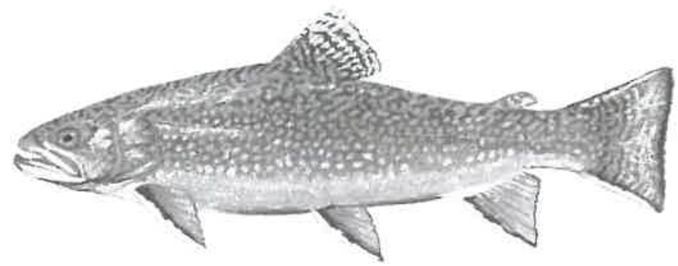

Figure 32. Brook Trout (Salvelinus fontinalis) require clear, cool, and well-oxygenated waterbodies (Becker, 1983).

A use class analysis was conducted on all assessed waterbodies within the Rainy River-Headwaters Watershed. Streams designated as exceptional receive additional protections from a more stringent water quality standard. The upstream reach of the Little Isabella River (-530), from its headwaters to Flat Horn Lake, met the exceptional use criteria. One biological monitoring station (14RN079) was located just upstream of the Little Isabella River Campground (Superior National Forest). This station was sampled once by the MPCA for both fish and macroinvertebrates, with additional fish data provided by the USFS. All five of the fish visits were above the exceptional use standard, with numerous sensitive fish species present during monitoring. A total of 14 fish species were captured consisting primarily of blacknose dace, brook trout, and longnose dace. The macroinvertebrate community indicated similar conditions, with a high number of species and several sensitive individuals.

The Little Isabella River and its tributaries have a vibrant brook trout population that is well known to local anglers (Figure 32). The downstream reach (-561) of the Little Isabella River had one biological monitoring station (14RN008) that was monitored just upstream of BWCAW entry point #75 (Little Isabella River). This station had a diversity of in-stream habitat and a variety of fish species (15). Although the F-IBI is just below the exceptional use threshold, numerous sensitive species (longnose dace, mottled sculpin, blacknose shiner, etc.) were captured including brook trout, which is a sensitive cold-water obligate. The macroinvertebrate community performed well on the M-IBI, with a score (54.66) above the exceptional use threshold. Numerous sensitive species were present during monitoring; including several cold-water obligates (Glossosma, Brachycentrus, and Rhyacophila).

Data for Sphagnum Creek (-577), a tributary to the Little Isabella River, was provided by the USFS and consisted of two fish visits at 06RN016. A total of six fish species were surveyed and contained some sensitive species (brook trout, mottled sculpin). Not all parameters were meeting exceptional use standards but it did indicate good water quality.

The intensive water chemistry station was located near the outlet of the Little Isabella River off Sand River Road (FR 381), adjacent to the Little Isabella River BWCAW entry point (#75). The conventional parameters collected at this location indicate excellent water quality. Sediment and nutrient concentrations were consistently low. The DO dataset here was lacking early morning data. Of the 46 samples collected, three were below the 7mg/L cold-water standard (CWg). There is potential that the

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Summary

The Greenwood River Subwatershed had one assessable stream segment, containing one biological monitoring station, and one lake assessed for aquatic recreation (Table 14 and Table 15). All of the streams and lakes met the applicable standards or criteria and fully support aquatic life and/or aquatic recreation (Figure 29). The only biological monitoring station (14RN077) was located near the outlet of this subwatershed on the Greenwood River (-602). In-stream habitat was in good condition throughout this reach and was reflective of the entire drainage (Appendix 5). As a result of quality habitat and good water quality, a relatively diverse fish and macroinvertebrate community was present. The low amount of disturbance within this subwaterhed almost assured excellent biological integrity. Streams that have exceptional biological, chemical, and physical parameters are worthy of additional protection. Some parameters met the exceptional use standards but not enough of them to designate the reach as exceptional (WWe). A total of eight fish species were captured during monitoring. The reach was dominated by several sensitive species, including the longnose dace which comprised of 86.5% of the sample. In addition, several sensitive macroinvertebrates were captured during monitoring and indicated good water quality.

Greenwood (38-0656-00) was the only lake with assessment level water quality data in this subwatershed. Greenwood Lake is a very shallow, wild rice dominated lake, that fully supports aquatic recreation. In shallow lakes, such as Greenwood, chlorophyll levels are often low, as the lake is dominated by macrophytes (rooted vegetation) instead of algae. This lake had naturally low Secchi transparency due to bog staining from the surrounding wetlands (Figure 27).

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Protection of aquatic life means the maintenance of a healthy aquatic community, including fish, invertebrates and plants. Using the condition, composition, and abundance of aquatic organisms to assess water quality conditions is called "biological monitoring". Biological monitoring is a direct means to assess aquatic life use support, as a community of aquatic organisms integrates the effects of all pollutants and stressors over time. To effectively use biological indicators, the MPCA employs the Index of Biotic Integrity (IBI), a scientifically-validated combination of biological community measurements (called metrics). An IBI is comprised of multiple metrics that measure different aspects of aquatic communities (e.g., dominance by pollution tolerant species, loss of habitat specialists). Metric scores are summed together and the resulting index score characterizes the biological integrity or "health" of a stream. The MPCA has developed stream IBIs for both fish (MPCA 2014b) and macroinvertebrates (MPCA 2014c) since these communities can respond differently to various types of pollution. Because rivers and streams in Minnesota are physically, chemically, and biologically diverse, unique IBIs were developed for different types of streams. In an assessment framework, IBI scores are compared to a numeric threshold ("biocriteria") to provide a quantitative evaluation of a stream's health. In general, IBI scores above biocriteria are indicative of aquatic life use support, while scores below biocriteria are indicative of non-support. Chemical parameters are also measured and assessed against numeric standards developed to be protective of aquatic life. In Minnesota, chemical aquatic life indicators include: pH, dissolved oxygen, un-ionized ammonia nitrogen, chloride and total suspended solids.

Aquatic life use protections are divided into three tiers of biocriteria: Exceptional, General, and Modified. Exceptional Use waters support fish and macroinvertebrate communities that have minimal changes in structure and function from natural condition. General Use waters harbor "good" assemblages of fish and macroinvertebrates that have an overall balanced distribution of organisms, though some changes from natural condition are evident. At this level of condition, ecosystem functions are maintained, but possibly through redundant attributes. Modified Use waters typically reflect a legacy of extensive physical modification which limits the ability of their biological communities to attain the General Use. The Modified Use classification is essentially limited to waterbodies with channels that have been directly altered by humans (e.g., maintained for drainage, riprapped), and is determined prior to assessment based on attainment of applicable biological criteria and/or an assessment of the stream's habitat. For additional information see MPCA (2016b).

Protection of aquatic recreation means maintenance of conditions safe and suitable for swimming and other forms of water recreation. At Lake Superior beaches, and in streams, aquatic recreation is assessed by measuring the concentration of *Escherichia coli* bacteria in the water. To determine if a lake supports aquatic recreational activities, trophic status is evaluated using total phosphorus, transparency (Secchi depth) and chlorophyll *a*. Lakes that are enriched with nutrients and have abundant algal growth are eutrophic and do not support aquatic recreation.

Protection of consumption means protecting citizens who eat fish from Minnesota waters or receive their drinking water from waterbodies protected for this beneficial use. Concentrations of mercury and polychlorinated biphenyls (PCBs) in fish tissue are used to evaluate whether or not fish are safe to eat in a lake or stream, and to issue recommendations regarding how often fish from a particular water body can be safely consumed. In terms of drinking water protections, MPCA primarily measures the concentration of nitrate in the water column of lakes, rivers, and streams that are assigned this designated use.

A small percentage of Minnesota's stream miles (~1% of 92,000 miles) have been individually evaluated and re-classified as Class 7 Limited Resource Value Waters (LRVWs). These streams are characterized by an inability to achieve aquatic life standards, both currently and in the future, due to either: a) natural conditions as exhibited by poor water quality characteristics, lack of habitat or lack of water; b) the quality of the resource having been significantly (and irreversibly) altered by human activity; or c)

7050.0265 ANTIDEGRADATION STANDARDS WHEN CHANGES IN EXISTING WATER QUALITY ARE REASONABLY QUANTIFIABLE.

Subpart 1. **Scope.** This part applies to activities regulated by the following control documents: → see page 4 for reference

A. new, reissued, or modified individual NPDES wastewater permits;

B. new, reissued, or modified individual NPDES storm water permits for industrial activities, as defined under part 7090.0080, subpart 6;

C. new, reissued, or modified individual NPDES storm water permits for construction activities, as defined under part 7090.0080, subpart 4;

D. section 401 certifications for new, reissued, or modified individual federal licenses and permits; and

E. other control documents that authorize net increases in loading or other causes of degradation and where changes in existing water quality of individual surface waters can reasonably be quantified through antidegradation procedures.

Subp. 2. **Protection of existing uses.** The commissioner shall approve a proposed activity only when existing uses and the level of water quality necessary to protect existing uses are maintained and protected. ~~Evaluation of the maintenance and protection of existing uses includes consideration of:~~

~~A. aquatic life that utilizes or is present in or on the surface waters;~~

~~B. recreational opportunities in or on the surface waters;~~

~~C. hydrologic conditions, geomorphic conditions, water chemistry, and habitat necessary to maintain and protect existing aquatic life or recreation in or on the surface waters; and~~

~~D. commercial activity that depends on the preservation of water quality.~~

Subp. 3. **Compensatory mitigation~~; loss of existing uses~~.**

A. ~~Except as provided in item D,~~ The commissioner shall allow compensatory mitigation ~~for the loss of an existing use resulting from~~ as a means to preserve an existing use when there is a physical ~~alterations~~ alteration to a surface water only when all of the following conditions are met:

(1) prudent and feasible alternatives are not available to avoid or minimize adverse impacts to the ~~existing use~~ surface water;

(2) the mitigation is sufficient in quality and quantity to ensure replacement of the lost ~~existing use~~ surface water;

(3) the mitigation is accomplished by:

(a) restoring a previously impacted surface water of the same type, or other type if required by statute; or~~,~~

(b) when restoring is not a prudent or feasible alternative, establishing or enhancing a surface water of the same type, or other type if required by statute;

(4) the mitigation occurs within the same watershed, to the extent prudent and feasible; and

(5) the mitigation is completed before or concurrent with the actual physical alteration, to the extent prudent and feasible.

B. For the purposes of subpart 2 and part 7050.0250, item A, existing uses are maintained and protected when regulated activities involving the physical alterations of surface waters are in compliance with item A.

C. When the physically altered surface water is of high quality, the commissioner shall ensure the requirements specified in subpart 5 are satisfied.

~~D. The commissioner shall prohibit the loss of existing uses resulting from physical alterations, regardless of the compensatory mitigation proposed, when~~

~~the proposed activity would physically alter or otherwise degrade the exceptional characteristics of an outstanding resource value water designated in part 7050.0335.~~

Subp. 4. **Protection of beneficial uses.** The commissioner shall not approve a proposed activity that would permanently preclude attainment of water quality standards.

Subp. 5. **Protection of surface waters of high quality.** Items A to D apply to surface waters the commissioner determines to be of high quality.

A. The commissioner shall not approve a proposed activity when the commissioner makes a finding that prudent and feasible prevention, treatment, or loading offset alternatives exist that would avoid degradation of existing high water quality. When the commissioner finds that prudent and feasible prevention, treatment, or loading offset alternatives are not available to avoid degradation, a proposed activity shall be approved only when the commissioner makes a finding that degradation will be prudently and feasibly minimized.

B. The commissioner shall approve a proposed activity only when the commissioner makes a finding that lower water quality resulting from the proposed activity is necessary to accommodate important economic or social changes ~~resulting from the proposed activity are important~~ in the geographic area in which degradation of existing high water quality is anticipated. The commissioner shall consider the following factors in determining the importance of economic or social changes:

(1) economic gains or losses attributable to the proposed activity, such as changes in the number and types of jobs, median household income, productivity, property values, and recreational, tourism, and other commercial opportunities;

(2) contribution to social services;

(3) prevention or remediation of environmental or public health threats;

(4) trade-offs between environmental media; and

(5) the value of the water resource, including:

(a) the extent to which the resources adversely impacted by the proposed activity are unique or rare within the locality, state, or nation;

(b) benefits associated with high water quality for uses such as ecosystem services and high water quality preservation for future generations to meet their own needs; and

(c) factors, such as aesthetics, that cannot be reasonably quantified; and

(6) other relevant environmental, social, and economic impacts of the proposed activity.

C. A proposed activity that would result in degradation of existing high water quality shall be approved only if the commissioner determines that issuance of the control document will achieve compliance with all applicable state and federal surface water pollution control statutes and rules administered by the commissioner.

D. The commissioner shall provide an opportunity for intergovernmental coordination and public participation before allowing degradation of existing high water quality.

Subp. 6. **Protection of restricted outstanding resource value waters.** The commissioner shall restrict a proposed activity in order to preserve the existing water quality as necessary to maintain and protect the exceptional characteristics for which the restricted outstanding resource value waters identified under part 7050.0335, subparts 1 and 2, were designated.

Subp. 7. **Protection of prohibited outstanding resource value waters.** The commissioner shall prohibit a proposed activity that results in a net increase in loading or other causes of degradation to prohibited outstanding resource value waters identified under part 7050.0335, subparts 3 and 4.

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Summary

The Lower Stony River Subwatershed had six assessable stream segments, containing seven biological monitoring stations, and one lake assessed for aquatic recreation (Table 10 and Table 11). All of the streams and lakes met the applicable standards or criteria and fully support aquatic life and/or aquatic recreation (Figure 26). In-stream habitat tended to score worse downstream but was in fair condition overall (Appendix 5). One station (14RN070) located on an Unnamed Tributary to the Stony River had a poor habitat rating, which likely resulted from its low gradient, fine sediment, and headwater nature (Figure 24). The score for this station alone was low enough to push the overall rating for this subwatershed below the good rating. Despite the fair habitat rating, the low amount of disturbance within this subwatershed almost assured excellent biological integrity.

A use class analysis was conducted on all assessed rivers and streams within the Rainy River-Headwaters Watershed. Streams designated as exceptional receive additional protections from a more stringent water quality standard. Denley Creek (-627), a major tributary to the Stony River, met the exceptional use criteria. A total of 11 fish species were captured during monitoring at 14RN067, dominated by northern rebelly dace. The dominance of this species, along with the presence of other sensitive species indicated excellent water quality. The macroinvertebrate community also had a diverse species assemblage that contained several sensitive individuals.

Figure 24. Unnamed tributary to Stony River – 14RN070.

The upstream reaches of Denly Creek are designated cold-water resources (CWg) and include both Nira (-573) and Harris Creek (-555). The United States Forest Service (USFS) provided data for the two biolgocial monitoring stations (06RN009 and 11RN003) that were located on these stream reaches. A total of 11 fish species were captured during monitoring and comprised of a mixture of warm, cool, and cold-water obligates. The only biological monitoring station (06RN009) located on Harris Creek was just downstream of FR 1464 and had brook trout captured at all three visits. Nira Creek had one fish visit to 11RN003 and consisted mostly of cool/warm-water species. Macroinvertebrate suggested similar conditions as indicated by the fish community. This reach, along with Harris Creek, were assessed using the Northern Coldwater F-IBI and M-IBI and resulted in scores that suggested full support for aquatic life. Further information should be collected for Nira Creek to assess its viability to support a cold-water fishery.

Although not all of the stream reaches met the exceptional use (WWe and CWe) designation, all of the assessed streams in the Lower Stony River Subwatershed were in excellent condition and supported aquatic life. A total of 29 fish species and 3,965 individuals were captured during monitoring of the Stony River and its tributary streams, with several sensitive individuals present. The macorinvertebrate community also had a diversity of sensitive species and indicated simlar conditions as the fish.

Water quality at the outlet (Stony River; -985) of this subwatershed was in excellent condition. This stream segment has sufficient data for an assessment of river eutrophication, including 40 phosphorus observations and a late-summer DO dataset from a sonde deployment. Phosphorus concentrations

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Executive summary

The Rainy River-Headwaters Watershed (09030001) lies in northeastern Minnesota and covers approximately 2,954 mi^2 or 1,890,689 acres. A total of 1,273 lakes (>10 acres) and 408 stream reaches reside within this watershed. Streams are generally small to moderate in channel size, short, and vary in gradient; many are direct tributaries to the many lakes in the watershed. Both drinking water quality and the recreational value of lakes and streams are important to the health and wealth of local economies throughout this watershed. The waterbodies also provide habitat for aquatic life, riparian corridors for wildlife. The immaculate waters found within this watershed not only produce some of the highest quality fisheries in the state but also offer visitors many scenic and natural views. The most visited wilderness area (Boundary Waters Canoe Area) in the United States is located within this watershed, with water as a major focal point. Today over 99% of the Rainy River-Headwaters Watershed is undeveloped and utilized for timber production, hunting, fishing, hiking, and other recreational opportunities. Large tracts of public land exist within this watershed, including county land, national and state forests, wildlife management areas, scientific and natural areas, state parks, and a national park.

In 2014, the Minnesota Pollution Control Agency (MPCA) undertook an intensive watershed monitoring (IWM) effort of surface waters within the Rainy River-Headwaters Watershed. Sixty-two stream stations were sampled for biology at the outlets of variable sized subwatersheds. These locations included the mouth of the Ash, Bear Island, Black Duck, Cross, Dumbbell, Dunka, Island, Little Indian Sioux, Little Isabella, Shagawa, South Kawishiwi, and Stony rivers, as well as the upstream outlets of major tributaries, and the headwater outlets of smaller streams. Cook and Lake County Soil and Water Conservation Districts (SWCD) and Vermilion Community College completed stream water chemistry sampling at the outlets of 13 streams. In addition, the MPCA, Lake County SWCD, Natural Resources Research Institute, National Park Service, and local volunteers completed lake monitoring on 60 lakes. In 2016, a holistic approach was taken to assess all surface waterbodies within the Rainy River-Headwaters Watershed for support of aquatic life, recreation, and consumption (where sufficient data was available). Additional data from other state and federal agencies, local units of government, lake associations, and/or individuals were used in the assessment of these designated beneficial uses. Sixty-four stream segments and 245 lakes were assessed in this effort.

Of the assessed streams, 97% fully supported aquatic life and 92% fully supported aquatic recreation. There were impairments for total suspended solids (TSS), Escherichia coli (bacteria), and mercury in fish. All but one lake assessed met eutrophication standards for lake trout, cold, and warm-water lakes in the Northern Lakes and Forest ecoregion, and had good water quality that indicated oligotrophic to mesotrophic conditions. A number of lakes deep within the Boundary Waters Canoe Area Wilderness (BWCAW) fully supported aquatic recreation based on satellite estimated Secchi transparency. One-hundred and eighty-eight lakes had existing aquatic consumption impairments due to an exceedance of standards for mercury in fish tissue. The Minnesota Department of Health (MDH) has issued numerous fish consumption advisories for specific lakes throughout this watershed.

Overall, water quality conditions are good to excellent and can be attributed to the forest and wetlands that dominate land cover within the Rainy River-Headwaters Watershed. A limited number of impairments do occur and persist throughout the watershed. They are typically limited to the lower reaches where stressors from land use practices may accumulate. Impairments found within this watershed are likely a function of both natural and anthropogenic stressors. Historical and recent forest cover changes, along with urban/industrial development, and draining of wetlands are likely stressors affecting biological communities within the watershed. The majority of the waterbodies within this watershed had exceptional biological, chemical, and physical characteristics that are worthy of additional protection.

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Biological monitoring

Fish

The Rainy River Basin spans a total of 26,882.4 square miles, encompassing one state (Minnesota) and two provinces (Ontario and Manitoba). Seventy-four different species of fish can be found within this basin. Although the Rainy River-Headwaters Watershed encompasses only a small percentage (11%; Minnesota Only) of the entire basin, 38 species were sampled during this monitoring (Appendix 4.1). Historically, fisheries management activities have focused on the stocking of brook trout within cold-water (trout) streams.

The Rainy River Basin does not have any endangered or threatened species under federal law but the watershed does have six fish species listed by the state of Minnesota as being of special concern (DNR, August 2013). These speciesies include; *Ichthyomyzon fossor* (northern brook lamprey), *Acipenser fulvescens* (lake sturgeon), *Coregonus zenithicus* (shortjaw cisco), *Couesius plumbeus* (lake chub), *Lepomis gulosus* (warmouth), and *Lepomis peltastes* (northern longear sunfish). In addition, many introduced and invasive species are known to exist within the watershed, including curly-leaf pondweed, Heterosporis, purple loosestrife, spiny water flea (*Bythotrephes longimanus*) and numerous fish species (*Osmerus mordax*: rainbow smelt, *salmo trutta*: brown trout, *salvelinus fontinalis*: brook trout, *Lepomis gulosus*: warmouth, and *Micropterus dolomieu*: smallmouth bass). Many of the fish species were either introduced during historical stocking efforts or likely transported by recreational users. Streams and lakes near population centers and other heavily used recreational areas are the most vulnerable to aquatic invasive species. Only two introduced species were encountered during sampling for this assessment, including brook trout and smallmouth bass.

Some fish species occurred in high densities while others had a more limited distribution and low numbers of individuals. The most ubiquitous fish species within this watershed was the *Catostomus commersoni* (white sucker), which occurred at 65 of the 72 stations (Appendix 4.1). Although the white sucker was the most frequently captured, it was not the most abundant fish species. While only encountered at 51 stations throughout the watershed, the *Luxilus cornutus* (common shiner) was the most abundant fish species with 3,387 individuals collected. Numerous other species of fish were encountered at the majority of the stations, including *Umbra limi* (central mudminnow), *Semotilus atromaculatus* (creek chub), *Rhinichthys cataractae* (longnose dace), *Rhinichthys atratulus* (blacknose dace), and *Cottus bairdii* (mottled sculpin). Fish that were encountered during sampling consisted of both warm-water riverine and cold-water obligate species. This is likely due to the diversity of water temperature, habitat, and overall channel morphology found throughout the Rainy River-Headwaters Watershed.

Certain attributes of the fish community, such as pollution tolerance, trophic (feeding) habits, reproductive traits, habitat preferences, species richness, and life history strategies can provide insight into the quality of the streams in which they inhabit. These attributes cannot only be beneficial in identifying a streams status but also in identifying environmental stressors that may be contributing to aquatic life impairments. Fish species that are known to be intolerant or sensitive of disturbances are almost always a good indication of quality stream habitat, water chemistry, and connectivity. On the contrary, a fish assemblage that is dominated by tolerant species is likely an indication of poor water quality, habitat, or other natural or anthropogenic factors. Though there were some tolerant fish species captured throughout the watershed, most streams had a robust population of sensitive fish species. Anthropogenic stressors were few throughout this watershed and resulted in sufficient habitat and water chemistry to support these assemblages. The most frequently captured sensitive species was the longnose dace, which was found at 38 of the 72 stations. Overall, the presence of relatively sensitive species and a limited number of tolerant species indicates exceptional water quality. Problem areas do persist and are likely attributed to natural and anthropogenic stressors that can be found in select drainages.

Macroinvertebrates

Between 2010 and 2015 there were a total of 76 macroinvertebrate monitoring visits (representing 61 stations) within the Rainy River-Headwaters Watershed. Of the 398 unique taxonomic groupings observed within this watershed, approximately 30% of these represent sensitive individuals. The most numerous taxonomic groupings observed were *Chimarra* (finger-net caddisflies), *Simulium* (blackflies), *Hydrobiidae* (gastropods), *Hydropsychidae* (net-spinning caddisflies), *Rheotanytarsus* (midges). Many of these taxa represent ubiquitous species found across Minnesota. The macroinvertebrate surveys did not identify species that are considered to be endangered or threatened but one species of special concern (*Boyeria grafinana*; Odonata) were observed at five monitoring location throughout this watershed. However, many of the specimens collected during these surveys could be representative of species on this list, based on their known range, distribution, and habitat requirements. Many of the macroinvertebrate communities in the Rainy River-Headwaters Watershed are representative of excellent/exceptional water quality. These catchments should be managed to maintain their valuable aquatic resources.

Watershed-wide condition

Fish and macroinvertebrate communities throughout the Rainy River-Headwaters Watershed are in generally excellent condition. The relatively low amount of anthropogenic stressors within the Rainy River-Headwaters Watershed likely contributes to the exceptional quality of its waterways. Most F-IBI and M-IBI scores are very near, or actually attain an exceptional use designation. Good habitat, water chemistry, and flow conditions may all play a role in the high overall diversity of species and the relatively high frequency of sensitive species. Fish communities in particular tend to perform relatively well, perhaps due to fairly diverse and abundant habitat found in most Rainy River-Headwaters streams. Some of the most noteworthy waterways according to the F-IBI and M-IBI scores, include Bezhik Creek, Denley Creek, MItawan Creek, Jack Pine Creek, Snake River, Little Isabella River, and the Cross River (Table 59).

Fish contaminant results

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Upper and Lower Stony River, Bear Island River and Greenwood River 12HUC subwatersheds support the highest percentage of wetland among all the 12-HUC subwatersheds in the Rainy River-Headwaters Watershed ranging in area from 32.1 to 50.2%. These estimates and distribution observations are derived from the updated Minnesota NWI based primarily on 2009 spring leaf-off imagery http://www.dnr.state.mn.us/eco/wetlands/nwi_proj.html. This updated inventory revealed slightly less wetland area (21.2%) compared to the original wetland inventory (22.9%). Given the lack of development within the Rainy River-Headwaters Watershed, the slight difference in wetland percent is likely due to improved data and advanced geographic data analysis methods currently available.

Special wetland features

To protect and maintain existing high water quality uses, all waters, including all wetlands, within the BWCAW and those within Voyagers National Park are prohibited from receiving net increases in pollutant loading or other causes of degradation in accordance with Minn. R. ch. 7050 parts 0265 and 0270. The southern region of the watershed, which is outside the BWCAW, includes nine 12-HUC watersheds where more than 25% of the area is wetland. In all nine of these subwatersheds forested wetlands are the dominant wetland type. There are six subwatersheds that support less than 15% wetlands, the lowest being Lac La Croix with 8.7% wetland. In most of these subwatersheds, deep-water habitats (i.e. lakes and large rivers) comprise at least 20% of the area with the balance being upland. The Sea Gull River subwatershed is the exception to this characterization as it supports less than 17% deep-water habitat, 15% wetland with the balance being upland.

Another special feature present throughout the wetlands in this watershed is the presence of wild rice. Analysis of a recent compilation of waters known to support wild rice finds 170 locations where wild rice grows in the Rainy River-Headwaters Watershed, the majority of these locations are lakes, however 18 locations are emergent or shallow water wetlands.

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Summary

The Upper Stony River Subwatershed had two assessable stream segments, containing three biological monitoring stations, and one lake assessed for aquatic recreation (Table 12 and Table 13). All of the streams and lakes met the applicable standards or criteria and fully support aquatic life and/or aquatic recreation (Figure 28). In-stream habitat in this subwatershed was in good condition and was one of the highest overall scores (80.17 out of 100) within the Rainy River-Headwaters Watershed (Appendix 5). As a result of quality in-stream habitat and good water quality, a relatively diverse fish and macroinvertebrate community was present. The low amount of disturbance within this subwaterhed almost assured excellent biological integrity. Streams that have exceptional biological, chemical, and physical parameters are worthy of additional protection in order to preserve their valuable aquatic resources.

A use class analysis was conducted on all assessed rivers and streams within the Rainy River-Headwaters Watershed. Streams designated as exceptional receive additional protections from a more stringent water quality standard. The Stoney River was not designated as exceptional but it did have some characteristics of an exceptional stream system. Two biological monitoring stations (14RN072 and 14RN073) are located along the Stony River proper (-984). A total of eight fish species were captured between the two stations, with several sensitive species present. Both stations had a F-IBI scores (14RN072: 83.1 and 14RN073: 87.3) that were well above the exceptional use threshold for the Northern Streams fish class (61). However, M-IBI scores were just below the exceptional use threshold.

In addition, Wilbar Creek (-693) met exceptional use standards for fish but had a mixture of results from its two macroinvetebrate samples. One macorinvertebrate sample was collected during fall of 2014 and resulted in a M-IBI score above the exceptional use standard, while the 2015 sample was just below it. Although similar habitats were sampled (rock, wood, and macrophytes) between the two dates, water levels appear to be lower in 2015. It is plausible that a beaver dam both upstream and downstream of the station (14RN075) could have caused the decrease in flows that were observed in 2015; ultimately resulting in different M-IBI scores. Although the M-IBI score did vary between sampling years, numerous sensitive species were captured indicating good water quality. Sixteen fish species dominated by several sensitive species (longnose dace, burbot, etc.) were sampled within this subwatershed. The macroinvertebrate community indicated similar conditions as the fish, with numerous sensitive species present.

An intensive water chemistry station (S007-910) was selected near the pour point of this subwatershed to represent the segment (-984) of the Stony River from the headwaters to Stony Lake (38-0660-00). Water quality at this station was good, reflecting the subwatershed's forest and wetland land cover and low gradient characteristics. The dataset was small, but did indicate that low concentrations of phosphorus are present in the stream. Sediment and Secchi tube datasets indicated standards were being met, no observations exceeded water quality standards, likely due to the wetland complexes assimilating suspended sediments. Too few bacteria samples were collected for a formal assessment of recreational use, although all samples had consistently low level of bacteria. This was expected given the remote setting of most of this subwatershed.

North McDougal (38-0686-00) was the only lake in this subwatershed that had sufficient data for an assessment of recreational use and was assessed as fully supporting. Very little algae grows in this lake. Secchi transparency is limited by natural bog-stain and is not reflective of the trophic state of the lake.

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Little Isabella River Aggregated 12-HUC

HUC 0903000107-02

The Little Isabella River Subwatershed drains 51.49 square miles of Lake County and is the seventh smallest subwatershed within the Rainy River-Headwaters Watershed. The headwaters of the Little Isabella River begins in a forested wetland and flows 11.1 miles to the northeast while receiving additional flow from numerous unnamed tributaries before reaching Flat Horn Lake (38-0568-00). The Isabella River receives additional water from Weiss Creek, which connects to Flat Horn Lake through Gegoka Lake (38-0573-00). As the Little Isabella River exits Flat Horn Lake, it turns to the north and flows an additional 20.86 miles before reaching the Isabella River and exiting this subwatershed. On its path to the Isabella River it flows through Grouse (38-0557-00) and Dragon Lake (38-0552-00), while receiving additional flow from Sphagnum and numerous unnamed creeks. Numerous cold-water streams exist within this subwatershed with robust populations of brook trout (Figure 32). This subwatershed is a part of the larger Kawishiwi River system, which is the largest river system in the Rainy River-Headwaters Watershed. There are a total of 14 lakes greater than 10 acres, with the most prominent being Gegoka, Gourse, Gragon, Flat Horn, and Cat. This subwatershed is dominated by forest (60.55%) and wetland (32.26%). Only 3.52% is developed, 2.32% is open water, 1.33% is rangeland, 0.02% is row-crop agriculture, and there is no barren/mining. This entire subwatershed lies within the Superior National Forest, with a portion (6.36%) of it within the BWCAW. Much of the land is owned and managed by local, state, and federal entities (USGS, 2008). A small portion of this drainage has been burned by both prescribed and wild fires. Intensive water chemistry sampling was conducted at the outlet of the subwatershed at the end of Sand River Rd (FR-381), 13 miles northwest of Isabella on the Little Isabella River. The outlet is represented by water chemistry station S007-899 and biological station 14RN008.

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Summary

The Little Isabella River Subwatershed had three assessable stream segments, containing three biological monitoring stations, and two lakes assessed for aquatic recreation (Table 18 and Table 19). All of the streams and lakes met the applicable standards or criteria and fully support aquatic life and/or aquatic recreation (Figure 34). In-stream habitat was in good condition with the highest overall habitat score (84.08 out of 100) in the Rainy River-Headwaters Watershed (Appendix 5). As a result of quality in-stream habitat and good water quality, a relatively diverse fish and macroinvertebrate community was surveyed during monitoring. The low amount of disturbance within this subwatershed almost assures excellent biological integrity. A portion of this subwatershed had exceptional performing biological, chemical, and physical parameters and are worthy of additional protection in order to preserve them.

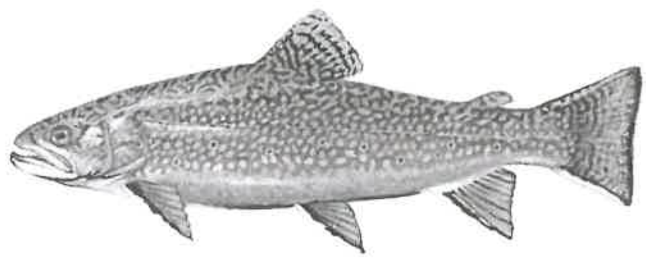

Figure 32. Brook Trout (Salvelinus fontinalis) require clear, cool, and well-oxygenated waterbodies (Becker, 1983).

A use class analysis was conducted on all assessed waterbodies within the Rainy River-Headwaters Watershed. Streams designated as exceptional receive additional protections from a more stringent water quality standard. The upstream reach of the Little Isabella River (-530), from its headwaters to Flat Horn Lake, met the exceptional use criteria. One biological monitoring station (14RN079) was located just upstream of the Little Isabella River Campground (Superior National Forest). This station was sampled once by the MPCA for both fish and macroinvertebrates, with additional fish data provided by the USFS. All five of the fish visits were above the exceptional use standard, with numerous sensitive fish species present during monitoring. A total of 14 fish species were captured consisting primarily of blacknose dace, brook trout, and longnose dace. The macroinvertebrate community indicated similar conditions, with a high number of species and several sensitive individuals.

The Little Isabella River and its tributaries have a vibrant brook trout population that is well known to local anglers (Figure 32). The downstream reach (-561) of the Little Isabella River had one biological monitoring station (14RN008) that was monitored just upstream of BWCAW entry point #75 (Little Isabella River). This station had a diversity of in-stream habitat and a variety of fish species (15). Although the F-IBI is just below the exceptional use threshold, numerous sensitive species (longnose dace, mottled sculpin, blacknose shiner, etc.) were captured including brook trout, which is a sensitive cold-water obligate. The macroinvertebrate community performed well on the M-IBI, with a score (54.66) above the exceptional use threshold. Numerous sensitive species were present during monitoring; including several cold-water obligates (Glossosma, Brachycentrus, and Rhyacophila).

Data for Sphagnum Creek (-577), a tributary to the Little Isabella River, was provided by the USFS and consisted of two fish visits at 06RN016. A total of six fish species were surveyed and contained some sensitive species (brook trout, mottled sculpin). Not all parameters were meeting exceptional use standards but it did indicate good water quality.

The intensive water chemistry station was located near the outlet of the Little Isabella River off Sand River Road (FR 381), adjacent to the Little Isabella River BWCAW entry point (#75). The conventional parameters collected at this location indicate excellent water quality. Sediment and nutrient concentrations were consistently low. The DO dataset here was lacking early morning data. Of the 46 samples collected, three were below the 7mg/L cold-water standard (CWg). There is potential that the

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Mitawan Creek Aggregated 12-HUC

HUC 0903000107-03

The Mitawan Creek Subwatershed drains 42.06 square miles of Lake County and is the second smallest subwatershed within the Rainy River-Headwaters Watershed. The headwaters of this subwatershed begins in a forested wetland and continues to the northwest 2.8 miles through Hill Creek before reaching Mitawan Lake (38-0561-00). A small channel connects both Kitigan (38-0559-00) and Mitawan Lake. Mitiwan Creek begins at the outlet of Kitigan Lake and continues 14.2 miles to its confluence with the Isabella River, while receiving additional flow from Victor, Jack Pine, Inga, and various unnamed tributaries. Numerous cold-water stream exist within this subwatershed and support a vibrant brook trout population. This subwatershed is a part of the larger Kawishiwi River system, which is the largest river system in the Rainy River-Headwaters Watershed. There are a total of 10 lakes greater than 10 acres, with the most prominent being Bog, Mitawan, and Kitigan. This subwatershed is dominated by forest (63.15%) and wetland (29.46%). Only 3.33% is developed, 2.83% is open water, 1.23% is rangeland, and there is no barren/mining or row-crop agriculture. This entire subwatershed lies within the Superior National Forest, with a portion (18.34%) of it within the BWCAW. Much of the land is owned and managed by local, state, and federal entities (USGS, 2008). A portion of this drainage was burned in the Pagami Creek fire of 2011, along with other wild and prescribed fires. As a result of the overall remoteness; there was no intensive water chemistry sampling conducted on rivers and streams within this subwatershed.

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Summary

The Mitawan Creek Subwatershed had five assessable stream segments, containing seven biological monitoring stations, and no lakes assessed for aquatic recreation (Table 20 and Table 21). All of the streams met the applicable standards or criteria and fully support aquatic life (Figure 36). In-stream habitat was in good condition and was a reflection of the land use throughout this subwatershed (Appendix 5). As a result of quality in-stream habitat and high water quality, a relatively diverse fish and macroinvertebrate community was captured during monitoring. The low amount of disturbance within this subwatershed almost assures excellent biological integrity. Streams that have exceptional performing biological, chemical, and physical parameters are worthy of additional protection in order to preserve them.

A use class analysis was conducted on all assessed waterbodies within the Rainy River-Headwaters Watershed. Streams designated as exceptional receive additional protections from a more stringent water quality standard. Two stream reaches, Jack Pine (-564) and Mitawan Creek (-568), met all the required parameters for this designation. Most streams throughout this subwatershed are designated trout streams and have a vibrant brook trout population

Jack Pine Creek (-564), a tributary to Mitawan Creek, is a small headwater stream that supports a robust fish and macroinvertebrate community. The only biological monitoring station (14RN081) located on this reach had a fish community dominated by individuals (creek chub, mottled sculpin, etc.) that are endemic to cold-water streams, including multiple year classes of brook trout. The average summer temperature (June 1 – August 31) of 16.5 oC is easily within the growth range for brook trout. The macroinvertebrate community was also comprised of several sensitive species, with numerous cold-water obligates present.

Mitawan Creek (-568) receives flow from both Hill and Jack Pine Creeks, along with numerous other lakes and streams. There are three stations located on this reach, with five fish visits conducted by the MPCA. A long-term biological monitoring station was established at 05RN073 to measure variability in sampling efforts, long-term resource trends, and climate change (Figure 35). The USFS provided an additional seven fish visits that gave further insight into the biological condition of Mitawan Creek. A total of 14 fish species were captured with the most prevalent being creek chub, blacknose dace, brook trout, and mottled sculpin. Several sensitive cool and cold-water obligates were sampled at the three stations, indicative of exceptional water quality. This reach also had a rich macroinvertebrate community dominated by several sensitive and cold-water obligate species. All of the F-IBI and M-IBI scores met the exceptional use standard, resulting in this reach being designated as exceptional (CWe). In addition, the thermal regime supported a brook trout fishery, with an average summer temperature of 18.9 oC in 2013, 18.6 oC in 2015 at 05RN073, and 17.2 oC in 2015 at 05RN190. Stress for brook trout was only reach 12.9-38.4% of the time between the sampling dates and sampling locations.

Figure 35. Mitawan Creek (05RN073) long-term biological monitoring station.

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Island River Aggregated 12-HUC

HUC 0903000107-04

The Island River Subwatershed drains 99.80 square miles of Lake County and is the fourteenth largest subwatershed within the Rainy River-Headwaters Watershed. Its headwaters starts in Elixir Lake (38-0218-00) and continues downstream through a tributary to Fulton Creek. Harris Lake (38-0048-00) receives flow from Fulton Creek and two additional unnamed tributaries before pouring into Harris Creek. Harris Creek continues 4.3 miles to Silver Island Lake (38-0219-00), while receiving additional flow from numerous unnamed tributaries. The Island River begins at the outlet of Silver Island Lake and flows to the west 13.6 miles to its confluence with the Isabella River, while receiving additional flow from the Dumbbell River (Dumbbell River Aggregated 12-HUC), Comfort Creek, Jack Creek, and Arrowhead Creek. Numerous cold-water streams are in this subwatershed, supporting a vibrant brook trout population. This subwatershed is a part of the larger Kawishiwi River system, which is the largest river system in the Rainy River-Headwaters Watershed. There are a total of 47 lakes greater than 10 acres, with the most prominent being Silver Island, Windy, T, Harriet, and Sister. This subwatershed is dominated by forest (54.98%) and wetland (35.42%) Only 6.57% is open water, 2.48% is developed, 0.55% is rangeland, and there is no barren/mining or row-crop agriculture. This entire subwatershed lies within the Superior National Forest, with a small portion (7.00%) of it within the BWCAW. Much of the land is owned and managed by local, state, and federal entities (USGS, 2008). A small portion of this subwatershed was burned by the Pagami Creek fire of 2011. Intensive water chemistry sampling was conducted at the outlet of the subwatershed at Tomahawk Road (FR-377), 12 miles north of Isabella on the Island River. The outlet is represented by water chemistry station S007-779 and biological station 14RN009.

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Summary

The Island River Subwatershed had six assessable stream segments, containing eight biological monitoring stations, and six lakes assessed for aquatic recreation (Table 22 and Table 23). All of the streams and lakes met the applicable standards or criteria and fully support aquatic life and/or aquatic recreation (Figure 38). In-stream habitat was in good condition and is a reflection of the upstream drainage (Appendix 5). As a result of quality in-stream habitat and good water quality, a relatively diverse fish and macroinvertebrate community was present throughout the subwatershed. The low amount of disturbance within the subwatershed almost assures excellent biological integrity. A use class analysis was conducted on all assessed waterbodies within the Rainy River-Headwaters Watershed. Streams that support an exceptional use designation receive additional protections from a more stringent water quality standard. Although specific parameters met the exceptional criteria, not all the requirements were met to receive the exceptional use designation (WWe and CWe) but did indicate excellent water quality.

The upstream reach (-979) of this subwatershed was located on Harriet Creek which contained one biological monitoring station (14RN084). This stream reach was assessed for its viability to support a cold-water assemblage and to determine its appropriate use class designation (WWg or CWg). Both biological and thermal data indicated that there was a reasonable potential for this reach to support a cold-water community. The MPCA collected both fish and macroinvertebrate data from this station during 2014 and 2015 season. The 2014 sample had an F-IBI score (42.72) that was just above the general use threshold, while the 2015 sample (79.34) was well above the exceptional use threshold. The 2014 F-IBI score was driven down by a small number of warm-water individuals (pumpkinseed, iowa darter) that likely migrated upstream from Silver Island Lake (38-0219-00). A total of 10 fish species were captured and was dominated by creek chubs, longnose dace, and pearl dace. Numerous sensitive species (longnose dace, pearl dace, and mottled sculpin) indicated good water quality. Species richness was very high for the macroinvertebrate community, with several sensitive and cold-water obligates present. The 2014 sample contained Ocellated Darner (*Boyeria grafiana*), which is a species of special concern. The thermal regime was also suggested support for a brook trout fishery, with an average temperature of 18.3 °C and thermal stress reached 29.1% during the summer months (June 1 – August 31) of 2015. In addition, the USFS also provided fish community data for five visits at two separate stations along this reach. Although this data was not directly used in the assessment of aquatic life, it does provide further insight into the condition of this waterbody.

Three other known cold-water (trout) streams fully supporting aquatic life. Arrowhead (-550), Trappers (-801), and West Camp Creeks (-586) all support a robust brook trout fishery, with numerous cold-water obligates present. Both West Camp and Trappers Creek contribute their waters to Arrowhead Creek. Brook trout were most abundant in Arrowhead Creek, but tended to decrease in abundance with an increase in drainage area. This trend may be a result of variations in thermal regime and habitat between stations. The macroinvertebrate community also consisted of numerous sensitive species, including several cold-water obligates. Additional fish community data was provided by the USFS for both Trappers and Arrowhead Creek. Trappers Creek (06RN017) was assessed as fully supporting for aquatic life using this data.

The Island River is the largest warm-water system within this drainage. It had three biological monitoring stations (14RN009, 14RN083, 15EM097) located along two stream reaches (-529 and -563). The upstream reach had two biological monitoring stations that were partially overlapping. One station was established as part of the IWM program, while the other was established using the systematic random sampling design of the EMAP. Both stations had a robust fish and macroinvertebrate community that contained several sensitive species. The M-IBI score varied between years. The variation may have been the result of fluctuations in water levels and habitat sampled. The downstream reach

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Summary

The Dumbbell River Subwatershed had five assessable stream segments, containing five biological monitoring stations, and one lake assessed for aquatic recreation (Table 24 and Table 25). All streams and lakes met the applicable standards or criteria and fully support aquatic life and/or aquatic recreation (Figure 39). A use class analysis was conducted on all assessed waterbodies within the Rainy River-Headwaters Watershed. Streams that support an exceptional use designation receive additional protections from a more stringent water quality standard. Although specific parameters met the exceptional criteria, not all the requirements were met to receive the exceptional use designation (WWe and CWe) but did indicated good water quality throughout this subwatershed. The low amount of disturbance within the subwatershed almost assures excellent biological integrity.

The Dumbbell River, along with three other major tributaries, were assessed in this effort. In-stream habitat was in good condition and is a reflection of quality of the upstream drainage (Appendix 5). As a result of quality habitat and good water quality, a relatively diverse fish and macroinvertebrate community was present throughout this subwatershed. A total of 22 fish species were captured, with numerous sensitive individuals present. The biological community transitioned from cool/cold-water obligates in the headwaters to warm/cool-water individuals near the pour point. The headwaters

(<15 sq mi) of this subwatershed had F-IBI scores that were very similar, with the exception of Scott Creek (-574) which was significantly better than the other stations. Scott Creek (14RN091) had an F-IBI score that was just above the exceptional use threshold and an M-IBI just below it. A single adult brook trout was captured at this location, indicated good water quality. This was the only station within this subwatershed where a trout species was captured. In addition, the macroinvertebrate community consisted of several sensitive species, including a species of special concern (Ocellated Darner; *Boyeria grafiana*). This species was also found at the adjacent drainage, Folly Creek (-773).

Tomlinson Creek (-578), the smallest tributary assessed, drains a total of 6.21 mi^2 before entering the Dumbbell River. The USFS provided fish data for this station (14RN101), which consisted of nine species with numerous sensitive individuals present (longnose dace, mottled sculpin, etc.). Although trout were not present during monitoring of this cold-water stream, numerous other cool/cold-water obligates were present.

The Dumbbell River had two biological monitoring stations located along two stream reaches. There was a considerable amount of variation in species composition between the two stations. The upstream reach (-632) is considered a cold-water (CWg) resource, along with its tributaries, while the downstream reach (-634) is designated as warm-water (WWg). Although the thermal regime and species composition varied between stations, both stations had numerous sensitive species that indicated good water quality. Macroinvertebrates were only sampled at the downstream station due to habitat limitations in the upper reaches of this river, which was relatively low gradient (0.020 m/km). A diverse macroinvertebrate community (50 unique species) were collected in 2014, with several sensitive species present. Nutrient and sediment concentrations were low at this location, consistently meeting water quality standards. *E. coli* bacteria concentrations were consistently low, and indicated full support for aquatic recreation.

Dumbbell Lake (38-0393-00) was sampled by MPCA staff in 2013 and 2014 and was the only lake with sufficient data available for assessment purposes in this subwatershed. Phosphorus, Chl-a, and Secchi transparency were consistently meeting NLF water quality standards. Summer average total phosphorus concentrations in the headwaters of this subwatershed (Dumbbell Lake) were essentially the same as those at the 10X station, (~ 13 µg/L) indicating near-oligotrophic conditions. Dumbbell is a high quality lake, with summer average clarity of 3.1 meters (10.1 feet). The other small lakes in this subwatershed did not have sufficient data for assessments.

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single sample. A damaged culvert was noted just downstream of the Wanless Creek biomonitoring station; this culvert appears to be causing sedimentation upstream of the road crossing. Repair or replacement of this culvert should be a high priority, considering Wanless Creek's high quality biological communities.

Figure 64. The lower Cross River, near Schroeder, at the Superior Hiking Trail.

The lower Cross River was monitored off of the Superior Hiking Trail, about a mile upstream of its confluence with Lake Superior. Here the river cascades down a steep hillside and water temperatures tend to be colder than in the upper reaches. Water quality was excellent at this location; over two summers of intensive water chemistry monitoring no samples exceeded water quality standards. Bacteria levels were consistently low and indicated support of aquatic recreation. An electrofishing survey indicated the lower river supports both Rainbow Trout (which are stocked as fry) and wild Brook Trout, while the macroinvertebrate community included six stenothermic taxa (*Rhithrogena, Epeorus, Leuctra, Glossosoma nigrior, Eukiefferiella, Baetis tricaudatus*) and several other highly-sensitive insects (*Chimarra, Acroneuria*). Fish and macroinvertebrate IBI scores met exceptional use biocriteria.

Fish and macroinvertebrate communities of the Two Island River were monitored at two locations: four miles west of Schroeder at Cook County Highway 1, and also at a remote location farther upstream, accessed via the North Shore State Trail. Brook Trout were found at both locations, and the stenothermic Slimy Sculpin was found at the lower station. The macroinvertebrate communities included nine stenothermic taxa and several other highly-sensitive insects, including a state-listed "species of special concern", the dragonfly *Boyeria grafiana*. Fish and macroinvertebrate IBI scores met exceptional use biocriteria, indicating excellent coldwater habitat and water quality.

Most of the Cross River subwatershed is forested and undeveloped, but it does include an extensive road network. Road-stream crossings are particularly concentrated in the Two Island River catchment (11 crossings are found in the stream's 19 square miles of drainage area), and some may negatively impact stream function and inhibit ecological connectivity. Potential barriers in the form of poorly-functioning road crossings have documented on both the Two Island River and tributaries such as Fredenberg Creek. Protection strategies for the Cross River subwatershed's high-quality streams should include a focus on maintaining ecological connectivity through its many road-stream intersections. Emphasis may also be placed on minimizing new road-stream crossings, where possible. For example, the middle and lower reaches of Cross River flow through remote national forest lands, crossed by only a few roads and trails. Between Forest Road 166 and Temperance River State Park, the Cross flows for approximately four miles, crossed by no roads and only one snowmobile trail. Between Forest Roads 166 and 170, another five miles of the Cross River remains uncrossed by roads. As mentioned above, this section of Cross River is characterized by excellent water quality and habitat, and supports exceptional biological communities.

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Cross River subwatershed HUC 0401010109

The Cross River subwatershed drains 108 square miles of Lake and Cook counties and includes 51 lakes, of which 16 are greater than 100 acres in size. Cross River is the major watercourse, originating in headwater lakes north of Schroeder and draining 76 square miles at its confluence with Lake Superior. The lower portion of the Cross River flows through Temperance River State Park, over steep rapids and waterfalls before entering Lake Superior. The Cross River is notable in being one of the few North Shore tributaries that was used for log drives around the turn of the 20th Century. To facilitate these log drives, dams and bank protection structures were installed, and the stream channel straightened in places. Though log drives on Cross River ended nearly 100 years ago, the effects of these modifications can still be observed in the contemporary channel. Two Island River is the other major stream in this subwatershed, draining 20 square miles where it enters Lake Superior at Taconite Harbor.

Land use in the subwatershed is primarily forest and wetland, with a smaller open water component. Development levels are generally low, but relatively high when compared to the Lake Superior – North watershed as a whole. Most development is found along the shore of Lake Superior, including the community of Schroeder and industrial facilities at Taconite Harbor. Some residential and seasonal properties are found in the middle and upper portions of the subwatershed, particularly along lakeshores. Land ownership is primarily public (83%, mostly federal); privately-owned lands are clustered around the lower reaches of Two Island River and in the upper watershed along lakeshores.

About 6% of the Cross River subwatershed lies within protected areas, primarily near Lake Superior. More than 2,700 acres of Temperance River State Park surrounds the lower reaches of the Cross River. Just west of the state park, Superior National Forest manages nearly 1,500 acres of the Two Island River catchment in a relatively undisturbed state as a Research Natural Area (RNA).

Cross River subwatershed summary

Aquatic life and recreation indicators for lakes, rivers, and streams of the Cross River subwatershed consistently reflected good water quality. In general, FIBI and MIBI scores were high, and streams were characterized by low levels of sediment, nutrients, and bacteria. The lowermost reach of the Cross River met exceptional use biocriteria based on FIBI and MIBI scores, as did two tributaries (Wanless Creek, Houghtaling Creek) and also the lowermost reach of the Two Island River; protection strategies should be developed for these and the other high-quality aquatic resources found throughout the subwatershed. Eight lakes in the subwatershed were assessed as supporting aquatic recreation. The subwatershed includes two Lake Superior beaches, the Schroeder Town Park Beach and the Sugarloaf Cove Beach. Data indicate support of swimmable use; bacteria concentrations were consistently low at both locations.

The headwater lakes that feed the Cross River are mostly undeveloped, though several have campgrounds and some are dotted with cabins and resorts. Some of these lakes are shallow and tend to be bog-stained; these are typically more productive than the deeper clearer lakes. Among these headwater lakes, Elbow, Timber, Toohey, and Whitefish were monitored and found to support aquatic recreation based on low levels of nutrients and algae. Whitefish Lake is one of the clearest lakes in this portion of the Lake Superior – North Watershed, with an average Secchi transparency of 4.3 meters.

The Cross River exits Cross River Lake and flows south towards Forest Road 170 ("The Grade"). As it approaches and crosses under The Grade, the river picks up four major tributaries within approximately one mile, more than tripling its drainage area. The first tributary is Wilson Creek, less than a half-mile long and draining Wilson Lake, the subwatershed's largest lake at 652 acres. Wilson Lake and Little Wilson Lake both support aquatic recreation based on low levels of nutrients and algae. Wilson Lake has been monitored for many years by the MPCA, USFS, and citizen volunteers. The lake is very clear, with

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an average Secchi transparency of 4.6 meters, which appears to be stable over time (Figure 63). Wilson Creek's fish community appears to reflect the stream's proximity to both Wilson Lake and the Cross River. The stream supports lake-oriented species like Yellow Perch, but also fluvial species like Longnose Dace. Like other streams in this area, Wilson Creek supports Tadpole Madtom, a species closely related to bullheads and catfish. The species was not recorded from the Lake Superior – North Watershed prior to 2001, and was likely introduced via "bait bucket release" into a lake or river; as a rule, introductions of non-native species should be discouraged as they may negatively affect native species and ecosystem function. In general, the fish and macroinvertebrate communities of Wilson Creek indicated good water quality and habitat conditions. The presence of Longnose Dace and Blacknose Shiner suggest that this stream consistently carries low levels of suspended sediment (as would be expected for a lake outlet), and several sensitive aquatic insects were collected (e.g., *Leuctra*, *Chimarra*, *Lepidostoma*).

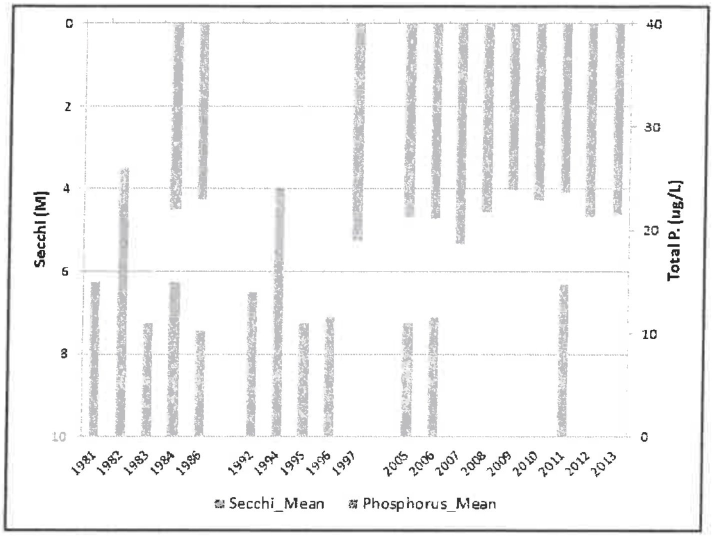

Figure 63. Wilson Lake water quality trends, 1981-2013.

The Cross River was monitored just downstream of Forest Road 170; it is a Designated Trout Stream at this location, but no trout were captured during the fish survey. However, the fish assemblage was dominated by the pollution-intolerant Longnose Dace, and the sensitive Blacknose Shiner was also present, indicating good water quality. The macroinvertebrate community also indicated good water quality, including two stenothermic stoneflies (*Leuctra*, *Isoperla*) and several other sensitive taxa (*Nigronia*, *Lepidostoma*). Water temperatures in the summer of 2013 were in the "stress" or "lethal" ranges for Brook Trout more than half the time, suggesting this portion of the Cross River has a thermal regime that is marginal for trout.

Further downstream of Forest Road 170, Fourmile Creek enters the Cross River from the east, draining a lake-dominated landscape and meandering slowly west from Fourmile Lake. Fourmile Lake and Richey Lake contribute flow to Fourmile Creek; both were monitored in the course of this study and were found to support aquatic recreation based on low levels of nutrients and algae. Both lakes are shallow and relatively productive for this part of the state. Fourmile Creek was monitored downstream of the Richey Lake Road, where the creek supports Yellow Perch, Northern Pike, and sensitive non-game species such as Iowa Darter and Longnose Dace; FIBI scores met general use biocriteria. The macroinvertebrate community consisted of a mix of fluvial and lentic taxa, but included sensitive insects such as *Chimarra*, *Oxyethira*, and *Acerpenna*.

Slightly more than a half-mile downstream of Fourmile Creek, Houghtaling Creek enters the Cross River from the west. Houghtaling and its major tributary, Wanless Creek, were both monitored at Forest Road 1855, where both streams are high-quality coldwater habitats. IBI scores from both streams met exceptional use biocriteria, reflecting the presence of Brook Trout, Mottled Sculpin, and macroinvertebrates that require clear, cold water. *Apsectrotanypus* (a type of midge that lives in small, cold streams) has been found in both Wanless and Houghtaling; MPCA has recorded this insect at only three other locations across the state of Minnesota. Other sensitive, stenothermic insects found in Wanless and Houghtaling included *Chimarra*, *Emphemerella*, *Nigronia*, and *Glossosoma nigrior*. Caddisfly taxa richness was particularly outstanding in Wanless Creek, with 16 different genera observed in a

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Manitou River subwatershed HUC 0401010110

The Manitou River subwatershed drains 139 acres of Lake and Cook counties. The subwatershed contains 34 lakes, but only 6 are greater than 100 acres in size and the largest, Ninemile, covers only 325 acres. As a result, open water comprises a relatively low proportion of the subwatershed and land cover is dominated by forest and wetland. A small amount of developed land is present, mostly in the form of roads, though some residential and seasonal cabins are scattered throughout the subwatershed.

Manitou River is the major watercourse, formed by the confluence of several tributaries. The westernmost tributary, or South Branch, drains extensive wetlands southeast of Isabella and includes the Junction Creek drainage. To the north, the North Branch arises in Delay Lake east of Isabella and picks up several unnamed tributaries as well as the Balsam Creek drainage before entering the Manitou mainstem. Farther east, Moose Creek drains small lakes and extensive wetlands before entering the mainstem river in remote country west of the former railway village of Cramer. The easternmost tributary, Ninemile Creek, arises in Ninemile Lake and flows through wetlands and Cramer Lake before entering the mainstem southwest of the Cramer townsite. Downstream of Ninemile Creek, the river enters George Crosby Manitou State Park and plunges through a steep canyon for seven miles before pouring over a waterfall directly into Lake Superior. At its confluence with Lake Superior, the Manitou River drains approximately 98 square miles.

The Manitou River subwatershed also includes several direct tributaries to Lake Superior. Caribou River is the largest, draining approximately 23 square miles west of the Cross River drainage. Other smaller direct tributaries include the Little Marais River, Little Manitou River, Kennedy Creek, and Crystal Creek.

The Manitou River subwatershed has the highest proportion of privately-owned lands among all Lake Superior – North subwatersheds (27%). The largest cluster of private lands is along the Highway 61 corridor (particularly the Little Marais River catchment) but large blocks of private land are found throughout the Manitou and Caribou River drainages. Federal land is more frequently found in northern regions of the subwatershed, while state-owned lands are more prevalent in the southern region. Lake County administers much of the South Branch Manitou River and Junction Creek catchments.

Protected lands make up approximately 8% of the Manitou River subwatershed, one of the higher proportions among Lake Superior – North subwatersheds that do not include BWCAW lands. More than 6,000 acres lie within state parks, nearly 1,300 acres are within MNDNR Aquatic Management Areas (AMAs), and more than 2,000 acres are managed by Superior National Forest as a Candidate Research Natural Area. The Nature Conservancy also manages a significant portion of the subwatershed for sustainable timber harvest.

Manitou River subwatershed summary

Aquatic life and recreation indicators for lakes, rivers and streams of the Manitou River subwatershed consistently reflected good water quality. In general, FIBI and MIBI scores were high, and streams were characterized by low levels of sediment, nutrients, and bacteria. In-stream and riparian habitat was excellent; the subwatershed's average MSHA score of 82.3 was the highest across the entire Lake Superior – North Watershed. Three streams met exceptional use biocriteria based on FIBI and MIBI scores; protection strategies should be developed for these and the other high-quality aquatic resources found throughout the subwatershed.

The North Branch of the Manitou River arises in Delay Lake, a few miles east of Isabella. Delay was monitored by Lake County in 2013 and 2014, and was found to support aquatic recreation based on Secchi transparency and low levels of phosphorus. This region of the subwatershed also includes Divide Lake, a unique, high quality soft-water seepage lake, which has been monitored by the MPCA and

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community was particularly robust, including 60 taxa in a single sample. Boyeria grafiana, a state-listed Species of Special Concern was observed, along with several other sensitive insects. Although Brook Trout and a few stenothermic insects were found in Cabin Creek, water temperatures appear to be warmer than other streams in the area; temperatures were in the Brook Trout stressful or lethal ranges for more than half the summer of 2013. MNDNR monitoring also indicates that thermal conditions may be only fair for Brook Trout survival and poor for growth. The geographic context of Cabin Creek likely contributes to its marginal thermal regime and may make its coldwater biota particularly vulnerable to additional warming. The stream flows for approximately three miles between shallow Cabin Lake and the Moose River (which is not a designated trout stream), and may be highly dependent upon riparian forest shading and localized groundwater contributions to provide thermal refugia during periods of stress. Protection strategies for the high-quality biological communities found in Cabin Creek should focus on maintaining stream and watershed characteristics that promote cool water temperatures in this unique resource.

Water quality and biological communities of the Manitou River were monitored downstream of the North Branch and Moose River confluences. An intensive water chemistry monitoring station was established just downstream of the Cramer Road; at this location the river had consistently low concentrations of bacteria, sediment, and nutrients. Biological indicators reflected the excellent water quality and habitat conditions; FIBI and MIBI scores met exceptional use biocriteria. MPCA biomonitoring crews have monitored this location several times since the late 1990s. Over the years, the fish community has consistently included Brook Trout, Mottled Sculpin, and Longnose Dace. The macroinvertebrate community has included 13 different mayfly genera, and eight different stenothermic insects. Thermal monitoring suggests that the Manitou River at this location is a relatively cold stream compared to others of similar size, making it a unique resource.

Figure 67. Manitou River at the Cramer Road.

Ninemile Lake is the largest lake in the subwatershed, and the headwater source of Ninemile Creek, the easternmost major tributary to the Manitou River. Ninemile Lake was found to support aquatic recreation based on Secchi transparency and low levels of phosphorus. Ninemile Creek was monitored off of the Cramer Road, upstream of Cramer Lake, where FIBI and MIBI scores met general use biocriteria and indicated good water quality and habitat conditions. The fish community was dominated by Longnose Dace and Mottled Sculpin; no Brook Trout were captured in MPCA surveys, though previous MNDNR surveys have recorded Brook Trout near this location. The macroinvertebrate community included a few stenothermic insects (e.g., Epeorus, Ephemerella, Eukiefferiella) and several other sensitive taxa.

The Caribou River is a cold, high-quality Lake Superior tributary draining forest and wetlands lying east of Ninemile Creek and the lower Manitou River. The catchment includes no significant lakes, so summer baseflow is highly dependent on springs and wetland seepage. Biota and water chemistry were monitored near the river's confluence with Lake Superior. At an intensive water chemistry monitoring station just upstream of Highway 61, water quality was excellent, characterized by low levels of bacteria, sediment, and nutrients. Biological communities were monitored a short distance upstream (above Caribou Falls) where FIBI and MIBI scores met exceptional use biocriteria. The fish community was relatively simple, composed entirely of Brook Trout, Slimy Sculpin, and Longnose Dace, and the FIBI

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Baptism River subwatershed HUC 0401010111

The Baptism River subwatershed drains 138 square miles of Lake County. The subwatershed is lightly-developed, but includes the town of Finland, a decommissioned U.S. Air Force radar station, Wolf Ridge Environmental Learning Center, and scattered rural residential development. Forest and wetland are the dominant land cover types, together comprising 96% of the subwatershed. Open water is relatively rare; the subwatershed contains 30 lakes but only two are larger than 100 acres in size.

Baptism River is the main watercourse, consisting of West and East branches that converge in the town of Finland. Headwaters of the East Branch are located north of Finland, in a series of wetlands near Murphy City. The East Branch flows east to Lake Twentythree, then southeast to a crossing of the Cramer Road, where the river picks up Schoolhouse Creek and Blesener Creek. From this point, the East Branch bends sharply to the southwest and flows through a series of shallow lakes and ponds for 6.5 miles to its confluence with the West Branch in Finland.

Headwaters of the West Branch are located in wetlands south of Isabella. The river flows south for most of its 15 miles, gradually bending to the southeast as it approaches Finland. West Branch tributaries include Crown Creek and Hockamin Creek, both entering from the west and draining landscapes dominated by forest, wetlands, and beaver ponds. Downstream of Finland, the Baptism flows approximately nine miles to its confluence with Lake Superior in Tettegouche State Park. Along the way it picks up one more sizeable tributary, Sawmill Creek, which enters from the east.

The Baptism River subwatershed includes a relatively high proportion of private lands (25%). The largest concentrations are found south and east of Finland (particularly the Sawmill Creek drainage), and also northwest of Finland, but large blocks of private land are found throughout the subwatershed. In contrast to most other Lake Superior – North subwatersheds, federal lands are relatively rare (10%); Lake County and the State of Minnesota together administer approximately 90% of the public land in the subwatershed. More than 4,000 acres of state park lands are found in the subwatershed, but few other protected areas exist.

Baptism River subwatershed summary

Aquatic life and recreation indicators for lakes, rivers and streams of the Baptism River subwatershed consistently reflected good water quality. In general, FIBI and MIBI scores were high, and streams were characterized by low levels of sediment, nutrients, and bacteria. Three streams met exceptional use biocriteria based on FIBI and MIBI scores; protection strategies should be developed for these and the other high-quality aquatic resources found throughout the subwatershed. The presence of Slimy Sculpin in Crown Creek and the West Branch is particularly notable, as they represent the southernmost verified records of the species from inland waters of the North Shore.

Crown Creek is the primary tributary to the West Branch Baptism River, and drains a larger catchment than the West Branch at the point where they converge. Fish and macroinvertebrate communities of Crown Creek were monitored a half-mile upstream of the streams' confluence; at this location, IBI scores met exceptional use biocriteria, indicating excellent water quality and coldwater habitat conditions. The fish community included Brook Trout, Slimy Sculpin, and Longnose Dace. The macroinvertebrate community was characterized by a high proportion of sensitive taxa, including six stenothermic insects and Boyeria grafiana, a state-listed Species of Special Concern.

The West Branch was monitored a half-mile upstream of the Crown Creek confluence. Habitat conditions at this site were similar to the Crown Creek station, as were fish and macroinvertebrate communities, and IBI scores also met exceptional use biocriteria. A notable addition to the macroinvertebrate community was the mayfly Ameletus, which MPCA has found at only four other locations in Minnesota.

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Additionally, MNDNR surveys in pooled sections of the East Branch indicate that a wild Brook Trout population persists, though these fish may utilize only certain areas during periods of thermal stress. Although no trout were observed at MPCA's stream biomonitoring station, the site wasn't fully representative of the character of the reach, and current monitoring protocols cannot accurately sample and assess the pooled sections that dominate this reach. The weight-of-evidence supporting assessment for aquatic life considered the following factors: good water quality observed at the 10x site, a supporting MIBI score, a "Level 3" BCG rating for the fish assemblage (indicating a non-impaired community), MNDNR data regarding the Brook Trout population of the reach, and the fact that habitat conditions at the biomonitoring station characterized only a small portion of the reach. It should be noted that some potential stressors are present along this reach, in the form of a road encroaching upon the stream for a significant portion of its length, and also rural residential development adjacent to the stream in a few places. Three sections of this reach already lie within MNDNR AMAs, but private ownership of riparian lands is common between Blesener Creek and the West Branch confluence. Protection strategies for this reach of the East Branch may include working with private landowners to promote riparian land uses that promote cool water temperatures (e.g., forest shading) and minimize inputs of sediment and nutrients. Efforts may also focus on minimizing impacts associated with the stream's proximity to the Cramer Road.

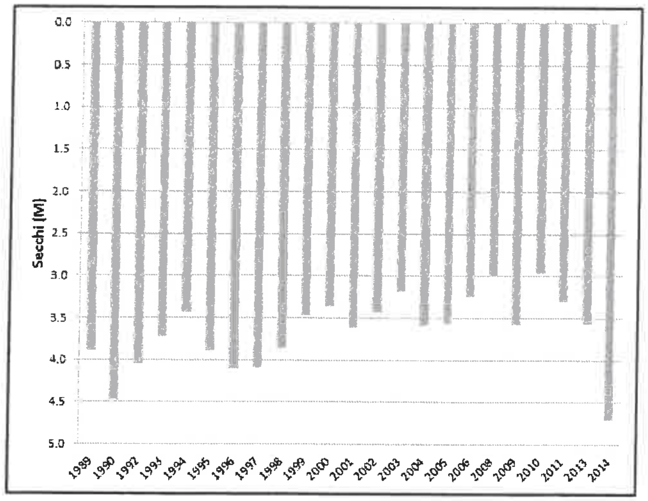

Figure 70. Johnson Lake water quality trends, 1989-2014.

Downstream of Finland, the Baptism River is a larger stream, draining the combined catchments of the East and West Branches. Johnson Lake drains to this lower reach of the Baptism via a small, unnamed creek. The lake has been monitored by citizen partners (Wolf Ridge Environmental Learning Center) since 1989, and is meeting aquatic recreation standards based on low levels of nutrients and algae. There is no long-term trend in lake transparency (Figure 70), but this parameter varies from year to year.

Approximately 3.5 miles downstream of Finland, Sawmill Creek enters the Baptism from the east, draining about nine square miles. Fish and macroinvertebrates were monitored just upstream of the confluence, at the Cranberry Road crossing. Both Rainbow Trout (stocked as fry in the Baptism River) and Brook Trout were captured, as well as Longnose Dace, indicating good water quality and coldwater habitat. Five different stenothermic insects have been recorded from this location, as have other pollution-intolerant macroinvertebrate taxa (e.g., Chimarra, Acroneuria). A culvert replacement project was carried out just upstream of the biomonitoring station during the summer of 2013, designed to facilitate ecological connectivity as well as reduce erosion and sedimentation. Construction disturbance may have affected the macroinvertebrate community in 2013, as the 2014 MIBI score was 10 points higher. Ongoing macroinvertebrate monitoring may be particularly useful in tracking effectiveness of the culvert replacement project. It should be noted that much of the Sawmill Creek catchment consists of private land; approximately 60% of the catchment and 70% of the riparian zone are privately-owned (though a significant portion of the lower creek's riparian zone is within an AMA). Protection strategies for Sawmill Creek will likely require collaboration with private landowners.

The lowermost reach of the Baptism River was monitored at three locations downstream of Minnesota State Highway 1. The upper biological monitoring station was located at the state highway, just before the river begins its descent through a steep canyon. The fish community included both Rainbow Trout

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Summaries and recommendations

Water quality in the Lake Superior – North Watershed is generally good, and consistently met state standards, reflecting its lightly-developed, heavily-forested landscape. Many exceptional streams were identified and outstanding water quality was noted in a number of lakes. However, a small number of streams were identified as impaired due to high levels of suspended sediment, and, although no lake water quality impairments were identified, transparency in some lakes appears to be declining.

Approximately 40% of the streams monitored in the course of this study were found to support "exceptional" biological communities. These streams typically contain Brook Trout and other fishes that require clean, cold water, including species that are rarely found outside of the Lake Superior – North Watershed (e.g., Longnose Sucker). Lake Chub, a state-listed Species of Special Concern, was found in several streams in the far northeast corner of the watershed. The macroinvertebrate communities of these exceptional streams are typically diverse, include high densities of sensitive insects, and are particularly rich in stonefly and caddisfly genera. The larval dragonfly *Boyeria grafiana*, a state-listed Species of Special Concern, was found in 22 streams and several other rare macroinvertebrates were observed in various streams across the watershed.

Exceptional streams were found throughout the Lake Superior – North Watershed, but were more concentrated in certain subwatersheds (e.g., the Devil Track River and Temperance River subwatersheds). The lowest proportions of exceptional streams were found in the two subwatersheds that include aquatic life use impairments due to high levels of suspended sediment (Poplar River subwatershed, Flute Reed River subwatershed).

Essentially all of the Lake Superior – North's exceptional streams drain minimally-developed, lightly-disturbed catchments. However, a few may be threatened by ongoing and future land use. For example, the catchment of Irish Creek contains a significant proportion of private land and is adjacent to an area that has experienced relatively rapid development in recent decades. Similarly, the Little Devil Track River drains the outskirts of the watershed's largest developed area (Grand Marais), and the river's lower reaches are completely surrounded by private land. Poor land use practices in developing areas may contribute to water quality degradation, and should be an ongoing concern in the Lake Superior – North Watershed.

Shoreland protection is an important means for maintaining water quality in lakes. Although no lake water quality impairments were identified in the Lake Superior – North Watershed, transparency appears to be declining on four lakes (Poplar, Deer Yard, Devil Track, Tom). The causes of these declines are uncertain, but it's notable that each of these lakes' shorelines ranks among the most-developed in the watershed. Efforts are underway to identify and address potential threats to lake water quality (i.e., non-compliant septic systems) on some of these lakes.

A multi-agency effort has recently been undertaken to systematically identify and prioritize watershed protection opportunities in Minnesota. The purpose of this approach is to provide state agencies and their partners with a consistent method and rationale for how to identify water bodies at risk, set reasonable goals for protection, incorporate locally held water quality values and considerations, and provide recommendations for specific protection methods. In this process, lake monitoring data is subjected to a multi-step analysis that forms a preliminary ranking of protection priorities. A combination of factors are reviewed to determine priority ranking. Among these factors are a lake's sensitivity to an increase in phosphorus, a documented decline in water quality or monitored phosphorus concentrations close to the water quality standard, and the percentage of developed land use in the area. In the Lake Superior – North Watershed, highest protection priority is suggested for six

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lakes: Tom, Devil Track, Hungry Jack, Poplar, Birch, and Deer Yard (Appendix 9). As mentioned above, all these lakes are currently meeting water quality standards.

Portions of the Lake Superior – North Watershed experienced rapid residential development in the 1990s. For example, the population of Cook County, which lies nearly entirely within the watershed, grew by 33% between 1990 and 2000. Although population growth has slowed in recent years, the Arrowhead Region remains an attractive destination for many people, and development is unlikely to decrease in the future. Protection strategies might employ development projections to identify the likely locations of future growth, and compare these regions with the occurrence of high-quality or at-risk aquatic resources. In situations where ongoing or future development is likely to occur in close proximity to high priority aquatic resources, protection strategies could be developed to encourage development design and related BMPs that promote good water quality and aquatic habitat.

More than 90% of lands in the Lake Superior – North Watershed are publicly-owned. While the catchments of some Lake Superior - North streams include significant proportions of protected lands, many streams drain landscapes that are largely managed for "general forestry", and logging is often the most obvious form of disturbance on these lands. Well-managed forests provide both economic and ecological benefits, and timber harvest should not be condemned as a wholesale detriment to water quality. However, in some cases, logging and associated development (e.g., roads, culverts) may contribute to degradation of water quality and aquatic habitat via loss of riparian shading, food web alteration, and increased sedimentation. Site-level forest management guidelines (MFRC 2013) designed to mitigate impacts to water quality are an important starting point for protecting high-quality streams. It is possible that additional BMPs or management strategies may be needed to protect some high quality and sensitive aquatic resources. At a broader scale, regional collaboratives are making an effort to manage forests in a way that promotes forest health and resiliency, and at the same time protects water quality (e.g., North Shore Forest Collaborative, The Nature Conservancy).

Other localized land-use activities may contribute stress to aquatic resources in certain circumstances. For example, aggregate mining (i.e., "gravel pits") may alter local groundwater and surface-water levels, interrupt groundwater conduit flow paths, and broadly impact thermal conditions. Portions of several streams in the Lake Superior – North Watershed (e.g., Caribou Creek, Cascade River, Ninemile Creek, Two Island River) flow closely adjacent to aggregate mining sites; some of these streams meet exceptional use biocriteria. While disturbances from aggregate mining typically are relatively small in scale, protection strategies should consider the location and proximity of aggregate mining sites relative to aquatic resources, and recommend that water quality be a consideration in their operation and potential expansion.

The Lake Superior – North Watershed's extensive network of paved and gravel roads intersects rivers and streams at more than 300 locations, and many more crossings occur at intersections between streams and non-road features such as trails and railroads. Road crossings may directly contribute sediment, contaminants, and warm water to streams as precipitation flows across and off of road surfaces. Improperly sized or positioned culverts may affect hydrology and stream geomorphology, causing scouring and aggradation which negatively affect in-stream habitat. Stream crossings may also inhibit ecological connectivity within stream networks, in the form of reduced movement of water, energy, material, and organisms (Forman and Alexander 1998, Freeman et al. 2007). Several streams in the Lake Superior – North Watershed have crossings that may be potential impediments to connectivity or could be causing habitat degradation. Potentially problematic road crossings were observed on Assinika Creek, Fredenberg Creek, Hockamin Creek, Woods Creek, Wanless Creek, Manitou River, and Spruce Creek. Other road crossings in need of repair or redesign surely exist within the watershed; identifying and prioritizing the rehabilitation of problematic road-stream intersections should be an important component of protection strategies for the Lake Superior – North Watershed.

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One of the principal concerns identified by County SWCDs for the Lake Superior North – Watershed is groundwater protection, for both quality and quantity. Groundwater withdrawals have increased nearly 30% over the last 20 years, partly due to the rising demand for water supply for private consumption and recreational water related needs. It is estimated that the development pressure is moderate in some parts of the watershed where land is converted from timberland, resorts and lakeshore into home and recreation development (USDA-NRCS). This increase in recreational development can be seen with a significant increase (p=0.001) from 1994 to 2013 in non-crop irrigation for golf courses and special categories. At this time, aquifer drawdown is now a concern; however, if water usage and land use conversion continue to increase, the probability of the water table being drawn downwards also increases. It is for this reason that the MNDNR monitors and takes precautions when permitting water use appropriations.

Groundwater quality is based on the sensitivity of the aquifers and the effects of naturally occurring and anthropogenic influences for constituents found in the water. Special consideration should be practiced in areas of high groundwater contamination susceptibility, which are sparsely located throughout the watershed. Overall, the groundwater quality of the watershed appears to be healthy, despite some exceedances of constituents, including arsenic. However, the primary source of contamination for this watershed is geology. Additional and continued monitoring will increase the understanding of the health of the watershed and its groundwater resources and aid in identifying the extent of the issues present and risk associated. Increased localized monitoring efforts will help accurately define the risks and extent of any issues within the watershed. Adoption of BMPs will benefit both surface and groundwater.

While land management, riparian and shoreland development, and road-stream intersections may represent acute threats to aquatic health in the Lake Superior – North Watershed, longer-term and more nebulous threats may be posed by climate change, and the interaction of climate change with other stressors. Many of the watershed's streams support sensitive, stenothermic organisms that depend on perennial, coldwater streams carrying low concentrations of sediment and nutrients. These habitat and water quality conditions are the result of interacting factors of climate, hydrogeology, and land cover, and may be degraded by changes in any of these factors. Predictive models incorporating climate and land use changes suggest that aquatic resources of the Lake Superior – North Watershed are likely to experience higher temperatures, reduced dissolved oxygen, increased erosion, and other associated stress in the near future (Johnson et al. 2013, Herb et al. 2014). These changes are likely to have negative effects on the health of aquatic systems, though planning and BMP implementation may mitigate some impacts. For example, understanding the importance of small, cold tributaries to the ecological integrity of larger river systems may be of critical importance in protection planning efforts. Tributaries often spawning and nursery habitat for trout and other fishes, and may serve as critical refugia for fish and other aquatic organisms during periods of thermal stress. A watershed-based focus that recognizes the connection between landscapes, riverscapes, and the condition of aquatic resources will be essential to protection and restoration efforts.

In general, aquatic habitats in the Lake Superior – North Watershed are in very good condition; streams, lakes, and wetlands rank among the highest-quality in the state, and some represent near-reference quality examples at a national scale. Stream biological monitoring surveys suggest that sensitive indicator taxa are widespread and abundant, and several rare species of fish and macroinvertebrates were observed. Many streams were designated as exceptional aquatic resources, which should provide a higher level of protection from degradation. From a protection and restoration standpoint, the watershed possesses several favorable characteristics. A relatively high proportion of its lands are already under some form of protective management (e.g., state parks, federal wilderness designation, AMAs), and much of the remainder is administered by public agencies charged with incorporating water quality considerations in their management and planning efforts. The watershed's aquatic resources are

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of great interest to stakeholders and the general public, and there seems to be strong public support for water quality protection and restoration efforts. This report provides a baseline assessment of water quality in the Lake Superior – North Watershed, and suggests some avenues for moving forward with restoration and protection strategies.

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Water quality standards

Water quality standards:

- Protect water resources for uses such as fishing, swimming and other recreation, and sustaining fish, bugs, plants, and other aquatic life
- Are a measure to identify polluted waters or healthy waters in need of protection
- Guide the limits set on what regulated facilities can discharge to surface water

The federal Clean Water Act requires states to designate beneficial uses for all waters and develop water quality standards to protect each use. Water quality standards consist of several parts:

- Beneficial uses — Identify how people, aquatic communities, and wildlife use our waters
- Numeric standards — Amounts of specific pollutants allowed in a body of water and still protects it for the beneficial uses
- Narrative standards — Statements of unacceptable conditions in and on the water
- Antidegradation protections — Extra protection for high-quality or unique waters and existing uses

Together, the beneficial uses, numeric and narrative standards, and antidegradation protections provide the framework for achieving Clean Water Act goals. The Clean Water Act specifies healthy aquatic life and recreation as beneficial uses. Others that are protected in Minnesota's rules are:

- Drinking water
- Industrial and agricultural uses

PG. 1 TO

DC 11

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The MPCA conducts biological monitoring and employs the recently adopted Tiered Aquatic Life Uses (TALU) framework to provide a more direct method to assess biological health; biological monitoring complements the information provided by chemical (pollutant) monitoring. Both data sets are used to assess whether Class 2 aquatic life uses are being met.

Numeric and narrative standards are not available for all pollutants and water quality concerns. When needed, Minnesota rules provide for the development of site-specific criteria to address pollutants and concerns for which standards are not available. Also, numeric standards in rule can be modified based on site-specific data. More information about both is available on the site-specific water quality standards webpage.

Antidegradation

Antidegradation (formerly referred to as nondegradation) is the third element of water quality standards. Antidegradation protections help maintain high quality waters (waters better than what is necessary to protect aquatic life and recreation) from deterioration. Antidegradation protections were established to provide future generations with the opportunity to enjoy high quality and highly valued recreational and aesthetic resources that might suffer degradation without them. Preventing degradation is almost always less costly and more effective than restoration, which cannot always be fully achieved.

Three levels of protection are incorporated into antidegradation rules:

1. Existing uses of the water body must be maintained and protected.
2. Existing high water quality must be maintained unless a lowering of water quality is deemed necessary to accommodate important economic and social development.
3. The exceptional characteristics of specific waters designated in Minnesota rules as outstanding, very sensitive, or unique resources – called "outstanding resource value waters" or ORVWs (Minn. R. 7050.0335) -- must be maintained and protected. Minnesota rules specify two classes of ORVWs: "prohibited" and "restricted":

- ORVWs listed as prohibited include waters within the Boundary Waters Canoe Area Wilderness and Voyageurs National Park. New or expanded discharges are banned in these and other prohibited ORVWs..
- ORVWs listed as restricted include portions of Lake Superior, and federal and state designated scenic and recreational river segments such as the St. Croix River. New or expanded discharges are controlled in restricted ORVWs to maintain their exceptional character.

Additionally, all surface waters in the Lake Superior basin are designated as outstanding international resource waters (OIRWs). Antidegradation protections for the Lake Superior basin focus on reducing the contribution of bio-accumulative pollutants to the basin.

How to determine the beneficial uses of a particular waterbody

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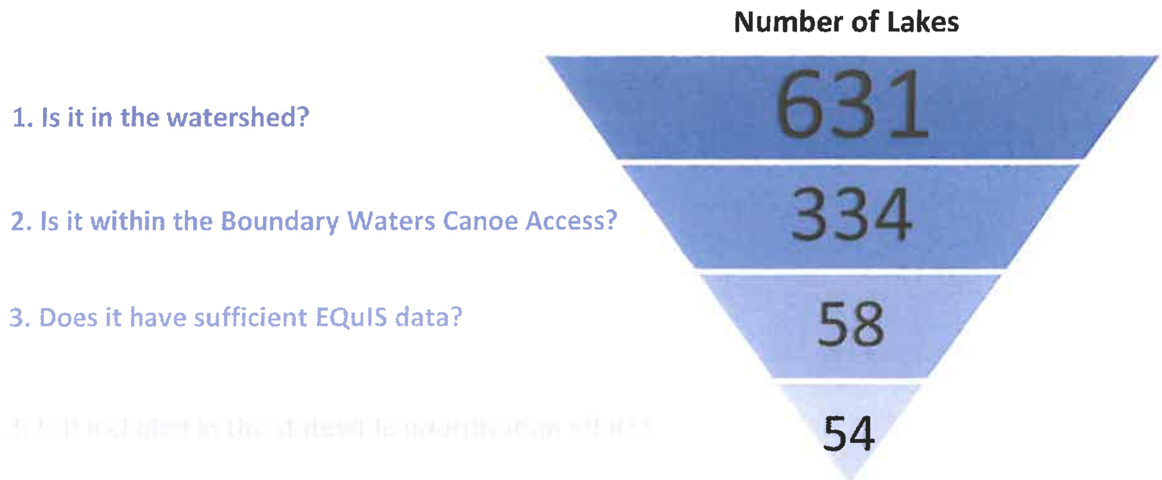

Figure 27. Lake Prioritization Process for the LSN Watershed.

A final check was also conducted to ensure all 54 lakes were mentioned in the Monitoring and Assessment Report for LSN (MPCA 2017). Of the 54 lakes, Johnson Lake was not included in the Monitoring and Assessment Report, but was still included in the final list.

Remaining lakes were then prioritized for protection based on the ranks provided in the statewide prioritization effort and local stakeholder input. Lakes of biological significance (lake trout lakes or designated trout lakes), especially those with phosphorus levels nearing the standard, and lakes with existing and active lake associations were given higher prioritization based on stakeholder input (Table 11). Lake Superior is also identified for protection consideration, as it has experienced some change in trophic status in nearshore areas with increasing levels of attached algae and turbidity. In addition, Lake Superior has been identified by the U.S./Canada International Joint Commission as a demonstration lake and is recognized nationally and internationally as one of world's most important freshwater lakes. Appendix B provides the full list of lakes that were analyzed.

Table 11. At-risk lakes identified for protection

Lake Name	Lake ID	Lake Type	Secchi Depth (m)[a]	Average Total Phosphorus (µg/L)[a]	P Sensitivity Score[a]	% Disturbed[a]	Lake Association[b]	HUC 10
Tom	16001900		3	12.1	22.4	2.6%		401010102
Devil Track	16014300		3	12.1	4.7	1.9%	√	401010105
Hungry Jack	16022700		5.3	7.8	50.5	2.6%	√	401010101
Birch	16024700	LT[c]	5.5	8.1	73.2	3.8%		401010101
Deer Yard	16025300		2.9	16.3	31.8	1.2%	√	401010106
Divide[d]	38025600	T	3.7	15.0	8.9	0.7%		401010110
Poplar	16023900	LT	3.7	9.6	18	2.5%	√	401010104

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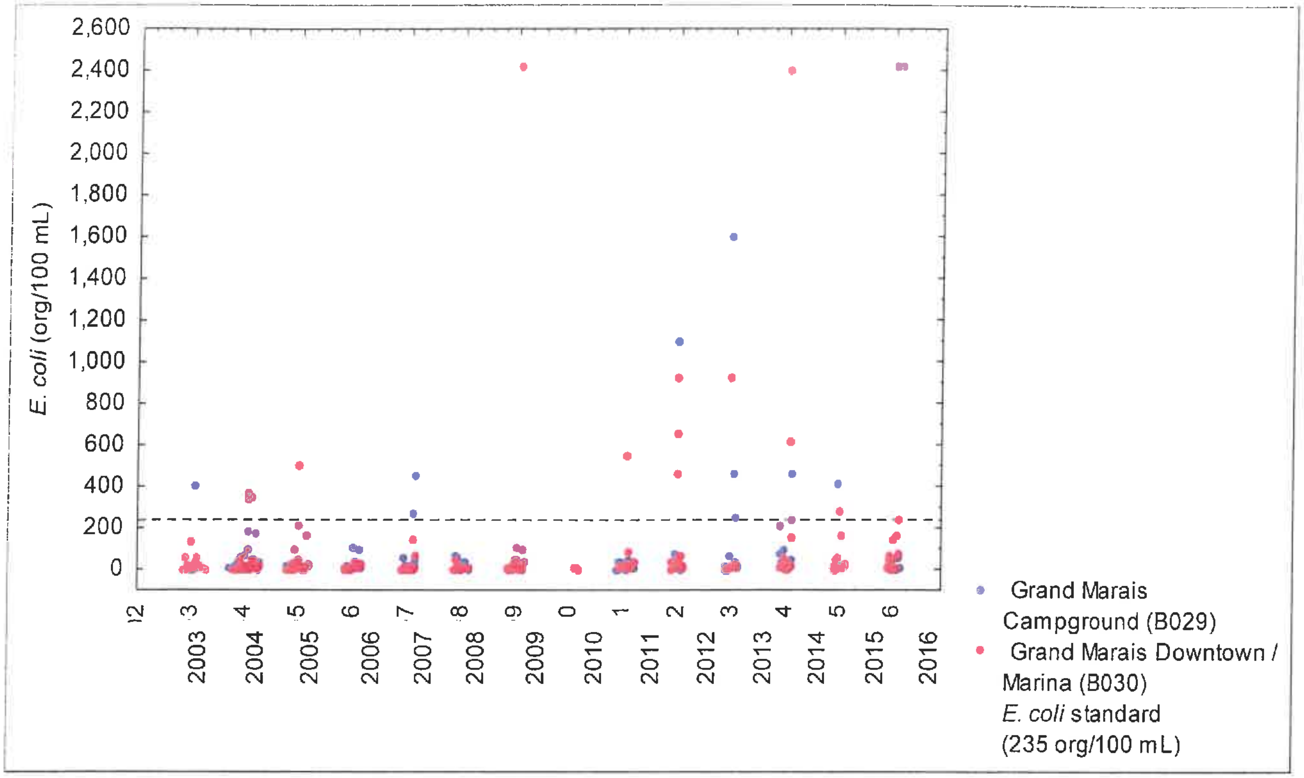

Figure 7. *E. coli* concentrations at Grand Marais beaches.

Due to water quality concerns along the shore of Lake Superior, Cook SWCD began sampling Lake Superior near shore sites in 2014 (Figure 8). Sediment plumes had been observed in the lake at tributary inputs, in addition to increased levels of attached algae. Samples were collected at five sites near Grand Marais. Transparency varied among the sites, with the best (highest) transparency at the most south-western site (site 204) and the poorest (lowest) transparency at the site closest to the shore (site 212; Figure 9). Phosphorus concentrations varied slightly among the sites, with no clear spatial patterns (Figure 10). TSS concentrations were low—the majority of the samples were below the detection limit, with the remaining samples at or less than 2 mg/L TSS.

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WisCONTEXT

Series: Extreme Precipitation And Wisconsin's Climate

The Outsized Impact Small Streams Have On Lake Superior

Plumes Fed By Minor Tributaries Affect Ecology Of Great Lakes

.Kaley Fech, Great Lakes Echo

Dec. 27, 2018 | Noon

Wisconsin Department of Natural Resources (CC BY-ND 2.0)

Larson Creek, the Flag River and other small tributaries flow into Lake Superior at Port Wing.

Very little is known about the smallest tributaries that flow into Lake Superior. Several researchers at Michigan Technological University are changing that.

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Michael Leland (CC BY-NC 2.0)

But the smaller streams may be more important than people tend to think, she said. The study counted approximately 2,800 tributaries that empty into the lake.

"That was a significantly bigger number than anyone else had calculated before and really helped to emphasize the potential importance of streams as contributors to the Lake Superior ecosystem," said Colin Brooks, co-author of the study and manager of the Environmental Science Laboratory at the Michigan Tech Research Institute in Ann Arbor, Mich.

There are eight or 10 major tributaries that are well monitored, and those tributaries make up about half of the watershed area on the United States side, Marcarelli said. But if you look at the other half of the watershed area, most of the streams are very, very small.

"These are the little streams that in the summer you can stand over with one foot on either bank," she said.

The researchers suspected that the importance of small streams to the nutrient budget and ecology of Lake Superior has not been properly considered before, Brooks said. They tried to measure the effect small streams have on Lake Superior, but were left with more questions than answers.

Roughly 60 percent of the tributaries are on the American side, while 40 percent are on the Canadian side, Marcarelli said.

Stream outputs into Lake Superior don't get mixed in immediately. Instead, they form plumes, which Marcarelli described as "mini water bodies" that are slowly mixed into the lake. Most of the time they are fairly small

But sometimes, the plumes are very big, particularly during snowmelt or big storms, Marcarelli said. Those plumes are visible because the water coming out of the tributaries is quite different than the water in the lake.

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University of Wisconsin Cooperative Institute for Meteorological Satellite Studies

A satellite image from June 18, 2018 shows plumes of sediment flowing into the south shore of Lake Superior following heavy rains over June 15-17.

The plumes have the potential to allow the researchers to measure how much water is coming in from the tributaries.

However, the weather can make them difficult to view.

"It's really hard to get satellite pictures in these regions because it's cloudy all the time," Marcarelli said. "The plumes are probably happening in the time when it's most difficult to get on Lake Superior."

The researchers used an autonomous underwater vehicle, which can provide an alternative way to detect the plumes.

"They can swim through the plumes and measure the changes in water chemistry to try to

figure out how big they are and how deep they are," Marcarelli said.

They also used drones, which can be flown over various stretches of shoreline and used to map the plumes.

"If we can use things like drone imagery, it will become a lot more practical to understand how changes in nutrients and organic matter are being affected by changing climate," Brooks said.

By ignoring the contributions from all of the little streams, a big part of the story is missing, said Evan Kane, a researcher in the School of Forest Resources and Environmental Science at Michigan Technological University.

"Little streams behave a lot like big streams do say in the spring or late in the fall," he said. "What's really interesting is that during storm events, the little streams and the big streams, that's when their true personalities seem to come out."

3/5

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It's important to realize that plumes are a part of the natural lake dynamic, Marcarelli said. They contain nutrients delivered into the lake, which fuel the productivity of algae, which feed the zooplankton, which feed the little fish, which feed the bigger fish.

But human activity modifies the amount of nutrients in the plumes, which can lead to negative effects, she said.

A post-storm plume colors the waters of Lake Superior at Port Wing.

Sharon Mollerus (CC BY 2.0)

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Large summer rain storms appear to be connected to cyanobacterial blooms in Lake Superior, Marcarelli said.

"When those storms happen, they cause a lot of erosion in the watersheds," she said. "When they do, the plumes tend to have a lot of sediment with phosphorus bound to it, which researchers think can then lead to these cyanobacterial blooms."

Climate change has caused rain patterns to change, with more frequent and more extreme rainfalls, Kane said.

It's important to understand the connection between the lake and its tributaries to predict the long-term impacts of climate change, Marcarelli said.

"With climate change, not only do we expect those storm frequencies to change, we also expect the conditions in the lake to change," she said.

Editor's note: This article was originally published on Dec. 21, 2018 by Great Lakes Echo, *which covers issues related to the environment of the Great Lakes watershed and is produced by the Knight Center for Environmental Journalism at Michigan State University.*

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Doc 88A -407-

Minnesota Board of Water & Soil Resources

Protecting Minnesota's wild rice lakes

June 2015 Snapshots

Minnesota is the epicenter of the world's natural wild rice. Protected, undeveloped shoreland is important to preserving sensitive wild rice lakes for current and future generations of wildlife and outdoor enthusiasts. Although once found throughout most of the state, today, the heart of the state's wild rice acreage falls within eleven counties: Aitkin, Becker, Beltrami, Carlton, Cass, Clearwater, Crow Wing, Hubbard, Itasca, St. Louis and Wadena.

A young man harvests wild rice.

Wild rice is important both socially and culturally in Minnesota. Wild rice also provides important ecological benefits. Wild rice shoreland encompasses a complex of shallow lakes, rivers, and shallow bays of deeper lakes that support rice and provide some of the most important habitat for wetland-dependent wildlife species in Minnesota. Wild rice habitat is especially important to Minnesota's migrating and breeding waterfowl and provides Minnesotans with unique recreation opportunities: hunting waterfowl and harvesting the rice itself for food. Wild rice also improves and protects water quality by keeping soil and nutrients in place and acting as a buffer to slow winds across wetlands.

The Minnesota Board of Water and Soil Resources (BWSR) has received Outdoor Heritage Funds to support and protect our state grain. Working in cooperation with the DNR and soil and water conservation districts, BWSR will complete 46 easement projects on 29 lakes and rivers.

Funding for wild rice protection began in 2012. This first phase of the project was awarded $1.89 million which yielded 18 completed projects extending permanent protection to almost 10 miles of wild rice shoreland. Phase II began in 2013 and is still underway. Working together with the Department of Natural Resources and Soil and Water Conservation Districts (SWCDs), the program has prioritized the list of wild rice lakes for protection efforts and is working on outreach with landowners to fully allocate $1.63 million in funds. Over 25 easement applications are in the pipeline to provide permanent protection for these valuable lakes.

This program is expected to continue in the coming years with $2.66 million in funding available for phases three and four of the program. In addition to continuing to promote easements and permanent land protection, BWSR and SWCDs will hold more local wild rice lake prioritization sessions to focus protection on the most significant wild rice resources.

Above, Mallard Lake, part of a large Wildlife Management Area in Aitkin County. Two easements are in process on the lake and, when completed, there will be no more unprotected shoreland.

Overall, these efforts have resulted in protection over 20 miles of wild rice shoreland. "Wild rice, and the lakes that support it, are an important part of Minnesota's cultural livelihood and ecological health," Board Conservation Dan Steward said, "and we're pleased with the work we've been able to do so far to protect this resource for future generations. We will continue to partner with state and local agencies to make sure wild rice shoreland continues to be a healthy, thriving part of the landscape."

- 7 roads totaling 4 miles in length were recommended to be converted to trails.

Road Funding

On the Superior National Forest, road maintenance funding has decreased by over 60% since 2000 without a similar decrease in total mileage. At the current funding level we are not able to properly maintain the road system. Based on a model developed by the Region 9 Regional Office the total estimated funding needed to maintain the 2500 mile road system is approximately $2,000,000 per year for basic road maintenance. Additional funds are needed for bridge replacement and replacement of surfacing on maintenance level 3-5 roads. We currently have a backlog of approximately $15,000,000 for surfacing replacement. The past few years we have been receiving $500,000 to $600,000, approximately 30% of the amount needed. The analysis completed for this TAP did not result in identifying a significant number of roads or miles that are likely not needed in the future.

At the current funding level, roads can not be maintained to standard and the Forest is not able to meet the Forest Plan Desired Conditions of providing safe traveling conditions for the public and providing reasonable access to private land and other public lands.

The Forest recognizes that the trend of decreasing funding will most likely continue. To address, while balancing balance mission requirements and public needs the Forest will continue to implement the following strategies:

- Seek other sources of funding to apply to road maintenance
- Take advantage of opportunities for road maintenance work to be completed under timber sale contracts and stewardship
- Work with the State of Minnesota and local counties to share maintenance activities
- Maximize opportunities to turn road maintenance and jurisdiction over to State and counties
- Where practical, reduce maintenance levels to reduce needed maintenance
- In NEPA analysis for vegetation management, maximize use of temporary roads, minimize addition of new system roads and maximize opportunities to reduce system roads

Superior National Forest Road Definitions

Forest system roads are classified roads under Forest Service jurisdiction that the national forests plan to maintain for long-term use (permanent). These roads are given road management objectives, and have road maintenance commensurate with their intended use and function. They may be closed either seasonally or for longer periods of time when no land management activities are in progress. The Superior NF further defines Forest system roads as follows:

• **All-Season roads** are constructed for year-round use and are normally aggregate surfaced, with use only restricted during normal spring load restrictions. These are typically Objective Maintenance Level 3, 4, and 5 roads, and are suitable for passenger car travel.
• **Summer Seasonal roads** are constructed for dry weather use, and are normally constructed of native or pit run borrow material. In additional to normal spring load restrictions, these roads are normally closed to use during unseasonably wet weather periods. These are typically Objective Maintenance Level 1 and 2 roads, and suitable for high-clearance vehicles.
• **Winter roads** are constructed to lie lightly on the land to reduce ground disturbance, typically without removal of the existing topsoil, and utilize snow and ice as part of the road surface. They are only used during frozen roadbed conditions, and are closed at other times of the year. These are typically Objective Maintenance Level 1 roads (closed) when not maintained for winter travel, and move up to an OML 2 when in winter use. On the Superior National Forest about 20% of the system roads are winter roads. Winter roads are a very important part of winter timber harvest, allowing needed access over very poor soil types without damaging the ground.

Figure F-7. Winter road during non-use period.

• **Temporary Roads.** Each national forest also uses Temporary Roads for land access. These are temporary routes needed for short-term vehicular access to allow the accomplishment of individual land management activities. They are not included in the Forest system road inventory (INFRA Travel Routes). Most importantly, temporary roads will lie lightly on the ground, requiring minimal cuts and fills, have a minimum number of wetland/drainage crossings, and are decommissioned after their use is completed. Most temporary roads are built for timber sale access and follow-up activities such as site preparation and reforestation. They are generally used for a one to five year period. These roads

Doc 91 -410-

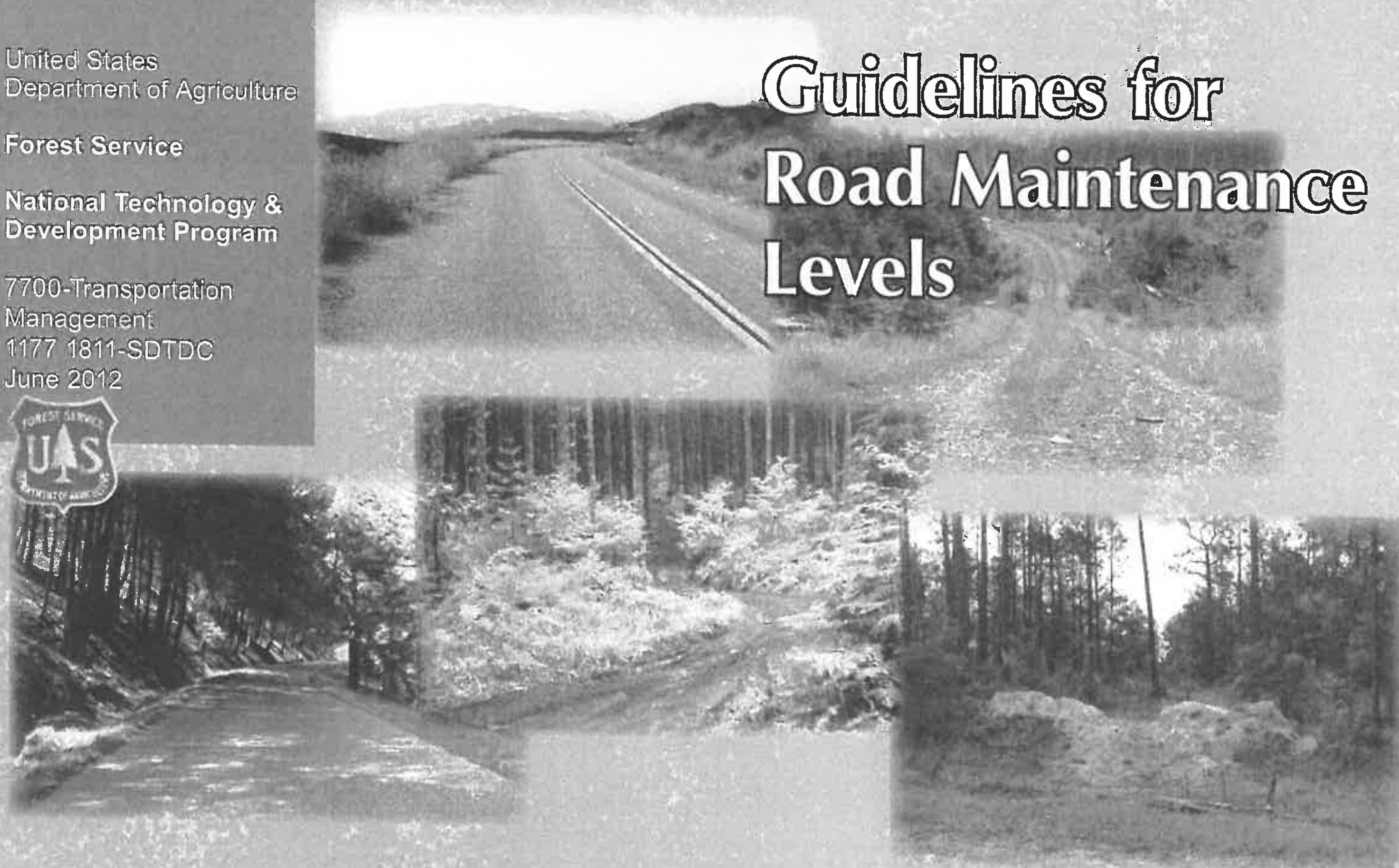
United States
Department of Agriculture

Forest Service

National Technology &
Development Program

7700-Transportation
Management
1177 1811-SDTDC
June 2012

Guidelines for Road Maintenance Levels



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Road Maintenance Level 2

Road maintenance level 2 is defined in the FSH 7709.59, sec. 62.32 as:
"Assigned to roads open for use by high-clearance vehicles. Passenger car traffic, user comfort, and user convenience are not considerations. Warning signs and traffic control devices are not provided with the exception that some signing, such as W-18-1 "No Traffic Signs" may be posted at intersections. Motorists should have no expectations of being alerted to potential hazards while driving these roads. Traffic normally is minor, usually consisting of one or a combination of administrative, permitted, dispersed recreation, or other specialized uses. Log haul may occur at this level."

Appropriate traffic management strategies are encourage, accept, discourage, and prohibit.

Maintenance level 2 roads have the following attributes:

- Are maintained for use by high-clearance vehicles and not suitable for passenger cars.
- Do not consider passenger car traffic, user comfort, and user convenience.
- Have low traffic volume and low speed.
- Typically, are local roads that connect to collectors and other local roads.
- Have dips or cross drains as the preferred drainage treatments.
- Avoid the use of culverts, arches, and bridges when possible.
- Typically, have very few, if any, signs or other traffic control devices.
- Are subject to the requirements of EM-7100-15 and MUTCD for all signs.
- Do not consider surface smoothness.
- Do not always provide motorists with alerts to potential hazards.
- May not be passable during periods of inclement weather.

Doc 91 -412-

Maintenance level 2 prescription guidelines:

Traveled way. Log out and brush only as necessary to provide passage for high-clearance vehicles. Maintain road prism for drainage and to provide for passage of high-clearance vehicles. Traveled way should only be bladed to maintain drainage functionality and not to provide a smooth surface for passenger cars.

Shoulder. Shoulder is usually not defined and maintenance is not required unless necessary to maintain structural integrity of the roadway, drainage functionality, or access by high-clearance vehicles.

Drainage. Drain as necessary to keep drainage facilities functional and prevent unacceptable environmental damage while maintaining passage for high-clearance vehicles.

Roadway. Remove or rampover slides and repair slumps as needed to provide access for high-clearance vehicles and to control resource damage.

Roadside. Generally no work is required unless necessary to provide clearance for existing traffic. Fallen trees may be left in place if not an obstacle to safe passage of intended traffic.

Structure. Maintain all structures to provide for the passage of high-clearance vehicles and to protect natural resources.

Traffic service. Install and maintain route markers. Maintain warning, regulatory, and guide signs, and other traffic control devices as warranted in the sign plan to provide for existing traffic and the appropriate traffic management strategy. Generally, few, if any, signs or other traffic control devices are required.

Public Access Needs

The public uses Forest Service roads to access their private seasonal or year-round homes, commute to areas within the forest, access to recreational sites and dispersed recreation areas and to travel to the Boundary Water Canoe Area Wilderness access points. The roads on the SNF also have a fair amount of commercial traffic traveling between various areas within the forest and to areas outside of the forest.

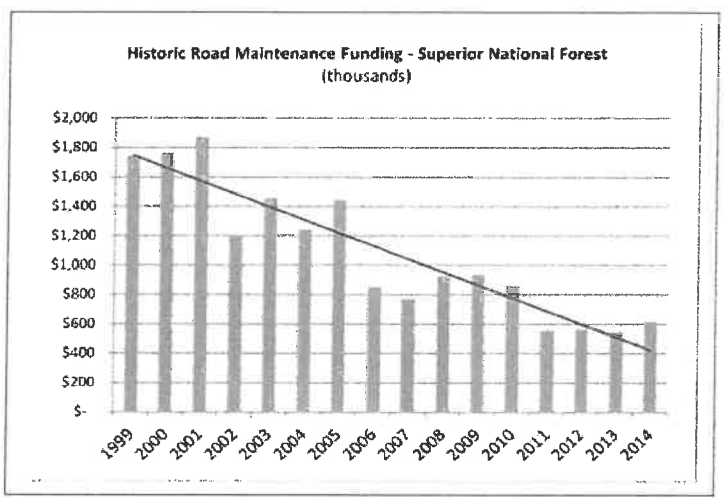
Current Resources to Maintain and Operate the Forest Transportation System

Budget

Road operations and maintenance is funded primarily by CMRD allocations. As shown in Figure 2.1 below, the road maintenance funding has decreased by over 60% since 2000 without a similar decrease in total mileage. Road maintenance is accomplished by contracting with local small companies. As the overall budget has decreased, fuel and costs of maintenance have increased resulting in funds are spread thinner over the same network of roads and the ability to maintain roads to standard is significantly less than 10-15 years ago.

The Forest has mostly eliminated expenditure of road maintenance funds on ML 2 roads and the reduced amount of funding is focused on higher traveled ML 3, ML 4, ML 5 roads.

The current budget does not allow for funds to replace or complete significant restoration of road bridges. Over 50% of our 46 structures are over fifty years old and at least 15 will require replacement or closure in the next 10 years.



(costs adjusted to year 2014)

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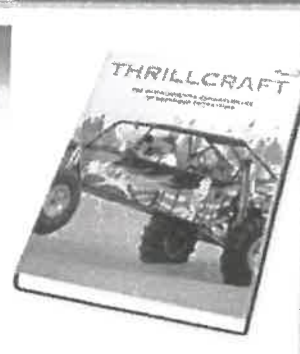

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George Wuerthner

Thrillcraft Culture

One cannot talk about thrillcraft without discussing the culture that spawns this kind of behavior. The culture is one that glorifies machines and human dominance of nature. It is a culture estranged from the natural world. The speed, noise, and air pollution associated with these machines blurs, obscures, and hides natural beauty and prevents appreciation. Worse yet, it destroys the land and jeopardizes the enjoyment of our public heritage by others.

A review of any of the ads for major thrillcraft machines demonstrates this attitude. You will find ads admonishing thrillcraft owners to use "brute—as in force," and that "going to the stand for coconut smoothies is for sillies," and other messages that imply that anyone who doesn't tear up the land, and "conquer" the obstacles is somehow less manly.

Reckless and Rude Behavior

Reckless and rude behavior is common among thrillcraft users. Speed combined with reckless behavior is prevalent among thrillcraft users—since that is one way you get thrills—by pushing the limits. Though not all thrillcraft users are inconsiderate, there are plenty who see nothing wrong with loud noise, racing close to other people, and creating a hazard for other public lands users. One ad for thrillcraft suggests users "thumb their throttle at the world."

Because of this reckless behavior, thrillcraft are often involved in serious injury. Nation-wide, jet skis make up only 9% of all motorized watercraft, but account for 46% of all injuries.

Trespass and Violation of Route Closures

A major problem endemic with thrillcraft culture is the notion that one straddles these machines to go "where no one else has gone." As a consequence, there is a strong tendency to ignore trail and road closures, and violate any limitations placed upon use of the machines.

For instance, a study in Georgia documented that of the 59 routes surveyed in the Chattahoochee NF, illegal ORV use occurred on 67 %, including designated wilderness and trails restricted to pedestrians.

Another study conducted in Colorado on behalf of Colorado Coalition for Responsible ORV Riding found that despite the fact that most thrillcraft enthusiasts understood that they should not stray from designated trails, more than two-thirds admitted they go off-trail occasionally, and 15-20% admitted they regularly rode off legal routes.

Violation of Rights of Other Public Lands Users

A peaceful walk in the woods is violated by the noise from thrillcraft. An otherwise successful stalk of a deer or elk might be jeopardized by the sudden appearance of a noisy machine. The fact is that the majority of people do not use these machines to access our natural areas. A

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recent survey by the Montana Department of Fish, Wildlife and Parks found that 90% of Montana trail users were on foot, and only 2% used thrillcraft.

Climate change / Davos —

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U.S. NEWS

CAPITAL ACCOUNT | By Greg Ip

Climate Change Alarms Business, to a Poin

Every year the World Economic Forum asks 1,000 business, policy and thought leaders to rank about 30 risks facing the world by both impact and likelihood. In this year's report, released Wednesday, climate-related risks top the list.

The WEF, which hosts its annual meeting in Davos, Switzerland, next week, has been running this exercise for 14 years. While some risks come and go with the headlines, climate has been rising steadily through the ranks and has led the list for the past three years.

If the first step to solving a problem is admitting you have a problem, this should mean climate change is well on its way to being solved. The reason it isn't is that the world is much readier to admit climate change is a problem than to do anything about it. This is especially true of businesses in the U.S., many of which claim concern about climate change then fight solutions that hit their bottom line.

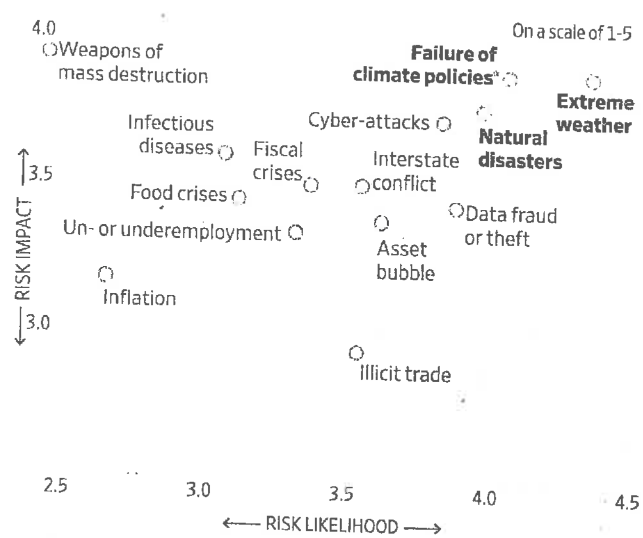
Digging a little deeper into the WEF's findings sheds only short-term risks, respondents ranked climate only 11th, well behind economic conflict between big countries, protectionism, and cyberattacks. In other words, the closer businesses and others focus on the here and now, the less pressing climate change becomes.

Perhaps this dichotomy shouldn't surprise. Any individual business can adapt to the consequences of a warming climate, from more intense hurricanes and wildfires to rising sea levels and warming oceans. Insurers can charge higher premiums, a real-estate developer can avoid the coasts. But none can solve it. Many are investing in clean-energy technology, but customers won't pay for that technology unless it's cheaper than the fossil-fuel alternative. That almost always requires a policy intervention such as a carbon tax, a cap on emissions with tradable permits, or mandates such as requiring a fixed percentage of electricity to come from renewables.

Small wonder that among WEF respondents' top climate-related concern is "failure of climate change adaptation and mitigation," in other

What Are You Worried About?

Climate change and its effects are ranked by business, political and thought leaders as the likeliest and among the most dangerous risks facing the world.



Note: Based on a survey of nearly 1,000 people from business, government, academia and nongovernmental organizations. Total of 30 risks; not all shown *Failure of climate change mitigation and adaptation

Source: World Economic Forum Global Risks Perception Survey 2018-19

are doing nothing. On the contrary, the World Bank counted 47 carbon-tax or emissions-trading programs around the world last year covering roughly 15% of annual greenhouse-gas emissions. When China kicks off its emissions-trading system

schemes don't go far enough. The vast majority charge a small fraction of the $40 to $80 per ton of carbon dioxide the World Bank says will keep emissions on track with levels agreed to in the Paris accord. The reason is to avoid a backlash from taxpayers and busi-

the regulations persist for some time, the strength of the regulation can be ratcheted up," says Solomon Hsiang, an economist specializing in climate at the University of California, Berkeley.

And there's the rub: businesses that are supportive of climate action become notably less so when faced with a tax, regulation or cap-and-trade plan that really bites. The U.S. Chamber of Commerce calls climate change a serious issue, yet worked to defeat Democrats' proposed cap-and-trade plan in 2010. After it collapsed, President Obama's Environmental Protection Agency enacted a Clean Power Plan to cut power-plant emissions. The Chamber and a dozen other business groups, along with Republican attorneys general, promptly sued to overturn it. The Supreme Court stayed the plan in 2016 and last year President Trump's EPA moved to kill it. Asked where the Chamber now stands, an official said: "We would evaluate a specific carbon tax or cap-and-trade proposal in consultation with our members."

Since then, many businesses have concluded

ber over the issue. They s as a way to avoid heavier-handed regulation. Even t oil industry is coming aro BP PLC, ConocoPhillips, E: Mobil Corp. and Royal Du Shell PLC have thrown the support behind a carbon t proposed by the Climate Leadership Council, a bipa san advocacy group, that would be revenue neutral-i.e., the revenue it raises would be returned to hous holds. Yet when a revenue neutral carbon tax was pu before Washington state ir 2016 ballot initiative, the c industry declined to suppo it. The initiative was defeated.

Last November, a secon ballot initiative asked the state to approve a carbon t that wasn't revenue neutra BP spent heavily to defeat because it exempted some carbon emitters and didn't pre-empt future regulation That initiative also failed.

If business opposes all b the most-flawless, market-friendly climate remedies, i is likely to end up with one two outcomes. Legislators will ignore their advice and turn to mandates, regulatic and public investments suc

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Explore climate changes in Minnesota

Minnesota keeps getting warmer and wetter

More damaging rains

Heavy rains are now more common in Minnesota and more intense than at any time on record. Long-term observation sites have seen dramatic increases in 1-inch rains, 3-inch rains, and the size of the heaviest rainfall of the year. Since 2000, Minnesota has seen a significant uptick in devastating, large-area extreme rainstorms as well. Rains that historically would have been in the 98th percentile annually (the largest 2%) have become more common. Climate projections indicate these big rains will continue increasing into the future.

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Climate and precipitation

Minnesota has a continental climate, marked by warm summers and cold winters. The mean annual temperature for the state is 4.6˚C (NOAA 2016); the mean summer temperature for the Lake Superior – North Watershed is 15.0˚C and the mean winter temperature is -11.7˚ C (MNDNR 2003).

Precipitation is an important source of water input to a watershed. Figure 17 shows two representations of precipitation for calendar year 2014. On the left is total precipitation, showing the typical pattern of increasing precipitation toward the eastern portion of the state. According to this figure, the Lake Superior – North Watershed area received 28 to 32 inches of precipitation in 2014. The display on the right shows the amount those precipitation levels departed from normal. For the Lake Superior – North Watershed, the map shows that precipitation ranged from four inches below normal to two inches above normal.

The Lake Superior – North Watershed is located in the northeast precipitation region. Figure 18 and Figure 19 display the areal average representation of precipitation in northeast Minnesota for 20 and 100 years, respectively. An areal average is a spatial average of all the precipitation data collected within a certain area presented as a single dataset. Though rainfall can vary in intensity and time of year, rainfall totals in the northeast region display no significant trend over the last 20 years. However, precipitation in northeast Minnesota exhibits a significant rising trend over the past 100 years (p=0.001). This is a strong trend and matches similar trends throughout Minnesota.

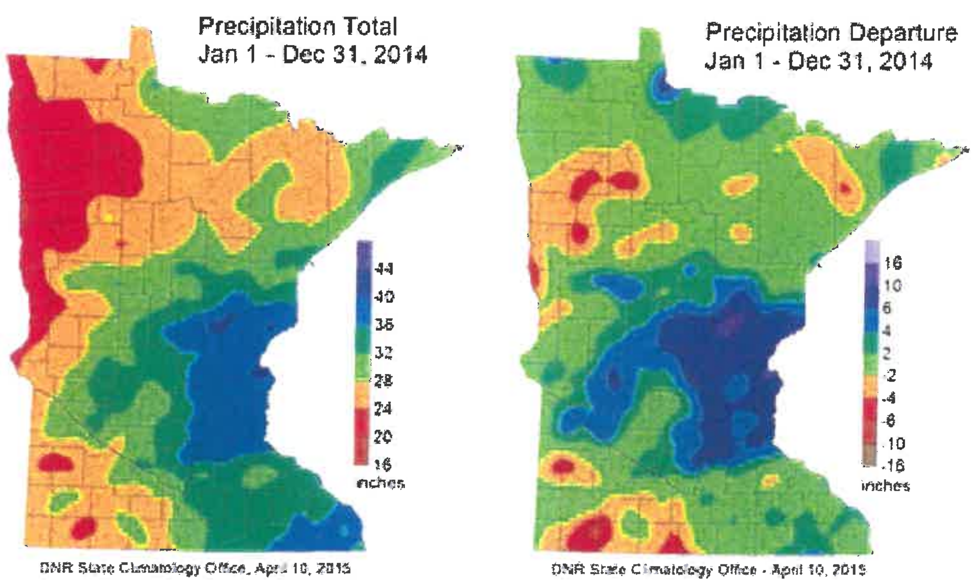

Figure 17. State-wide precipitation levels during 2014.

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Wemple (1996) evaluated road-stream connectivity as the sum of gully erosion length off of road prisms, and the sum of road segments directly linked to streams within a watershed area. Croke and Mockler (2001) employed a modified Wemple (1996) methodology to examine road-stream connectivity by examining roadway proximity to water resources. This method employed a categorical system to determine connectivity by examining the length of the erosion feature and its distance to the stream; determined at distances greater than 10 meters and less than 10 meters from the stream. This study employed the Croke and Mockler (2001) system of evaluation, but modified the approach to include categories used by Miller (2010), to examine road proximity to streams at distances of 3.04 m – 30.4m (10 – 100 ft) (Miller, 2010).

Erosion features

With low infiltration rates due to surfacing or compaction, roads persistently deliver overland flow to surfaces alongside roadways resulting in channel initiation and erosion. Detachment of sediment particles is likely to occur as a result of concentrated high energy flows that exceed critical shear stress of the soil (Horton, 1945, Poesen et al., 2003). Road related sediment transport can take many forms, from dispersive runoff flows that carry fine sediment (attributed to trafficking on gravel and native roads), and channelized flows leading to incised channels and landsliding (Figure 3). This study focused on rill and gully erosion.

To date there are many interpretations defining rill and gully processes, this study follows classifications by Poesen et al. (2003). Gullies can range in depth from 0.5 – 30 m (Poesen et al., 2003), and are often classified as a “permanent” or “ephemeral” gully. This study evaluated ephemeral erosion defined at concentrated flowpaths at depths of less than 1.54 m (Poesen et al., 2003).

Precipitation both in terms of rainfall intensity and volume can encourage rill and gully development. Poesen et al. (2003) cites “rain thresholds” of 7.5 mm as a lower limit for rilling, 14.5 mm for gullies extending to 22 mm of rain. Other observations cited within the literature review by Poesen et al. (2003), indicate rain on snow events can have a considerable effect on frozen/thawing soils, initiating ephemeral gullies (observed in Norway) (Oygarden (2003) cited in Poesen et al., 2003). Sullivan and Foote (1983), found water related erosion was most frequently observed along roadsides, accounting for 15,309 occurrences or 81.5% of the dataset. Precipitation intensity and duration were primary factors for sediment detachment, often dictating where sediment was deposited along a buffer.

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QUETICO SUPERIOR

Wilderness News

See pgs. 4+9

≡ MENU

Climate Change in the Northwoods Part II: What Climate Change Means for the Boundary Waters Region

July 30, 2016 by Editor

By Alissa Johnson

In the last issue of *Wilderness News,* we learned about Climate Generation: A Will Steger Legacy, which is reframing the way that people talk about the issue of climate change, incorporating not only the science but the potential solutions. In this issue, we learn about some of the ways that climate change is expected to affect the Boundary Waters region.

While there are still those who deny climate change, scientists from all types of institutions—from universities to state agencies—have been working to understand the effects of climate change in the Boundary Waters region.

Supporting the Protection of the Minnesota-Ontario border region and Superior National Forest including the Boundary Waters Canoe Area Wilderness, Quetico Provincial Park, Voyageurs National Park, La Verendrye Provincial Park, Isle Royale National Park, and Lake Superior. Published by the Quetico Superior Foundation Since 1964. More About Us >

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There are still many unknowns, but from their work, one thing is becoming clear: the central question is no longer if change will occur but to what degree. Changes are being seen in temperature, precipitation, and plant species, and changing climate conditions are also placing stressors on animal populations. Over the next several decades, the boreal forest so iconic to the northwoods could significantly change.

The Boundary Waters of Today.

A typical Quetico Provincial Park scene. As temperatures warm, scientists predict that the iconic boreal forest of the Boundary Waters Canoe Area Wilderness and surrounding region will be replaced by temperate forests and even oak savannah. Photo by Tim Eaton.

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WORK

Help us preserve the wilderness character of canoe country for future generations.

Lake, woodland and prairie vegetation in the Gneiss Outcrops Scientific and Natural Area in southern Minnesota offers an idea of what Voyageurs National Park and other parts of the Boundary Waters region might look like in 2070. Photo by Dave Hansen, University of Minnesota Agricultural Experiment Station.

The epicenter of warming

In many ways, the Boundary Waters region lies at the heart of warming in Minnesota. Kenny Blumenfeld is a climatologist with Minnesota's State Climatology Office. He says that the locations typically vying to set records as the coldest are being affected the most. "From a really basic standpoint, warming in northern Minnesota is well underway and is actually warming faster… than any other part of the state," he said.

Winter temperatures and overnight lows are seeing the greatest amount of change. While the region has set some warm weather records during the summer, there is no trend showing an increase in the intensity of summer heat. Instead, winter has been warming at a rate that is ten times faster than summer—one degree Fahrenheit per decade compared to 1/10th of a degree.

"That, to me, is the number one change that we have seen because it's reducing the extreme cold conditions in

Quetico Superior Wilderness News is published, in part, with a contribution from the Andrews-Hunt Fund of The Minneapolis Foundation.

COVID-19 Updates

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winter so fast that areas in northern Minnesota that routinely went to negative forty, struggle to do it now. As an example, this last winter, no official National Weather Service Cooperative Observer station hit -40°F. That's pretty unusual," he said. As a public speaker, Blumenfeld has had audiences cheer at the idea of a warmer winter, but he points out that cold temperatures play an important role in the ecosystem.

"It's true that winter, for the foreseeable future, will still get cold enough that it could kill a person if they're not prepared, but this eroding of the coldest temperatures causes secondary events that we're just starting to understand. There's a lot that we don't know—what that means for the forest ecosystem or anything depending on an integrative landscape. We're changing the settings," he said.

And temperatures aren't the only thing changing. According to Blumenfeld, northeastern Minnesota shows small signs of intermediate-term drying while the rest of the state grows wetter.

"In the area warming the fastest it's actually not getting any wetter so there is a net loss of water occurring… and that could be stressing some of the forest," Blumenfeld said. That could be important given the final trend that Blumenfeld noted: incidents of unprecedented rainfall. While things might tend to be drier, large rainfall events, like the one experienced in Duluth a few years ago, are getting slightly larger and happening more frequently.

Reopens May 18

Park closures, border closures, and permit information updated as available. More>

TOP STORIES

Small human-caused wildfire contained on Crooked Lake in Boundary Waters

Watch: Documentary traces long legacy of defending the Boundary Waters

DOC 98 -424- 5/9

"With the combination of the rapid temperature changes and the fact that precipitation isn't keeping up in northeastern Minnesota, the forests are going to be more susceptible to disturbance or damage by extreme weather events because there will be less structural hardiness. It's a time of pretty rapid change," Blumenfeld said.

Boundary Waters outfitters report high demand, take precautions to protect health

Changing landscapes

Change is already being documented in the Boundary Waters Region. Lee Frelich is director of the University of Minnesota Center for Forest Ecology. He and several PhD students have been studying the Boundary Waters Canoe Area Wilderness region for about a decade, and Frelich is also developing a model that will project biomes in each part of the region, down to an extremely small scale. Based on their combined work, Frelich expects the boreal forest—spruce, fir, birch, aspen and even jack pine and black spruce—to be invaded by temperate species like red maple, basswood and northern red oak over the next few decades.

Scientists are trying to save Minnesota's northern forests from global warming

Busy weekend in the Boundary Waters could also be dangerously dry

"We're already seeing that happen in the seedling layer," Frelich said. Graduate student Dave Chaffin surveyed over 2,000 plots throughout the Boundary Waters and nearly all of them had red maple seedlings. Another graduate student, Nick Fisichelli, studied summer temperature conditions for boreal and temperate forest and found that, at cooler temperatures, spruce and fir seedlings grow faster than maple and oak. At warmer

FACEBOOK

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temperatures, maple and oak seedlings grow faster. As temperatures continue to climb, conditions will favor those temperate trees.

Frelich expects that temperate forest to last in eastern parts of the Boundary Waters with possible pockets of boreal forest. But based on the work of a third student, Nick Danz, who studied the boundary between forest and prairie, Frelich projects that the central and western parts of the wilderness area will eventually transition to oak savannah.

That variation primarily stems from temperature differences across the region. Graduate student Chaffin also distributed temperature sensors across the Boundary Waters and measured the temperature every two hours for two years. The eastern part of the wilderness is about 10 degrees cooler in summer than the area surrounding Ely, Minn., and is more conducive to temperate forests than the central and western regions. In the northeastern parts of the Boundary Waters, Frelich also expects to see variation between north and south facing slopes, where more solar radiation creates higher temperatures and causes more water to evaporate than on northern slopes. It's on those northern slopes that boreal forest could remain. It's also possible that in the middle and western parts of the wilderness there will be oak savannah on southern slopes and temperate forests on northern slopes.

Frelich expects to see a similar transformation in Quetico Provincial Park. "Quetico will pretty much be the same

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because it's pretty much at the same latitude as the Boundary Waters," he said.

Impacts on animal and fish populations

Frelich is succinct when it comes to understanding what the change in forest will mean for animal populations. "When the boreal forest goes, the moose go with it, the lynx and probably the blackbacked woodpecker," he said, pointing out that lynx are already being replaced by bobcat in some areas. Bobcat are already being seen where lynx would typically thrive, and researchers have found that warming temperatures are a stressor for the region's declining moose population.

Parasites and diseases related to warming temperatures have contributed to the decline of moose across the Boundary Waters region. Photo by Ron Moen, PhD.

Ron Moen is an Associate Professor at the University of Minnesota Duluth and a Senior Research Associate at the Natural Resources Research Institute. He has studied both moose and Canada Lynx, among other mammals, and explained that northeastern Minnesota and Ontario

FROM THE ARCHIVES

Winter 1970

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are on the southern edge of the boreal forest. That can make animal populations more susceptible to change, and changes have occurred in moose and Canada Lynx that can be related to climate change. He emphasized, however, that there are many factors at play.

Bobcats are already replacing threatened lynx in some areas. Photo by Gary Kramer/USFWS.

Most recently, for example, moose have garnered attention because of their declining numbers in the region. According to Moen, warming temperatures have placed stressors on the species, but parasites, habitat changes and predation all play a role as well—and the decline is still being studied. However, for adult moose in particular, parasites and diseases related to warming temperatures have contributed to the decline. And a study conducted in conjunction with the Minnesota Zoo showed the respiration rate of moose increases at about 68 degrees Fahrenheit for the same reason that a dog or sheep might pant: moose don't sweat and need to lose heat. That can have significant implications, causing animals to forage at night rather than during the day, which is a less efficient way of eating.

The takeaway, according to Moen, is that, "Change is happening and we're seeing it. But it's something that you don't necessarily, as an individual, see from day to day or

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even from week to week."

Cold water fish are also showing signs of change, though in an interesting twist, lakes in the Boundary Waters could provide a refuge for such species. Peter Jacobson is a research scientist with the Minnesota Department of Natural Resources. He confirmed that some cold water fish have been on the decline since the early 1980s, most notably Cisco, a cold water fish found in 650 lakes across the state.

"We think climate change is a big part of that," he said. Yet the further north you go, he noted, and the deeper and clearer the lake, the better things are. "We used those properties to identify 176 of those 650 lakes that are probably going to be refuges from climate change."

In those 176 lakes, cold water fish are going to persist, and some of those lakes are in the Boundary Waters. "It's critical that we protect those lakes and ensure that they are going to be refuges from climate change in the future, protecting their water quality and for lakes in the northern part of the state, keeping watersheds forested," he said.

QUETICO SUPERIOR
Wilderness News

Doc 98A -428A-

Large swath of Superior National Forest lands protected from development

October 7, 2020 by Greg Seitz

see pg. 2

A portion of the property purchased by The Nature Conservancy. (Photo by Jason Whalen, Fauna Creative)

More than 2,000 acres of forests, wetlands, and open water in northeastern Minnesota will be protected in perpetuity, thanks to a retired forestry professor and The Nature Conservancy.

Landowner Mike Freed sought to ensure the land would be preserved by selling the land below market value to the nonprofit, even though it contains several attractive homesites and broad tracts of forest. He purchased the property in 1994, when it was advertised for subdivision and development.

The parcels in the Superior National Forest west of Tofte include six wild lakes with undeveloped shores, which ultimately drain into the Temperance River and Lake Superior.

"On the shorelines you can still see the rare bog plants and golden tamarack trees with that quite muted golden orange of the larch needles in the fall," Freed told the *Star Tribune*. "It's beautiful."

Most of the parcels are near 600-acre Fourmile Lake, where there is a small National Forest rustic campground.

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The land in Cook County, not far from the Boundary Waters Canoe Area Wilderness, is surrounded on almost all sides by federal land. It fills in the gaps in a 30,000-acre block of undeveloped public lands. Its protection will help ensure the forest remains wild enough for animals like wolves, moose, and Canada lynx.

General location of protected lands. (USGS National Map)

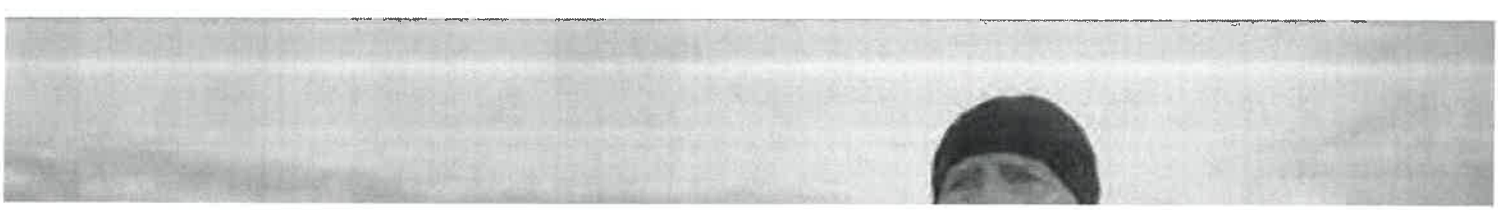
Keeping large tracts of wild lands intact is a priority for conservation in northeastern Minnesota.

"It's going to be fragmented, somebody's going to build a cabin, punch a road in," Freed said. "That's land fragmentation. That destroys the complexity of the habitat. That's what I wanted to avoid."

Roads and buildings can significantly disrupt the ecosystem, especially as the world faces other challenges. The Nature Conservancy and Freed say the land can both help reduce and mitigate climate change.

"When we start punching holes into this intact forest, you create barriers for movement. In climate change, species need to be able to move," said Jim Manolis of The Nature Conservancy.

A recent analysis released by The Nature Conservancy found the northeastern tip of Minnesota will be a critical area for maintaining habitat connections in a changing climate.



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“The Boundary Waters was a place that became the center of the Earth for me,” says Freed.

But his life and work took him elsewhere around the country, and working as a professor and department head threatened to consume his time. He started hiking all summer to compensate, and has hiked the Appalachian Trail multiple times. Freed wanted to make sure he left the land in the hands of “someone who can take care of it.” That will be The Nature Conservancy, which may ultimately sell it to the Forest Service, or may not. The 80-year-old now lives in Minnesota again, and is selling the land at a “significant” discount as a gift to all citizens of the state.

“This area is very important to the psyche and the emotional needs of a lot of people in Minnesota,” Freed told WTIP. “I’ve been privileged to take care of this land and I want to pass it onto someone who can continue to care for it.”

The Nature Conservancy says it may practice some sustainable logging on the lands, intended to promote species diversity and wildlife habitat. It will otherwise be open to hiking, hunting, and fishing, just like the surrounding Forest Service lands.

More information

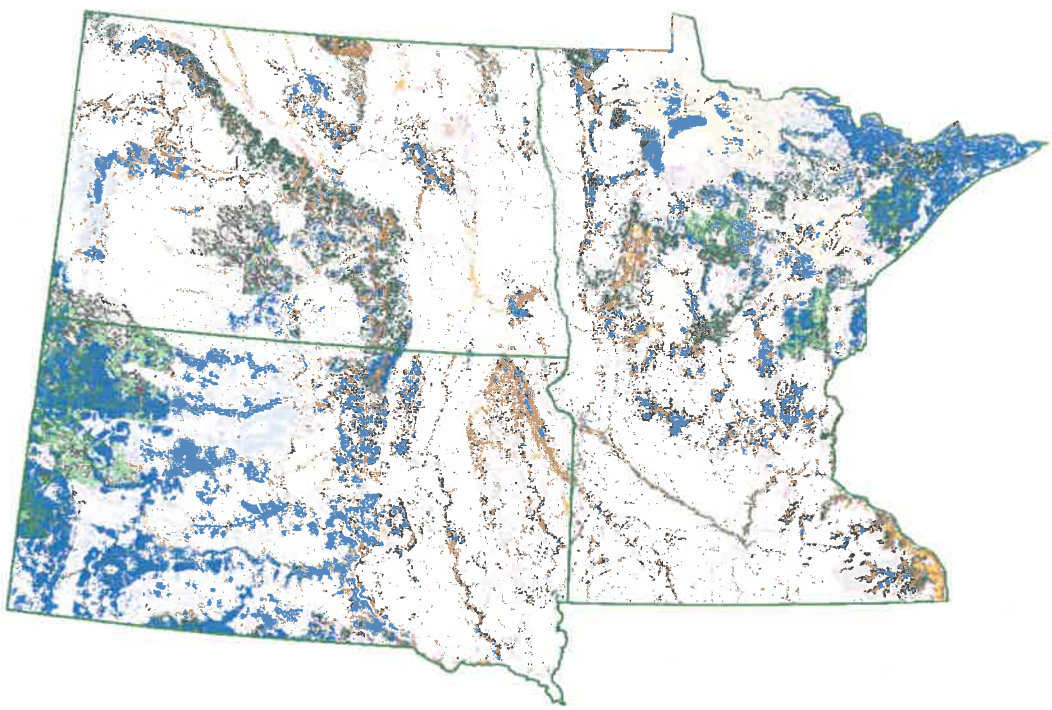
Doc 98B -428D-

Resilient and Connected Network: Overview
Minnesota, North Dakota and South Dakota

Nature is on the move as warmer temperatures, increased flooding and other climate impacts alter and destroy habitat, forcing species to search for new places to live. As nature faces growing threats, so do people who rely on healthy lands and waters for food, jobs and quality of life. With non-government, government and academic partners, scientists at The Nature Conservancy have identified and mapped a network of lands across the United States with unique topographies, geologies, and other characteristics that can withstand climate impacts, called the Resilient and Connected Network. This roadmap of "natural highways and neighborhoods" shows where plant and animal species have the best chance to move away from growing climate threats and find new places to call home.

The Resilient and Connected Network is based on three factors:

1) **Resilient Sites:** Sites with connected microclimates representing all physical environments therefore supporting a diversity of plants and animals as they respond climate change
2) **Recognized Biodiversity Value:** Sites recognized for their current biodiversity values
3) **Climate Flow:** Corridors or flow zones that facilitate plant and animal movement for climate adaptation



Resilient Land with Recognized Biodiversity – contains known locations of rare species or unique communities

Resilient Land Secured – contains many connected micro-climates

Climate Flow Zone – areas with high level of plant and animal movement that is less concentrated than a corridor

Climate Flow Zone with Recognized Biodiversity – a climate flow zone with known locations of rare species or unique communities

Climate Corridor – narrow conduit in which movement of plants and animals becomes highly concentrated

Climate Corridor with Recognized Biodiversity – a climate corridor with known locations of rare species or unique communities

MN-ND-SD Potentially Resilient Lands Additions – additions of local knowledge about confirmed biodiversity not included in broader analysis

MN-ND-SD High Resilience Land Additions – areas of land with high resilience added to fill in gaps based on local knowledge

MN-ND-SD Climate Flow Additions – additions of local knowledge to fill in known connectivity and ecosystem functionality not captured in broader analysis

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Resilient and Connected Landscapes

The Nature Conservancy

This Story Map highlights climate-resilient sites across the continental US that collectively represent the extraordinary natural diversity of the country. Each of these sites have unique topographies, geologies, and other characteristics that can help withstand climate impacts and keep nature safe in the face of climate change. This Resilient and Connected Network of lands was identified and mapped over a 10-year period by Nature Conservancy scientists using public data available at the state and national scale. More than 150 scientists from agencies, academia and NGOs across the US were involved in this process. If conserved, these "natural highways and neighborhoods" offer a chance of sustaining biological diversity into the future while helping species to move and adapt to a changing climate.

The Resilient and Connected Network is a starting point for conversations with local communities, Indigenous communities, land trusts, agencies, corporations and funders on how we can coordinate our conservation efforts to increase our collective impact and sustain nature. Resilient lands and waters may be conserved by a wide range of measures from good land stewardship, to other forms of private land conservation, to outright fee or easement acquisition by various levels of government.

Network Stats:

- Covers 33% of the continental US

- Encompasses multiple resilient examples of every geophysical habitat

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- Contains over 250,000 known occurrence of significant biodiversity features
- Is configured to facilitate range shifts and migrations by species
- Stores over 3 billion tons of carbon: 56% of all forest carbon in the US
- Is 44% secured against conversion to development

The resilient and connected network map (shown in green below) is composed of three essential ingredients:

Climate Resilient Sites: ecologically representative sites with a diversity of connected microclimates.

Connectivity and Climate Flow: Linkages that allow species to move across sites and climate gradients.

Recognized Biodiversity Value: Places with intact habitats, rare species, or exemplary communities.

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Resilient and Connected Network: What's New?
Minnesota, North Dakota and South Dakota

The **Resilient and Connected Network** (RCN) is a tool developed by The Nature Conservancy and many partners to achieve an ambitious vision for land protection: to *conserve a network of resilient sites and connecting corridors that will sustain North America's natural diversity by allowing species to adapt to climate impacts and thrive.* Here's how the work touches down in Minnesota, North Dakota and South Dakota including what's new and what's next in the development of this tool.

Where do I find data for Minnesota, North Dakota and South Dakota?
A team of Conservancy staff from states within the central US reviewed the RCN tool and augmented the results with local data and knowledge from Minnesota, North Dakota and South Dakota. In addition, the team considered how to implement our work collaboratively within TNC and with partners. Partners can view and download these local augmentations to the RCN, see the links below.

Will there be a Resilient and Connect Network created for freshwater resources?
The current RCN focuses on terrestrial systems and species. However, Conservancy scientists have taken the first step to identify freshwater sites that are likely to provide the best opportunities for biological resiliency in the face of climate change. The good news is that the Conservancy has secured funding and is currently developing the first comprehensive assessment of resilient freshwater networks across the US to complement the terrestrial resilience mapping. The results will allow conservationists to coordinate their efforts and strategies to sustain freshwater diversity that provides essential services for people and nature. In the interim, Conservancy staff in the central US have mapped initial freshwater resilience priorities, see the links below.

Forest Restoration and Resilience Plan for Minnesota
The Conservancy's Forest Team in Minnesota is currently developing a suite of tools to engage natural resource professionals in development of a forest restoration and resilience plan for Minnesota to prioritize forest restoration investment. Combining the RCN with several other data sets and LiDAR-based analyses, the team is working to provide a new mapping approach to identifying priority restoration landscapes and corridors that have the greatest opportunity to secure long-term forest resilience and productivity across all ownerships. These tools can inform efforts to achieve increased return on restoration investment while accelerating on-the-ground restoration in the highest priority areas.

Data Links and Resources

Resilient and Connected Network Online Mapping Tool

Downloadable Data for Resilient and Connected Network with **Minnesota** Augmentations

Downloadable Data for Resilient and Connected Network with **North Dakota** Augmentations

Downloadable Data for Resilient and Connected Network with **South Dakota** Augmentations

Report: Resilient and Connected Landscapes for the Central US. (aka Great Plains) (RCN Analysis)

Report: Resilient Sites for Terrestrial Conservation in the Great Plains (Analysis underlying RCN)

Report: Resilient Sites for Terrestrial Conservation in the Great Lakes and Tallgrass Prairie (Analysis underlying RCN)

Research Article: Estimating Climate Resilience

Research Article: Conserving Nature's Stage

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Plouff Creek was the uppermost Temperance River tributary monitored in the course of this study. The creek enters the Temperance River from the west, draining a remote, wetland-dominated landscape south of Alton Lake. Plouff was monitored just downstream of the Sawbill Trail, and was found to support Brook Trout and Mottled Sculpin, the presence of which indicate good water quality, cold temperatures, and excellent habitat conditions. Likewise, the macroinvertebrate community included several sensitive taxa, including some stenothermic insects (*Isoperla*, *Rhyacophila*, *Heterotrissocladius*). The macroinvertebrate fauna of Plouff Creek appears to be particularly rich in caddisfly taxa; 19 different genera have been recorded from the Sawbill Trail site. Fish and macroinvertebrate IBI scores indicated support for aquatic life, but it should be noted that some sensitive taxa that were present in the late 1990s have not been observed in recent years (e.g., Longnose Dace, *Glossosoma*, *Acroneuria*, *Boyeria*). Beaver activity is prevalent along most of Plouff Creek, and likely is a strong determinant of habitat and temperature conditions, which in turn play an important role in structuring biotic communities.

The upper Temperance River was monitored just west of the Sawbill Trail, near the USFS Temperance River Campground. At this location, the river supports Brook Trout, Slimy Sculpin, and other sensitive fish species. The macroinvertebrate assemblage also indicated excellent water quality, supporting sensitive and stenothermic insects (*Boyeria grafiana*, *Epeorus*, *Glossosoma*, *Chimarra*). Fish and macroinvertebrate IBI scores met exceptional use biocriteria on this highly scenic stretch of the river.

Several miles downstream, Sixmile Creek enters the Temperance River from the east, draining a mostly-undisturbed landscape of wetland and forest. The creek supports Brook Trout and Mottled Sculpin, as well as many sensitive macroinvertebrates (*Chimarra*, *Glossosoma*, *Epeorus*); IBI scores met exceptional use biocriteria. Near the confluence of the two streams, Sixmile Creek is substantially colder than the Temperance River. In addition to contributing cold water to the Temperance, the creek itself likely provides important thermal refugia for trout and other stenothermic organisms when temperatures in the mainstem river reach stressful levels. Cold tributaries like Sixmile Creek are important components of larger rivers' biological integrity, and should be included in protection strategies for these larger systems.

The Temperance River was monitored near the Sixmile Creek confluence, at the Forest Road 166 ("600 Road") crossing. An intensive water chemistry monitoring station indicated excellent water quality; concentrations of nutrients, sediment, dissolved ions, and bacteria were consistently low, with only a few minor exceedances of the pH water quality standard (Table 32). Biological communities also indicated a high-quality resource; FIBI and MIBI scores either met exceptional use biocriteria or rated just below the threshold. Brook Trout, Mottled Sculpin, and Longnose Sucker were present, as were many sensitive macroinvertebrates.

In 2015, fish and macroinvertebrates were monitored at two additional Temperance River sites downstream of Forest Road 166. Data from these biological surveys was not available during the formal assessment process, but support the aquatic life assessment decisions for this reach. Both fish and macroinvertebrate communities indicated good water quality and habitat conditions. Brook Trout were found at both stations, Brown Trout were captured at one station, and Longnose Sucker was captured at one station. Sensitive macroinvertebrates found at both stations included: *Epeorus*, *Glossosoma*, and *Acroneuria*. Macroinvertebrates were also collected farther downstream on the Temperance River, off the Temperance River Road, just before the river begins its steep descent to Lake Superior. MIBI scores at this location were near exceptional use biocriteria, indicating that the excellent water quality documented at upstream locations on the Temperance River is maintained for its entire length.

Heartbreak Creek was monitored at Forest Road 166, west of the Temperance River and several miles upstream of the creek's confluence. This station is monitored every other year as part of MPCA's long-term biological monitoring program. The creek drains a minimally-disturbed landscape of forest and wetlands, and appears to be one of the coldest streams in the Lake Superior – North Watershed; during

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One of the principal concerns identified by County SWCDs for the Lake Superior North – Watershed is groundwater protection, for both quality and quantity. Groundwater withdrawals have increased nearly 30% over the last 20 years, partly due to the rising demand for water supply for private consumption and recreational water related needs. It is estimated that the development pressure is moderate in some parts of the watershed where land is converted from timberland, resorts and lakeshore into home and recreation development (USDA-NRCS). This increase in recreational development can be seen with a significant increase (p=0.001) from 1994 to 2013 in non-crop irrigation for golf courses and special categories. At this time, aquifer drawdown is now a concern; however, if water usage and land use conversion continue to increase, the probability of the water table being drawn downwards also increases. It is for this reason that the MNDNR monitors and takes precautions when permitting water use appropriations.

Groundwater quality is based on the sensitivity of the aquifers and the effects of naturally occurring and anthropogenic influences for constituents found in the water. Special consideration should be practiced in areas of high groundwater contamination susceptibility, which are sparsely located throughout the watershed. Overall, the groundwater quality of the watershed appears to be healthy, despite some exceedances of constituents, including arsenic. However, the primary source of contamination for this watershed is geology. Additional and continued monitoring will increase the understanding of the health of the watershed and its groundwater resources and aid in identifying the extent of the issues present and risk associated. Increased localized monitoring efforts will help accurately define the risks and extent of any issues within the watershed. Adoption of BMPs will benefit both surface and groundwater.

While land management, riparian and shoreland development, and road-stream intersections may represent acute threats to aquatic health in the Lake Superior – North Watershed, longer-term and more nebulous threats may be posed by climate change, and the interaction of climate change with other stressors. Many of the watershed's streams support sensitive, stenothermic organisms that depend on perennial, coldwater streams carrying low concentrations of sediment and nutrients. These habitat and water quality conditions are the result of interacting factors of climate, hydrogeology, and land cover, and may be degraded by changes in any of these factors. Predictive models incorporating climate and land use changes suggest that aquatic resources of the Lake Superior – North Watershed are likely to experience higher temperatures, reduced dissolved oxygen, increased erosion, and other associated stress in the near future (Johnson et al. 2013, Herb et al. 2014). These changes are likely to have negative effects on the health of aquatic systems, though planning and BMP implementation may mitigate some impacts. For example, understanding the importance of small, cold tributaries to the ecological integrity of larger river systems may be of critical importance in protection planning efforts. Tributaries often spawning and nursery habitat for trout and other fishes, and may serve as critical refugia for fish and other aquatic organisms during periods of thermal stress. A watershed-based focus that recognizes the connection between landscapes, riverscapes, and the condition of aquatic resources will be essential to protection and restoration efforts.

In general, aquatic habitats in the Lake Superior – North Watershed are in very good condition; streams, lakes, and wetlands rank among the highest-quality in the state, and some represent near-reference quality examples at a national scale. Stream biological monitoring surveys suggest that sensitive indicator taxa are widespread and abundant, and several rare species of fish and macroinvertebrates were observed. Many streams were designated as exceptional aquatic resources, which should provide a higher level of protection from degradation. From a protection and restoration standpoint, the watershed possesses several favorable characteristics. A relatively high proportion of its lands are already under some form of protective management (e.g., state parks, federal wilderness designation, AMAs), and much of the remainder is administered by public agencies charged with incorporating water quality considerations in their management and planning efforts. The watershed's aquatic resources are

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DEPARTMENT OF NATURAL RESOURCES

Border to Border Touring Route
Project Summary

Project Administration: Minnesota Department of Natural Resources (MnDNR), Parks and Trails Division

Proposer: MnDNR and the Minnesota Four Wheel Drive Association (Mn4WDA)

Contractor: National Off-Highway Vehicle Conservation Council (NOHVCC, 2017-2019)

Project Users: High clearance highway licensed vehicles (HLV)

Partners: Lake County, Itasca County, St. Louis County, Beltrami County, Lake of the Woods County, Marshall County, Kittson County, Pennington County, Minnesota Department of Transportation (MnDOT), MnDNR, US Forest Service (USFS, Chippewa and Superior National Forests), French Township, Mn4WDA and NOHVCC.

Touring Route Location: Minnesota Counties: Lake, St. Louis, Itasca, Beltrami, Lake of the Woods, Marshall, Pennington and Kittson. See Appendix A for Township, Range and Section descriptions.

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Project miles by road authority:

Total mileage of the proposed Border to Border Touring Route is approximately 764.6 miles, including:

Road Authority	Approx. Miles	Roads
MnDOT	106.9	US 59, MN 6, MN 11, US 75, MN 65, MN 169, MN 72,MN 38, MN 1, MN 171, US 53, MN 46, MN 219,MN 175, MN 135
MnDNR Forestry	62.1	0146A, 0137, 0848, 0335, 0146, 0149, 0268, 0155, 0212, 0060
USFS-Chippewa National Forest (CNF) Blackduck RD	16.0	FR 2203, FR 2429,FR 2199
USFS-CNF Deer River RD	20.7	FR 3979, FR 2182, FR 2180, FR 2423, FR 2187, FR 3141, FR 2171
USFS-Superior National Forest (SNF) Laurentian RD	38.3	FR 533, FR 534, FR 256, FR 274, FR 257, FR 113, FR 120
USFS-SNF Kawishwi RD	37.1	FR 383, FR 377, FR 386, FR 1491, FR 113, FR 112
USFS-SNF Tofte RD	46.9	FR 172, FR 369, FR 174, FR 174R, FR 380, FR 369, FR 173, FR 377, FR 373
Lake County	36.8	CSAH 15, CR 4, CR 7, CSAH 5, CR 31, CR7
St. Louis County	77.3	CSAH 68, CR 473, CSAH 21, CR 65, UT 3182, CR 379, CR 303, CR 302, CR 730, CSAH 100, CR 405, CSAH 25, CR 416, CR 569, CSAH 5, CR 652, CR 138, CSAH 70, CSAH 110
Itasca County	89.5	CSAH 7, CR 578, CR 583,CR 126,CR 554,CR 254, CSAH 33,CSAH 52, CSAH 14, CR 527, CR 341, CR 546, CR 348, CR 345, CR 145, CSAH 29, CR 163, CR 340, CSAH 53,
Beltrami County	79.1	CR 82, CSAH 47, CSAH 30, CR 44, CSAH 32, CR 111, CR 311, CR 709, CR 328, CR 704, CR 37, CR 710, CSAH 23

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Road Authority	Approx. Miles	Roads
Lake of the Woods County	6.0	CR 77
Marshall County	61.2	CSAH 2, CR 39, CR 155, CR 30, CSAH 4, CR 37, CSAH 1, CSAH 26, CR 107, CR 128, CR 14, CR 38, CR 89, CR 114, CSAH 5, CSAH 27, CR 11, CR 54
Pennington County	34.4	CR 31, CR 67, CR 80, CR 81, CR 20, CR 73, CR 62, CR 65, CR 69, CR 68, CR 24, CR 63, CR 61
Kittson County	50.3	CSAH 5, CSAH 14, CSAH 28, CSAH 10, CSAH 22, CSAH 16, CSAH 14, CSAH 12
French Township	2.0	Snake Trail 1213, Dean Forest Road 1274
Total Miles	**764.6**	

Project Description:

The proposed Border to Border Touring Route (B2B) will be a route identified on existing roads intended for use by highway licensed vehicles. The route will provide a rustic experience primarily on low volume, unpaved roads across Northern Minnesota. Wisconsin and North Dakota have successfully developed similar routes and the project's goal is to facilitate a comparable opportunity for people to explore approximately 765 miles from Lake Superior to North Dakota.

The project was conceived by the Minnesota 4-Wheel Drive Association (Mn4WDA), and was made possible by legislation providing direction and funding in 2015[1]. Mn4WDA is a citizen-led, non-profit organization dedicated to creating new recreational opportunities for off-road vehicles (ORV) and educating the public about safe and sustainable motorized recreation.

- The route will consist entirely of roads currently open for public use, including state and national forest roads as well as township, county and state roads. Many of these roads feature gravel or natural surfaces.
- Maps, signs or other roadside markers will indicate the route.
- Only highway-licensed vehicles currently allowed on these roads will be able to travel the Border to Border Touring Route, and the route will not displace or change current uses of these roads.
- The Off-Road Vehicle account in Minnesota's Natural Resources Fund will support planning, mapping, visitor information and signing for this project. Revenues for this fund come from fees paid by off-road vehicle owners.

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[1] *Minnesota Laws 2015, 1st Special Session, Ch. 4, Section 3, Subdivision 5.*

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Intended touring route users

- The route will be intended for drivers of vehicles currently licensed through the Department of Public Safety, Driver and Vehicle Services (DVS). No other registration or license or pass is required. Vehicles must meet state and federal requirements and standards for road use. This includes meeting thresholds for overall noise emissions, per Minnesota Rules Part 7030.
- The route will responsibly direct people who want to visit northern Minnesota and drive backroads.
- The route will be promoted for a seasonal period, typically May or when spring road restrictions are lifted to November. Some segments of the route follows routes that are groomed snowmobile trails (and thus closed to motor vehicles when groomed) during the winter season. The route will not change normal road seasons or restrictions.

The Border to Border Touring Route will minimize asphalt for drivers and follow mostly dirt and gravel roads already open to highway licensed vehicles. No additional registration, license or pass is required to travel this route. The route is not expected to cause any change in land use within the vicinity of the route and no construction will be required. Visitors using the MN Border to Border Touring Route may generate increased traffic to rural/remote segments, but it is not expected to increase significantly. The daily increase is unknown and will be assessed once the route is in place. Forecast travel demand and roadway capacity will be monitored. Being part of the touring route will not supplant or replace any existing uses. This route is not being planned for all-terrain vehicles (ATVs), off-highway motorcycles (OHMs) or non-licensed off-road vehicles (ORVs); rather the proposed route is being designed for Department of Motor Vehicle (DMV) high clearance HLVs. However, road segments currently open to snowmobiles in the winter or ATVs now will not change as a result of this project.

Planning, public participate and review

The DNR, Mn4WDA and NOHVCC held 18 listening sessions from 2017 to 2019 to help develop a draft alignment. During the listening sessions and comment periods, 251 comments were received. Listening session details can be found in Appendix B. Local road managers and road authorities were involved in the selection of the roads and locations, and proposed segments have been reviewed by interdisciplinary DNR field staff. The touring route proposal was developed based on information from the listening session meetings, county township association meetings, county board meetings and input from townships as the proposed road alignment was developed.

Permits and approvals needed

The US Forest Service has informed DNR that an internal review and public input process will be completed subsequent to the findings of DNR's review. While that review is being conducted the project team will begin working on agreements and implementation planning with local road authorities, DNR Forestry and MnDOT.

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Development and maintenance

Maps and route signs will be provided by DNR as part of the touring route. Aside from the instillation of signs, the DNR does not anticipate any new construction as a result of the touring route. Careful consideration during the planning phase identified existing roads with sufficient infrastructure that do not need any immediate improvements. Generally, county highways and state forest system roads receive a higher level of maintenance. Township roads and state forest minimum maintenance roads receive less maintenance. US Forest Service roads receive maintenance according to their development level. In 2019, the Minnesota Legislature appropriated $200,000 from the ORV account to be used for maintenance along the route specifically related to maintenance needs stemming from the touring route use.

- Legislation passed in 2019 established a maintenance fund dedicated from the Off-Road Vehicle account. $200,000 was appropriated.
- The purpose would be to allow local road authorities to apply for funds if they see significant increases in ongoing maintenance needs associated with the Border to Border Touring Route.
- This funding was in direct response to listening sessions where we heard that counties and townships were concerned about possible significant increased costs associated with maintenance needs.
- Given that the route is already open to highway-licensed vehicles, there may be no additional maintenance needs. If an issue develops this legislation will allow us to work together to ensure a successful route.

Enforcement

Minnesota vehicle laws will be enforced by county sheriff deputies and DNR conservation officers along the route. The DNR Division of Enforcement plans to provide additional conservation officer time along the route during the first year of operation and as needed after that.

Legislation

Original legislation: 89th Legislature, 2015, 1st Special Session, Chapter 4, Article 3 Environment and Natural Resources Appropriations, section 3 Natural Resources, subdivision 5

Maintenance fund: 91st Legislature, 2019, 1st Special Session, Chapter 4, Article 1 Environment and Natural Resources Appropriations, section 3 Natural Resources, subdivision 5

Doc 101 430F

DNR Proposal-Border to Border Touring Route

Description

The Minnesota Department of Natural Resources (DNR) proposes to designate a scenic touring route for highway licensed vehicles (HLVs) stretching from Lake Superior near Silver Bay, MN to the North Dakota border near Pembina, ND, for approximately 765 miles. The touring route will follow existing county, state and Federal forest roads, township roads, county roads/state aid highways and state highways. Only HLVs currently allowed on these roads will be able to travel the Border to Border Touring Route, and the route will not displace or change current uses of these roads. Aside from the installation of signs, the DNR does not anticipate any new construction along the route. In 2019, the Minnesota Legislature appropriated $200,000 from the ORV account to be used for maintenance along the route specifically related to maintenance needs stemming from the touring route use. Future maintenance needs are unknown at this time.

Comparison to Mandatory Categories

MR 4410.4300 Subp. 37 - Recreational Trails	***Mandatory EAW?***	**Proposed Project**
A. New trail ≥ 25 miles for use other than snowmobile or x-country ski on forested or naturally vegetated land	No	The touring route is not considered a trail and will follow existing roads. No new construction is planned.
B. New use ≥ 25 miles – designated for a new motorized use that expands the treadway other than snowmobile	No	The touring route will be open to HLVs only. The entire route is currently open to HLVs. No expansion or road right-of-ways or surface/treadway widths are proposed.
C. New paving ≥ 10 miles of existing unpaved	No	The proposed route will not consist of new paving.

MR 4410.4300 - Other potential categories:	***Mandatory EAW?***	**Proposed Project**
Subp. 1 – Threshold test	No	The DNR has not completed any touring routes within the last three years and the proposal is not and extension or an expansion of an existing touring route.
Subp. 22 – Highways	No	Proposed project is not a highway project, no road expansions, no new lanes or road developments are proposed.
Subp. 24 – Water appropriation	No	No water will be appropriated
Subp. 26 – Stream diversion	No	The proposed route crosses several designated trout streams, however the route will utilize existing roads, bridges and culverts to avoid new impacts to streams. No diversions, realignments or channelization of any stream is proposed. Future maintenance needs are unknown at this time. If future maintenance may impact a stream crossing, any necessary environmental review and permitting will be completed at that time.
Subp. 27 – Wetlands and public waters	No	The route will utilize existing roads in wetland area. No new impacts to wetlands are anticipated during project implementation. Future maintenance needs are unknown at this time. If it appears future maintenance may

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MR 4410.4300 - Other potential categories:	*Mandatory EAW?*	Proposed Project
		have an impact on wetlands or public waters, any necessary environmental review or WCA requirements will be fulfilled at that time.
Subp. 28 – Forestry	No	No timber will be harvested for the route.
Subp. 30 – Natural areas	No	The touring route will follow existing MNDOT highways within the statutory boundaries of Lake Vermillion-Soudan Underground Mine State Park and the Red Lake Peatland SNA. The touring route will also follow a county highway through Lake Bronson State Park. The touring route will be limited to these existing roads and will only be open to vehicles that are currently permitted to use the roads. Signage within these natural areas will be consistent with the management plan for the sites. Parks and Trails staff have consulted site managers and the proposed route remains consistent with all applicable management plans.
Subp. 31 - Historic Places	No	No historical places or properties will be impacted by the proposed project.
Subp. 36 – Land Conversions in Shoreland	No	No permanent land conversions in shorelands will result from this project.

Comparison to Exemptions

4410.4600 – Exemptions	*Exempt?*	**Proposed Project**
Subp. 2 A – No approvals	No	Final DNR approval required.
Subp. 2 B – All decisions made	No	Final decisions have not been made.
Subp. 2 C – Permit denied	No	No permits have been denied.
Subp. 2 D – Project substantially complete	No	Project not yet started.
Subp. 2 E – Environmental Review completed	No	Environmental Review has not been completed.
Subp. 27 A – Rerouting < 1 continuous mile for safety or environmental sensitivity concerns.	No	Project is not a reroute.
Subp. 27 B – Reconstruction, rehab, etc. of existing trail, no change in use	No	Although the touring route will follow existing roads with no change in use, the project is not considered reconstruction or rehab of an existing trail.
Subp. 27 C,D,E – winter only use	No	Project is not winter use only,
Subp. 27 F – non-motorized, Twin Cities Metro	No	Project is motorized, outside the Twin Cities Metro.
Subp. 27 H – New motorized use to an existing motorized trail or trail segment located only on an abandoned railroad grade	No	Project will not be located only on an abandoned railroad grade.

INVERTEBRATE CONSERVATION GUIDELINES

Pollinators and Roadsides

Managing Roadsides for Bees and Butterflies

Roadsides in the U.S. cover more than 10 million acres of land.

Managing roadsides for bees and butterflies will create high quality habitat for wildlife of all types.

Pollinator habitat along roadsides supports the pollination needs of adjacent farms and natural areas.

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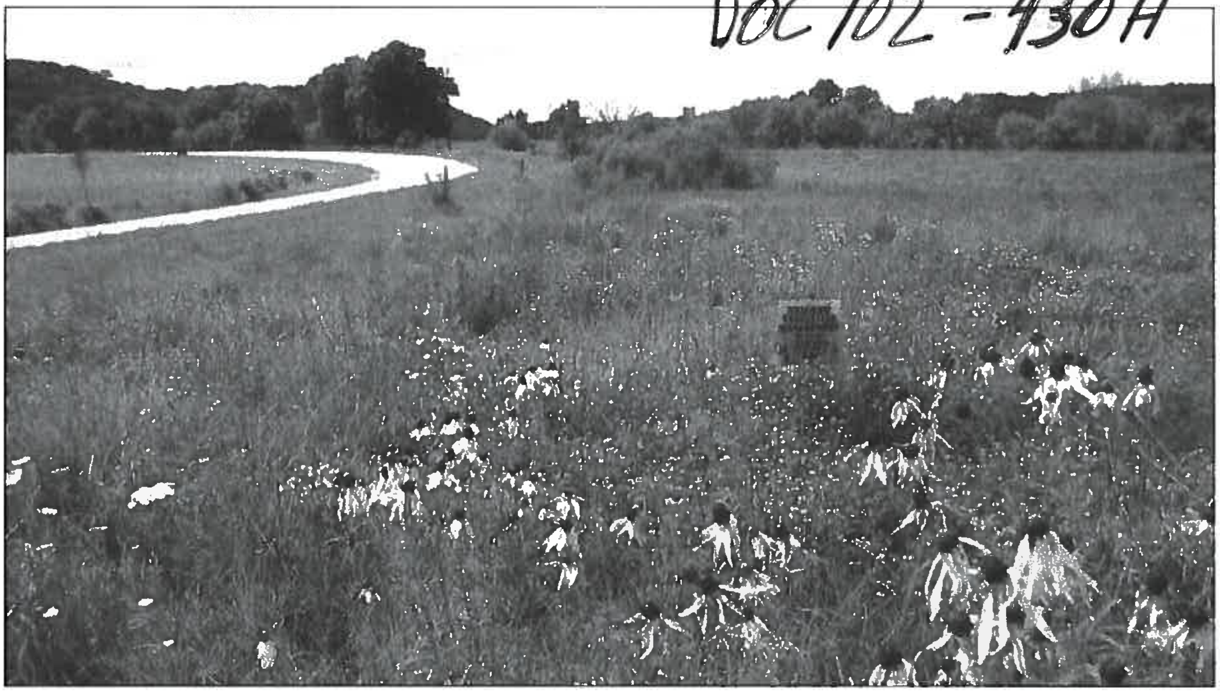

Photograph by Mara Urice, Iowa Living Roadway Trust Fund

Supporting a diverse community of wildflowers, this roadside in Iowa is an Integrated Roadside Vegetation Management site.

Roadsides cover more than 10 million acres of land in the United States (Forman et al. 2003), and in some states, they are the largest holdings of public land. Roadsides offer valuable habitat because they are typically set aside from further development and because they stretch across the landscape, connecting remnant habitat patches and creating a linear refuge for wildlife. This is particularly true in agricultural regions, urban areas, and other highly modified landscapes, where roadsides may be the only semi-natural habitat remaining. With four acres of open space in the United States lost to development every minute (U.S. Forest Service 2006), roadsides are too important to be neglected in conservation planning.

The abundance and diversity of insects and other invertebrates are key building blocks of the wildlife value of a site. They are a food source for birds, mammals, and other vertebrates and the services they provide maintain habitats on which these other animals rely. One such "ecosystem service" is pollination, a service that is central to the health of our environment. It is primarily provided by insects. Beetles, flies, wasps, moths, and butterflies all contribute to pollination but bees are considered to be the most important group of pollinators.

Managing roadsides to support pollinators brings benefits for both local natural areas and adjacent farms. One of the key considerations is the presence of native plants. Roadsides with a rich diversity of native plants support more pollinators. Incorporating native plants into roadside management strategies will not only make these areas better for wildlife, but it can also promote motorist safety, reduce maintenance costs, and improve roadside aesthetics.

Importance of Pollinators

An estimated 60 to 80 percent of the world's quarter of a million species of flowering plants depend on animals—mostly insects—for pollination (Kremen et al. 2007). Focusing on agriculture, eighty-seven of the world's 124 most commonly cultivated crops are animal pollinated, and insect-pollinated forage plants such as alfalfa and clover provide feed for livestock. Roughly 35 percent of global crop production is dependent on pollination by animals (Klein et al. 2006). Pollinators also sustain the wildland plant communi-

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ties that provide food and shelter for myriad other wildlife. Plant pollination by insects is essential to human health, global food webs, and protection of biodiversity. Pollinating insects are at the heart of a healthy environment.

Studies in multiple parts of the world give cause for concern about declining pollinator populations. In the United States, the National Research Council (2007) reported noteworthy losses of both managed and wild pollinators. Habitat loss, pesticide use, diseases, parasites, and the spread of invasive species were all cited as major causes of these declines. In Europe, parallel declines of pollinator and flowering plant diversity have been documented in both Great Britain and the Netherlands (Biesmeijer et al. 2006). Threats to pollinator communities affect not only pollinators themselves but also natural ecosystems and agricultural productivity.

In landscapes substantially altered by urbanization or agriculture, roadsides, hedgerows, and field edges can be particularly important for wildlife. These areas provide pollinators with places to forage for food and to nest, while also helping to link fragmented habitats.

Roadsides as Habitat

Roadsides have value as habitat for birds (Adams 1984), small mammals (Camp and Best 1994), amphibians and reptiles (Way 1977), and ants and beetles (Keals and Majer 1991; Vermeulen 1993). They also provide refuge for pollinators by supporting a diversity of wildflowers that provides nectar or pollen for all pollinators, as well as grasses and forbs that serve as caterpillar hostplants for butterflies and moths. In some cases, roadsides support plant communities that can no longer be found elsewhere (Forman et al. 2003; Noordijk et al. 2009). Roadsides offer nesting sites for bees, particularly ground-nesting bees because the soil is undisturbed compared to agricultural fields (Delaplane and Mayer 2000). Additionally, roadsides are protected from further development and promote connectivity between habitat fragments (Forman et al. 2003).

Natural History of Pollinators

In North America, most pollinators are insects: bees, flies, beetles, wasps, moths, and butterflies. Hummingbirds also pollinate some flowers, as do a couple of species of bats and a dove in the desert southwest. Pollinating insects have two basic habitat requirements: a source of food and a place to lay their eggs. Understanding which features in the landscape provide these resources is essential to maintaining or enhancing habitat for pollinators.

Bees and other pollinators are an essential component of any terrestrial ecosystem. Their basic habitat needs—flowers for nectar and pollen and a place to nest—can be successfully provided for on roadsides. Photograph by Eric Mader.

Nectar and Pollen Sources

Most flowers offer sugary nectar or nutritious pollen to attract floral visitors. The majority of flower visitors feed while at the flower. Bees are unusual because they provision nests for their offspring, so they not only feed but also gather and transport pollen, the major reason why they are particularly efficient and important pollinators. Pollinator habitat should have a diversity of flowers that bloom at different times to sustain a diverse group of pollinators throughout the growing season.

Sites for Nesting or Egg-Laying

Pollinating insects require a place to nest or to lay their eggs. Butterflies and moths generally lay their eggs on or next to the hostplant upon which their caterpillars will feed. In contrast, bees create a nest in which they construct and supply a series of brood cells. Nearly 70 percent of bee species nest underground, digging slender tunnels off which they excavate brood cells for their eggs. Most other bees choose to nest in wood tunnels, occupying existing holes in snags or chewing into the pithy center of stems, in which they create a linear series of partitioned cells. Some bees use materials such as mud, resin, leaf pieces, or flower petals to form the partitions (Linsley 1958). Bumble bees are social bees, forming their annual colony in a small cavity such as an abandoned mouse nest. Pollinator habitat should include a range of nesting substrates and materials to provide for the differing nesting requirements of pollinators.

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Native Plants and Roadside Management

While roadside management in the United States differs from state to state, the primary goals remain the same: motorist safety, noxious weed prevention, and soil stabilization. In recent years, many states have incorporated native grasses and wildflowers into rights-of-way to achieve these objectives. Often, techniques already in use can make a difference in the conservation of pollinators.

Integrated Roadside Vegetation Management (IRVM) combines the planting of native vegetation with site-appropriate strategies to achieve cost-effective and more environmentally sustainable management of roadsides. As an alternative to intensive mowing and blanket pesticide spraying of roadsides, IVRM offers several significant advantages.

- Native grasses and flowers are best adapted to local conditions, and are able to tolerate drought or heat.
- An established diverse plant community provides the most stable cover for reducing soil erosion and keeping out weeds. For example, tallgrass prairie restoration can limit the invasion of noxious weeds, due to strong root development (Blumenthal et al. 2005).
- Native plants offer improved weed and soil erosion control, reducing the need to mow or to spray herbicides, and consequently also the costs.
- Native plants are less likely to encroach on land bordering rights-of-way, a common complaint about non-natives such as crownvetch (*Securigera varia*) and sericea lespedeza (*Lespedeza cuneata*).
- Native plant communities will reduce runoff in the spring and act as snow fences in the winter, trapping and preventing snow from blowing across roads.
- Native plantings are aesthetically pleasing. Native flowers and mowing regimes that limit mowing to a single swath along the road were found to be the most attractive to drivers in Minnesota (Dan Gullickson, Minnesota DOT, pers. comm.).
- Native plantings may offer educational opportunities, as they demonstrate how the wider landscape once looked.
- Native plant communities support more native wildlife than nonnative plant communities.

Native plants offer several advantages for roadside management, such as erosion control and reducing the need to use herbicides, as well as improved habitat. Photograph by Kirk Henderson.

Benefits of Roadside Plantings to Pollinators

Seeding roadsides with native vegetation often increases the diversity of plants in the local area (Muguira and Thomas 1992; Forman et al. 2003) and may provide more abundant pollen and nectar sources compared to adjacent areas. Combined with the reduced need for pesticide spraying to control weeds when using native plantings, native roadsides offer a haven to pollinators and other wildlife.

Flowers

Research demonstrates the benefits to pollinators of having native wildflowers on roadsides. Working in Kansas, Hopwood (2008) found bees to be twice as abundant on roadsides supporting native plants compared with those dominated by nonnative grass and flowers; native roadsides also supported about 35 percent more bee species. Ries et al. (2001) compared butterflies on native prairie roadsides in Iowa with those on grassy or weedy roadsides. This work showed that habitat-sensitive butterfly species such as the regal fritillary (*Speyeria idalia*) and Delaware skipper (*Anatrytone logan*) were significantly more common in prairie roadsides. In Minnesota, butterflies were most abundant in filter strips between cropland and streams that were planted with tall and dense vegetation (Reeder et al. 2005).

These findings are supported by European studies. In Finland, the number of butterflies on roadsides was most influenced by the abundance of nectar producing plants, while moths were most abundant in areas with tall vegetation (Saarinen et al. 2005). In Britain, work by Munguira

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and Thomas (1992) suggests that planting roadsides with native plants would increase the already high diversity of butterflies on roadsides.

Nest Sites

Many bees prefer to nest in sunny, bare patches of soil (Linsley 1958), like those found around the base of native bunch grasses such as big bluestem (*Andropogon gerardii*) and Indiangrass (*Sorghastrum nutans*). The research by Hopwood (2008) in Kansas found that ground-nesting bees were more common in roadsides with native plantings. Roadsides with a tight sod of brome or other nonnative cool season grasses, in contrast, had fewer ground-nesting bees. Many bumble bees nest underneath grass clumps (Svensson et al. 2000). In Britain, roadsides have been identified as providing breeding habitat for 8 of the country's 17 species of bumble bees, as well as 25 of its 60 butterfly species (Way 1977).

Landscape Linkages

Given their linear structure, roadsides may serve as corridors for pollinators and other wildlife. In Iowa, Ries et al. (2001) found that habitat-sensitive butterflies were much less likely to leave a roadside planted with native vegetation, suggesting that for some butterflies, roadside restorations could serve as protective corridors through which pollinators could move in highly modified landscapes. For example, roadsides could become corridors for breeding monarch butterflies returning north from their overwintering grounds, because their caterpillars feed exclusively on milkweeds (*Asclepias*), which grow readily in roadsides and are sometimes included in reseeding mixes. These same roadsides can also be nectar corridors for monarchs making the long trip south in the fall.

Stretching across landscapes that are generally inhospitable to wildlife, roadsides link other habitats and provide food for pollinators, including migrating monarchs. Photograph by Kirk Henderson.

Roadside Habitat Creation and Maintenance

With so many acres of land in roadsides and the obvious value of these lands for wildlife, it is clear that roadsides can be of great benefit to pollinators. Plant communities can be enhanced with native species and maintenance methods and schedules can be altered to reduce negative impacts. The principal considerations are the diversity of native plants, the availability of bee nest sites, the impact of mowing, and pesticide use.

Increasing Flower Diversity

As noted above, a diverse plant community will support a wider range of pollinator insects. When planning a project, determine the grasses and wildflowers best suited to the climate, soil type, and location of the site. With native prairie plantings, it is often tempting to increase the proportion of grass in the seed mix to keep costs down. However, Dickson and Busby (2009) demonstrated that reducing the density of grass seeds increases forb establishment. Seed mixes for roadside restorations should include flowers with differing but overlapping bloom times, to provide pollinators with continuous floral resources. A rule of thumb is that a planting mix should contain at least three species that bloom in each season from spring to fall.

Planting a range of wildflowers of varying colors and shapes will benefit more pollinator species. Bees do not easily see red objects, so mainly visit blue, white, yellow, and purple flowers. Of the other flower-visiting insects, butterflies tend to visit orange, red, yellow and purple species, and hover flies go to flowers of white and yellow. Hummingbirds, the only non-insect pollinators in most of North America, are drawn to red flowers in particular. Floral shape also influences which pollinators visit which flow-

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ers; the various body sizes and tongue lengths of pollinators are adapted to certain sizes and shapes of bloom.

Many perennial flower species take several years to establish and begin to bloom, so consider including annuals in seed mixes. Annuals rapidly establish and offer pollinators nectar and pollen right away, while helping to block weeds during establishment of longer-lived species.

Providing Nest Sites

Bees that nest in the ground often prefer to dig their nests in patches of exposed earth, and while some species prefer sunny exposed slopes, others prefer level ground (Linsley 1958). Roadsides with trenches or ditches may provide more diverse locations for ground nesters. Native bunch grasses will stabilize ground while offering nesting resources to native bees: patches of bare earth for ground-nesting bees, and clumps under which bumble bees may nest. To encourage wood tunnel nesting bees within roadsides, consider leaving patches of native shrubs in areas furthest from the road itself.

While butterflies do not build nests, they do require the correct plants for their caterpillars to eat. In addition, they often overwinter in leaf litter or under dead vegetation, which should be left where possible.

Reducing the Impact of Mowing

Mowing of roadside vegetation generally has three aims: to improve driver visibility, to provide room for a vehicle to pull off the road if needed, and to prevent encroachment of brush or trees. There is no need to mow the entire roadside to achieve these objectives, even if tall grasses are present: it is only necessary to mow the portion of the road next to the shoulder, and any other areas required for safety. Planting native grasses and forbs in rights-of-way should reduce but not eliminate the need to mow, and determining appropriate times to mow may be a balancing act. Both the time of year to mow and the frequency of mowing have ecological consequences.

Well-timed mowing may improve species diversity of prairie roadsides. While mowing several times during the first growing season of a planting project can control noxious weeds and help native plants establish, frequent mowing in subsequent years reduces native plant growth and the ability of forbs to compete with grasses. For example, excessive mowing may have led to a decrease in flowers and a subsequent decrease in bumble bees in Belgium (Rasmont et al. 2006). Research in the Netherlands found that mowing roadsides twice a year, early and late in the growing season, resulted in the highest plant diversity (Forman et al. 2003) and was most beneficial for flower visiting insects (Noordijk et al. 2009). Collins et al. (1998) showed that in the U.S. Midwest mowing once a year in July knocked back dominant grasses and promoted wildflower growth. However, mowing at such a time will limit the growth of any fall wildflowers, such as asters and sunflowers, which are not only important forage sources for generalist insects but are also flowers which some specialist bees preferentially visit and are dependent upon. Mowing once a year in late autumn, when pollinators are not flying, or mowing every few years, may have the least impact on pollinators.

Pollinators are not the only wildlife vulnerable to the effects of mowing. Some Departments of Transportation

Mowing only a narrow road-edge strip can meet safety requirements and leave plenty of habitat. Photograph by Carl Kurtz

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(DOTs) have found ways to adapt mowing to accommodate wildlife while managing roadsides effectively, including:

- Minnesota DOT permits the first eight feet from the shoulder or road be mown on a regular basis, but the entire right-of-way may only be mown after August 1, in order to protect nesting birds.
- The state of Wisconsin works with state and federal agencies to protect roadside habitat of the federally endangered Karner Blue butterfly (*Plebejus melissa samuelis*). Lupine (*Lupinus perennis*) is the hostplant for Karner blue caterpillars and is common along roadsides. To prevent mowing of populations of these plants, Wisconsin DOT marks populations, allowing both lupine and the butterflies to persist (Forman et al. 2003).

Highway safety and good habitat are not mutually exclusive. Ultimately, roadside managers should develop a mowing policy that addresses the safety concerns of their area and the practicality of maintenance, while also considering potential benefits to the plants and animals.

Avoid Using Pesticides

Pesticides can kill bees, butterflies, and other pollinating insects. The impact of pesticides on pollinators can be lethal or nonlethal, fast–acting or delayed, limited to insects in the area sprayed or—as with bees—transferred to offspring in the nest.

Foraging pollinators are poisoned by pesticides when they absorb the toxins through the outer "skin" that forms their exoskeleton, drink toxin–tainted nectar, or gather pesticide–covered pollen or micro–encapsulated pesticides. Lower doses of pesticides may not kill pollinators but can affect their behavior. Bees that are exposed while foraging may have trouble navigating their way back to the nest, or they may simply be unable to fly. Sublethal doses—such as those that result from toxins brought into a nest along with nectar and pollen—may reduce egg–laying or stall the larval growth.

Wherever possible, avoid using pesticides. Where their use is unavoidable:

- Use a formulation that will offer the least threat (liquids are better than dusts) and apply in the lowest concentration possible.
- Avoid micro–encapsulated products: bees mistake it for pollen and will collect it to take back to the nest.
- Spot treat invasive plants to avoid killing non-target species. Avoid broadcast applications, which may destroy large numbers of beneficial plants.
- Choose equipment such as hand sprayers, which will minimize drift onto adjacent plants that may be in bloom—and therefore attracting bees and butterflies—even when flowers in the treatment area are not.
- Apply pesticides only when pollinators are inactive, such as at night or during those seasons when there are no flowers.

Traffic and Wildlife

For many roadside managers, the biggest concern about the presence of taller vegetation along roads is that it will increase the number of accidents involving deer. Although there has not been a study that specifically examines the relationship between tall, roadside native grasses and deer collisions, evidence from other studies indicates that the presence of tall vegetation does not increase deer-related collisions. Indiana DOT planted shrubs along roadsides, monitored mammal and bird mortality over a year, and concluded that there was no significant difference in road kill between planted and non-planted roadsides (Roach and Kirkpatrick 1985). Also, because deer often preferentially eat tender new growth of vegetation over tough older growth, allowing native plants to grow without frequent mowing may encourage fewer deer to browse in roadsides (Bonnie Harper-Lore, FHA, pers. comm.). It has also been suggested that taller grasses can provide a more secure place for deer to hide, reducing their need to bolt, and thus the chances of deer accidents (Joy Williams, Iowa DOT, pers. comm.).

Movement is fundamental to an animal's life, and roads can be barriers to animals moving between habitats. The degree to which roads are restrictive to animals appears to vary greatly between species (Bennett 1991). Although literature describing possible barrier effects of roads focuses primarily on mammals, it is likely that responses of insects to roads are also highly variable. Strong fliers are less likely to be isolated, and some insects are more vulnerable to traffic mortality than others. That pollinating insects die as a result of collisions with passing vehicles is certain, but studies of the impacts of roads on flying insects are few.

An inventory of dead Lepidoptera along roads in Illinois found that observed mortality was highest on roads with an intermediate level of traffic, with lowest mortality at the highest and lowest traffic levels (McKenna et al. 2001). In Iowa, research found that more butterflies were killed on roads that had predominately grassy roadsides than on roads flanked by prairie vegetation (Ries et al. 2001). In studying butterfly diversity, mortality, and movement within roadsides, Munguira and Thomas (1992) concluded that roads could not be considered barriers to the movement of the butterflies they observed. Between 0.6 and

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7% of butterfly species were killed by vehicles, figures that the authors considered to be small compared to mortality due to natural factors. There is no correlation between the amount of traffic on nearby roads and numbers of butterflies (Munguira and Thomas 1992) or with bee richness or abundance (Hopwood 2008) in roadside habitats. Such research suggests that the benefit from roadside native habitat outweighs the hazard from passing vehicles.

Balancing the Costs and Benefits

Native grass and wildflower seed does cost more per acre than typical turfgrass seed. Seeds of certain species with a limited distribution may be particularly expensive. One way to reduce costs is to harvest seeds from established stands of grasses or wildflowers. Limited amounts of seed can be harvested in the fall by hand, with the help of volunteers, or sometimes through the use of farming equipment. Another advantage of collecting seed locally is that local ecotypes may be well adapted to the area.

Even with the higher costs of seeds and planting, managing roadsides with native vegetation may ultimately be more cost effective. Management of powerline rights-of-way through native plantings along with selective use of herbicides and manual removal of woody plants, rather than repeated mowing and blanket herbicide use, reduces maintenance costs (Russell et al. 2005). Roadsides planted with native grasses and forbs should, after establishment, have less erosion as well as reduced need for mowing and spraying of herbicides, which may provide savings (Steven Holland, Iowa DOT, pers. comm.). In 1987, Massachusetts' Department of Public Works spent about $330 per acre to mow roadside turf six times; for every acre managed instead as wildflowers, nearly $280 could be saved by a reduction in mowing (Platt et al. 1994). Reduced storm water flow and reduced blowing snow due to native plantings are more difficult to calculate but may also produce savings (Steven Holland, Iowa DOT, pers. comm.).

Despite the proximity of apparent danger, roadsides rich in native plants provide valuable habitat to pollinators and other wildlife. Photograph by Maria Urice, Iowa Living Roadway Trust Fund.

For More Information

Websites

The Xerces Society: Regional information on plants, guidance on providing nest sites, and detailed guidelines for habitat creation and management in a variety of landscapes.
http://www.xerces.org/pollinator-conservation/

Federal Highway Administration: Roadside vegetation management program.
http://www.fhwa.dot.gov/environment/vegmgt/

Iowa Department of Transportation: Information about the use of native plants in Iowa for the state's roadside management program.
http://www.iowadot.gov/plant_guide/plant_profiler.pdf

Minnesota Department of Natural Resources: Roadsides for Wildlife program with information about using native plants on roadsides.
http://www.dnr.state.mn.us/roadsidesforwildlife/index.html

Monarch Watch: Information about providing habitat for monarch butterflies and monitoring migrations.
http://www.monarchwatch.org/

National Roadside Vegetation Management Association: Integrated Roadside Vegetation Management guide.
http://www.dot.state.mn.us/environment/pdf_files/irvm_howto.pdf

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The Xerces Society for Invertebrate Conservation

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Note: (20)- (30) are fully printed out

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DEPARTMENT OF NATURAL RESOURCES

Division of Parks and Trails
1601 Minnesota Drive
Brainerd, MN 56601

March 13, 2018

Jean Chadwick, President

Clearwater Lake Area Association

See page 2

Dear Ms. Chadwick,

I am responding to your letter to ensure you and all of the people you copied receive the same information. The same information that is posted on the DNR's web site is the proposal to date. The maps of the roads proposed to be used in the draft alignment for the touring route are the details of the proposal so far. Planning is currently underway to define a final alignment for the route. Listening sessions are being held across the state.

Session law of 2015 directs the Department of Natural Resources (DNR) to work in conjunction with Minnesota Four-Wheel Drive Association (MN4WDA) to address off-road vehicle touring routes and other issues related to off-road vehicle activities. Session law is a mandate or directive. The Minnesota Four-Wheel Drive Association (MN4WDA) in conjunction with the DNR started planning for a border to border touring route. The DNR contracted with the National Off-highway Vehicle Conservation Association to assist with planning.

Counties and townships do receive state funds and these roads are already open to any highway-licensed vehicle, but we recognize additional volume will be generated. MN4WDA is sponsoring legislation for an appropriation out of the ORV account that local road authorities can access.

In talking with the Rustic Roads Program Coordinator of the Wisconsin DOT Bureau of Planning & Economic Development, she notes the WI Rustic roads program has been in place for 40 years. They have brown and yellow Rustic Road signs demarcating over 700 miles of scattered rustic roads to assure travelers that they are on the route. The signs are furnished by Wi DOT. The Wisconsin Department of Tourism promotes travel to these roads as well. Over the years, Wisconsin Public Television, Midwest Weekends website, The Wisconsin State Journal, various community websites, published books and other groups have featured the WI rustic roads program. The Wisconsin Rustic Roads Coordinator noted the roads do not receive any additional maintenance, enforcement, litter or garbage pickup from the State. No environmental damage or additional spread of invasive species attributed to being a rustic road has occurred.

This proposal is not adding a new use, highway licensed vehicles are already legally using the all of the 2018 proposed route. The final touring route alignment keeps all current seasonal road closures or weight limit restrictions and will not displace existing uses. The touring route is proposed to be promoted to visitors from the time seasonal road restrictions are lifted in the spring to November 1st annually. Some of the proposed roads on the east side of the State are groomed for snowmobiles in the winter.

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There are groups that may submit new trail projects off this core road touring route or in other places in Minnesota in the future. You reference this as phase II. Grants-in-aid (GIA) riding areas or trail proposals may include new construction. All new GIA proposals with construction will go through appropriate environmental review and permitting with mandatory best management practices for construction including appropriate storm water management plans to control potential sediment runoff during and after construction and control of terrestrial invasive species. The DNR has a rigorous proposal review process for new loops or areas and all proposals are evaluated to ensure sensitive natural areas are avoided, wetlands are not impacted and all statutes and rules are applied as required. The DNR is the Responsible Government Unit (RGU) for GIA.

The planning for the touring route has evolved from the listening sessions in 2017. I stated during the listening sessions held in 2017 that many touring route drivers were looking for a scenic adventure "trail" of rugged, unpaved, low-maintenance roads, with obstacles like roots, trees, rocks, and travel at slower speeds. In 2018, based on input from the public, road authorities as well as county, state and federal natural resource staff, it is a touring route for highway licensed vehicles. In 2018, we are really talking about roads that are currently open to highway licensed vehicles and are not proposing to change that in any way with this touring route. Some of the sections proposed in the Superior National Forest area are across ledge rock or may have roots exposed and rocks that stick out. It will cross streams and rivers across Minnesota on the existing infrastructure of bridges and culverts. It will travel along wetlands and lakes on existing roads.

OHV is an umbrella term that includes ATVs, off-highway motorcycles (OHMs) and off-road vehicles (ORVs) that each have separate registration and operation requirements. OHMs and ORVs can be licensed through the DMV for road use if equipped with headlights, turn signals, mirrors, etc. and can be registered with the Mn DNR for trail use. MN law requires highway license vehicles meet minimum bumper heights, tire size, tire tread requirements, and sound requirements.

The draft alignment proposal on the maps right now came out of listening sessions held a year ago with the public and local field staff of the USFS and Mn DNR. All of the route will require an agreement or a permission from the road manager or road authority for the touring trail to be on that road section so the final dedicated route depends on the input from listening sessions and the agreement of the road manager/authority.

The visitors coming for the touring route will increase traffic and road usage and these people will need food/gas/camping/lodging as well as enjoy the opportunity to purchase unique items from the areas. The exact amount of increased people and vehicles on the touring route will require monitoring once the route is in place. An estimate may be a few thousand a year to start with on the more attractively marketed segments. Travelers will choose the locations that are more welcoming and that actively market the unique features along the touring route.

As a touring route for highway licensed vehicles, enforcement would stay in the hands of the existing jurisdictions that already enforce on these roads. Vehicle use on roads by visitors to an area will be monitored and volunteer groups are interested to adopt-a-touring route section for cleanup and stewardship.

No destruction of natural resources is anticipated since the touring route is on existing roads. Off road travel on private land without permission is trespass and violators should be prosecuted. Off road travel across county, state and federal forest lands by highway licensed vehicles is prohibited. Violation is a misdemeanor.

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Once a touring route project alignment is developed, the DNR Ecological Water Resources Division Environmental Review staff will analyze the project proposal, request additional information required and make a determination on the appropriate environmental review needed to meet MEPA as the RGU. The outcome of the Ecological Water Resources Division Environmental Review professional staff's analysis will be posted on the planning website information at Border to Border.

Sincerely,

Mary

Mary Straka
OHV Program Consultant

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Research article

Hitching a ride: Seed accrual rates on different types of vehicles

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ABSTRACT

Human activities, from resource extraction to recreation, are increasing global connectivity, especially to less-disturbed and previously inaccessible places. Such activities necessitate road networks and vehicles. Vehicles can transport reproductive plant propagules long distances, thereby increasing the risk of invasive plant species transport and dispersal. Subsequent invasions by less desirable species have significant implications for the future of threatened species and habitats. The goal of this study was to understand vehicle seed accrual by different vehicle types and under different driving conditions, and to evaluate different mitigation strategies. Using studies and experiments at four sites in the western USA we addressed three questions: How many seeds and species accumulate and are transported on vehicles? Does this differ with vehicle type, driving surface, surface conditions, and season? What is our ability to mitigate seed dispersal risk by cleaning vehicles? Our results demonstrated that vehicles accrue plant propagules, and driving surface, surface conditions, and season affect the rate of accrual: on- and off-trail summer seed accrual on all-terrain vehicles was 13 and 3508 seeds km^{-1}, respectively, and was higher in the fall than in the summer. Early season seed accrual on 4-wheel drive vehicles averaged 7 and 36 seeds km^{-1} on paved and unpaved roads respectively, under dry conditions. Furthermore, seed accrual on unpaved roads differed by vehicle type, with tracked vehicles accruing more than small and large 4-wheel drives; and small 4-wheel drives more than large. Rates were dramatically increased under wet surface conditions. Vehicles indiscriminately accrue a wide diversity of seeds (different life histories, forms and seed lengths); total richness, richness of annuals, biennials, forbs and shrubs, and seed length didn't differ among vehicle types, or additional seed bank samples. Our evaluation of portable vehicle wash units showed that approximately 80% of soil and seed was removed from dirty vehicles. This suggests that interception programs to reduce vehicular seed transportation risk are feasible and should be developed for areas of high conservation value, or where the spread of invasive species is of special concern.

1. Introduction

The role that humans play in the introduction and subsequent dispersal of native and non-native species has recently garnered attention (Arevalo et al., 2005; Pauchard et al., 2009; Seipel et al., 2012). Plant communities along transportation corridors can differ significantly from the composition of adjacent interior communities (Gelbard and Belnap, 2003; Tikka et al., 2001; Veldman and Putz, 2010). The effects of road maintenance (mowing, herbicide spraying, and grading of unpaved roads), combined with the abiotic effects of roads (altered substrate and hydrology), make roadsides unique ecosystems that can be more susceptible to the establishment of ruderal and non-native vegetation when compared with interior ecosystems (Coffin, 2007; Greenberg et al., 1997; Hansen and Clevenger, 2005; Hendrickson et al., 2005; Pickering and Mount, 2010; Rauschert et al., 2017; Veldman and Putz, 2010; Zwaenepoel et al., 2006).

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In addition to disturbances that create conditions favorable for the establishment of undesirable plant species, transportation corridors and roadways can act as vectors for seed transport (Taylor et al., 2012; Veldman and Putz, 2010; Vakhlamova et al., 2016; von der Lippe and Kowarik, 2007). Studies have recorded the presence of seeds from a range of species on and in vehicles (Auffret and Cousins, 2013; Clifford, 1959; Hodkinson and Thompson, 1997; Lonsdale and Lane, 1994; Pickering and Mount, 2010; Schmidt, 1989; Veldman and Putz, 2010; Zwaenepoel et al., 2006). Using roadway tunnels to study seed transport by vehicles, von der Lippe and Kowarik (2007) found significant seed quantities in tunnels and concluded that long-distance transport of seeds by vehicles is the rule rather than the exception. Seed transport by vehicles is likely due to both the slip stream (airflow) around a vehicle as it moves (von der Lippe et al., 2013) and/or by physical attachment onto the vehicle's frame (Taylor et al., 2012).

Seed transport by vehicles is likely to disperse seeds farther than other anthropogenic modes such has hiking (Wichmann et al., 2009) or mountain biking (Weiss et al., 2016). Taylor et al. (2012) showed that >85% of seeds previously attached to a vehicle remained in place for several hundred kilometers under dry conditions on either paved or unpaved roads. In their roadway tunnel study, von der Lippe and Kowarik (2007) found that non-native seeds accounted for half of the number of species found and over half of the total number of seeds. Furthermore, Vakhlamova et al. (2016) found national roads, where vehicles likely travel longer distance and into new regions, have higher richness and percentage of non-native species than local roads. Roadways have been found to contribute to the spread of non-native species in many different systems: mountain landscapes (e.g. Arevalo et al., 2005; Pauchard et al., 2009; Seipel et al., 2012), semi-arid landscapes (Gelbard and Belnap, 2003), taiga (Hendrickson et al., 2005), temperate deciduous forests (Huebner, 2010), and tropical dry forests (Veldman and Putz, 2010). The construction of new roads, and maintenance of existing ones, coupled with the increased vehicular traffic (on- and off-road), presents a unique conservation challenge in terms of preventing and managing the spread of non-native and invasive plant species.

Despite the literature on seed dispersal by vehicles and differences in the vegetation alongside and adjacent to roadways, studies have not quantified the rate of seed accumulation by different vehicle types, under different driving conditions (i.e. wet or dry conditions), or along different surfaces (paved, unpaved and off-road). This information is necessary to determine the potential of vehicular traffic to act as seed dispersal vectors, and assess the risk of spread of plant species (Auffret and Cousins, 2013). Thus, the first goal of the study was to evaluate the rate of seed accrual onto vehicles under a range of different conditions. For this goal, our objectives were to evaluate the rate of seed accrual (1 or 100 km^{-1}), total seed abundance, and species richness on: 1) all-terrain vehicles driven on- or off-trail in two seasons; 2) four different vehicle types driven on different surfaces during early summer.

To address the potential for vehicles to act as seed dispersal vectors, the USA Forest Service currently commissions portable vehicle wash units (VWU) to clean vehicles at sites where wildfires are being actively managed, the military cleans vehicles between training activities, and there is interest in the use of portable wash units to treat vehicles entering sensitive areas. However, the effectiveness of current portable cleaning equipment has not been quantified and there are few established guidelines by government agencies. To address this need, the second goal of our study was to quantify the effectiveness of different portable vehicle wash units (VWU) at removing plant propagules and soil from different types of vehicles. The objectives for this second goal were: 1) evaluate the efficacy of five different VWUs to remove soil waste from different vehicle types, 2) determine the efficacy of the VWU washing protocol (cleaning, filtering, and containment) on the survival of different seed types, 3) quantify the efficacy of the primary VWU over different wash durations.

2. Methods

2.1. Seed accrual studies

Seed accrual was assessed in two ways: (1) using all-terrain vehicles (ATV) driven on- and off-trail in summer and fall; (2) using four vehicle types driven primarily on unpaved roads during early summer.

2.1.1. All-terrain vehicles driven on- or off-trail

Seed accrual onto recreational ATVs was assessed during the summer (July) and the fall (September) of 2008, in Montana, USA. All-terrain vehicles were driven a fixed distance (3.2 km) on two different courses, with different surfaces (on-trail and off-trail). Both courses ran through mixed sagebrush and open conifer habitat. The on-trail course was conducted on a 2.5 m wide unpaved former logging road (45° 26′ 13″ N, 111° 10′ 09″ S) and the off-trail course was nearby (45° 26′ 19″ N, 111° 14′ 03″ S). After travelling the set distance the ATVs were washed. Due to the VWU's filtering (200 microns) and containment procedures taking hours to complete, washes from multiple vehicle runs of the same type were collated for each replicate. There were three replicates on each of the two courses/surfaces, in each season. Before starting each replicate, the ATV was cleaned using the VWU. Following this pre-wash, the ATV drove a lap around the course, after which it washed and the seeds and soil it accrued during the lap were captured and contained by the VWU. This iteration occurred 24 times per replicate (total of 76.8 km). The vegetation was tall (~1 m) at the off-trail site, causing some seed to accumulate on the vehicle (e.g. on top of wheel fairings). These seeds were removed and bagged prior to washing, and the seed biomass weight was recorded by species. Germinable seed numbers were assessed by germinating them in the same manner as the vehicular seed and soil waste samples (see below). This provided consistent estimates between the different seed collection methods.

Once a replicate was completed, the soil and seed waste from the vehicles was contained and transported back to the Montana State University (MSU) Plant Growth Center, where it was mixed with pasteurized soil to provide a consistent medium, placed in seed trays, and monitored for growth. (In previous experiments, seedling survival of the pasteurization process and subsequent contamination of greenhouse experiments has been non-existent, thus we did not have control trays.) Seedling establishment from our trays was monitored and recorded for 20 months. Seedlings were removed from trays after they had been identified to the species level and the soil was subsequently disturbed to facilitate further germination. To address possible seed vernalization requirements, after 9 months and when new establishment had ceased, the trays were moved to a cold, dark room (4 °C) for 8 weeks. After the 8 weeks, the trays were returned to the greenhouse and new seedling emergence was monitored for another 9 months. Plants were grown under a 16-h photoperiod of natural sunlight supplemented with mercury vapor lamps (165 μE m−2 s−1) at 22 °C (day), with 15 °C at night. Plants were watered as needed throughout. A few plant specimens were grown to maturity for identification purposes, these were placed in separate pots and a different greenhouse, with the same climate conditions, to prevent any seed contamination of the seed trays. The process from containing the soil and seed waste in the field, through to recording individual species' abundance, is hereafter referred to as the VWU seed protocol.

2.1.2. Wheeled and tracked vehicles

Seed accrual was assessed on four vehicle types representative of vehicles operated by government agencies, private contractors, and the public: ATVs, 4-wheel drive Humvees (4WD), large extended wheel base 4WD (large 4WD), and tracked vehicles. These vehicles were driven on different surfaces (paved, unpaved, off-road) through sagebrush steppe vegetation; the primary surface was unpaved roads. To have access to different vehicle types and longer travel distances we collaborated with the Montana Army National Guard over three years (2007–2009) during their annual training exercises. Limestone Hills Training Area, Montana (46° 19′ 44″ N, 111° 33′ 56″ S) was the site of training exercises 1–2 and 4–5: June 10–13, 2007 (Exercise 1), June 18–20, 2007 (Exercise 2), June 12–14, 2009 (Exercise 4), and June 19–21, 2009 (Exercise 5). In 2008, the annual training exercise occurred at Orchard Training Area, Idaho (43° 17′ 04″ N, 116° 04′ 46″ S): June 1–12, 2008 (Exercise 3), USA. It should be noted that the timing of the exercises is before seed shed for the plant species of our sagebrush steppe sites and, as such, represents a conservative estimate of seed accrual.

Before each military training exercise, each vehicle was washed once using the military wash facilities and again with our primary VWU (Fig. 1 a, d). During each military exercise, the different types of vehicles were driven within the sagebrush steppe, as determined by the commanding officer; individual training exercises had to be flexible to mission changes in the field. The intent was to sample the same number of each vehicle type, driven the same route, for each training exercise. This did not occur due to vehicle attrition (e.g. breaking down, mission change). However, the exact route each vehicle travelled was recorded using a Global Positioning System (GPS) mounted on the vehicle. Therefore, after each training exercise, route data for each individual vehicle was downloaded and combined with digital site data to provide length driven on paved, unpaved, and off-road surfaces: most driving was performed on unpaved roads. Data were then summed by vehicle type and training exercise.

After each training exercise, vehicles of the same type were grouped and washed sequentially using the VWU. There was no set wash length, rather they were washed until visually clean and the duration of each wash was recorded (average of 6.5 min for ATVs and 4WD, 12 min for large 4WD, and 15.5 min for tracked vehicles under dry conditions; under wet conditions all wash times doubled). The soil waste obtained from each vehicle type wash was processed using the VWU seed protocol. The metrics obtained for each vehicle type and training exercise were: number of seeds accrued km^{-1} driven, total number of seeds accrued, and species richness. To evaluate species composition similarity between seeds accrued from the vehicles and site vegetation, we collected and germinated 21 soil seed bank samples from each site, along belt transects that ran perpendicular to unpaved roads. Each of the 21 soil samples consisted of 10 subsamples of 6 cm wide by 10 cm deep soil cores from within a 10 m^2 area. The samples were collected from the unpaved road and stratified away from the road edge: at 5 m and 50 m from the road edge at the Limestone Hills site, and 1 m and 5 m from the road edge at the Orchard Training site (farther away was not permitted).

2.2. Evaluation of vehicle wash unit studies

We performed a field experiment to quantify the effectiveness of five commercial portable VWU to clean soil waste from three different vehicle types (4WD, large 4WD, and tracked). This study was performed during the summer (July–August) of 2008, at the California Department of Forestry and Fire Prevention Training Facility (CalFire) in Ione, California (38° 21′ 55″ N, 120° 56′ 24″ S), USA. The five VWUs were representative of portable units that are for hire in the USA and differed in the combination of water volume (liters minute^{-1} (l pm)) and pressure (kilograms of force centimeter^{-1} (kgf/cm^2)) used in the washing process, and by their cost (Fleming, 2008). The combinations ranged from low volume – high pressure to high volume – low pressure (Fleming, 2008). All VWUs used mats underneath their washing area with a drain and pump that transported the material to the individual unit's filtering and containment system (Fig. 1 a, d). The VWU used in our seed accrual experiments was one of the systems evaluated.

To evaluate the efficacy of each VWU, the three types of vehicles were "dirtied" by being driven through a ~1.4 km test loop (638 m off-road and 742 m on unpaved/paved surfaces). The off-road section contained an artificially created mud bog (Fig. 1 b, c) that was re-wetted between vehicle runs. The unpaved section was scarified daily to maintain the loop in a similar condition for each vehicle type. Wheeled vehicles were driven around the test loop and underwent a 5 min VWU contractor wash. After the contractor wash, we (study personnel) completed a follow up wash to evaluate and record what the contractor VWU had missed. This sequence was repeated 18 times for each wheeled vehicle type, after which we performed a final, meticulous post-wash that included removing and cleaning the wheels. The soil waste from the 18 iterations for each vehicle type was aggregated, dried, weighed, and recorded by VWU contractor. We modified the contamination routine and methodology for the tracked vehicle, to represent their typical field use and wash routine. The tracked vehicles were driven once for each different VWU, only on the off-road section that included the mud bog, and had a long wash (60 min). Again, we completed a follow up wash to evaluate and record what the VWU contractor missed. The post-wash data, for each of the three vehicle types, represented the total amount of soil waste not removed by each of the five VWUs.

Each VWU had a different internal filtration and containment system process, therefore, seed survival could have been differentially affected depending on seed attributes. Thus, we evaluated the effect of the different vehicle wash units' filtration and collection methods on seed survival within the soil waste. We placed a known number of seeds from nine plant species in a known amount of soil and water, which was then subjected to the filtering and containment procedure of each VWU. The resulting soil and seed waste was transported back to the MSU Plant Growth Center, where our seed protocol was applied and emerging seedlings were monitored for 9 months. The nine species were *Agropyron trachycaulum, Avena sativa, Echinacea purpurea, Fagopyrum sagittatum, Kochia scoparia, Linum usitatissimum, Melilotus officinalis, Poa pratensis*, and *Sinapis alba*. *Avena sativa* (11 mm long caryopsis) has the largest and *K. scoparia* (1–2 mm long) the smallest seeds. Total seed abundance and rate of seed accrual values used for the ATV and vehicle studies were calculated using the seed survival results from the appropriate VWU.

2.2.1. Wash duration

We evaluated the effect of wash duration on vehicle decontamination, using our primary VWU. We applied a known amount of soil onto a 4WD truck and washed it five times consecutively. The duration of each wash was 3 min, giving a total wash duration of 15 min. The soil removed by each successive wash was collected, dried, and weighed. This process was replicated ten times (6 at MSU and 4 at Orchard Training Area). Using the same process, we also evaluated if the pattern of seed removal was the same as soil. This was accomplished by adding known amounts of seed *(A. sativa, F. sagittatum, L. usitatissimum, M. officinalis, P. pratensis*, and *S. alba)* and soil to a 4WD truck and evaluating the amount removed after

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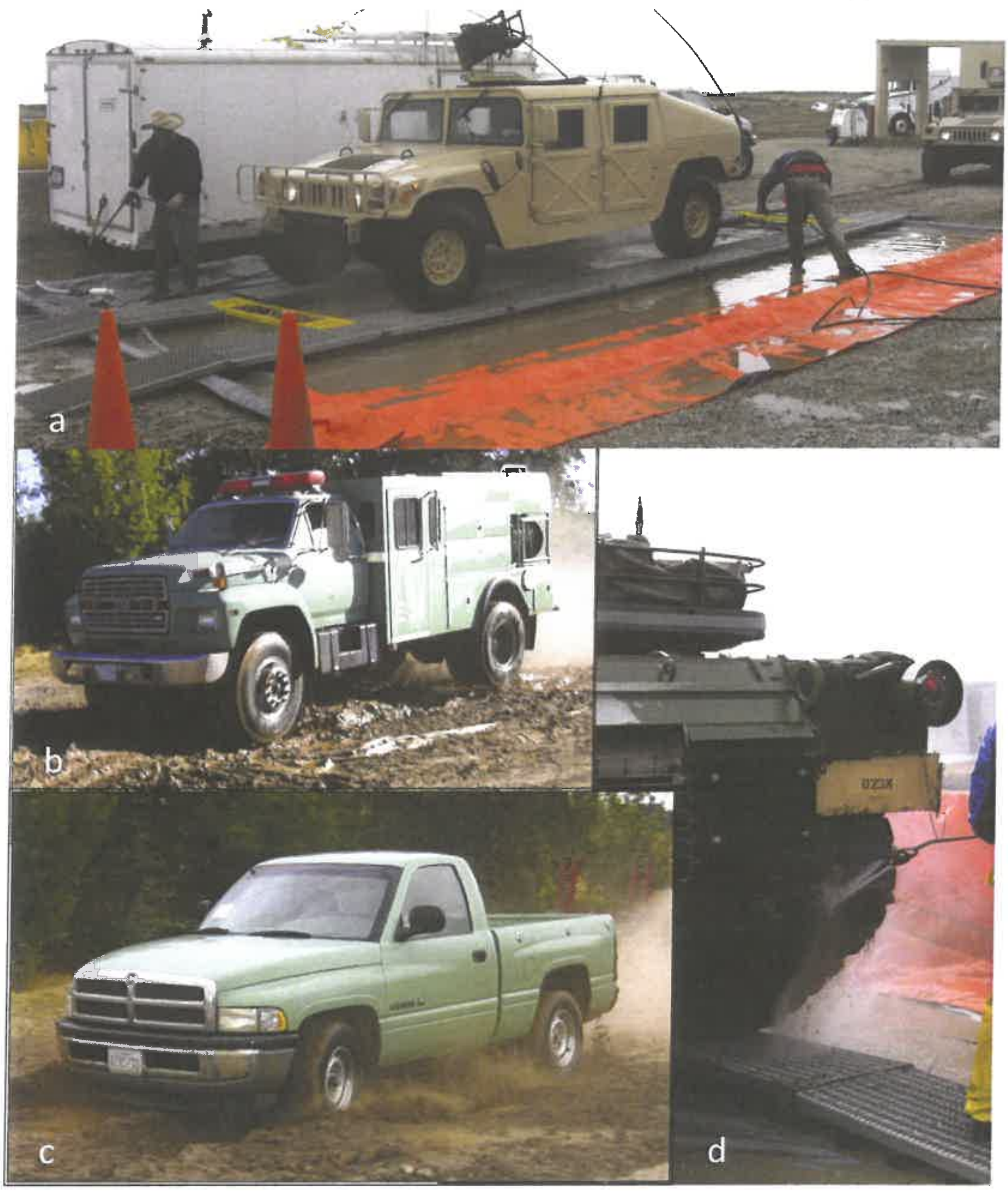

Fig. 1. The primary vehicle wash unit's (VWU) containment mats including raised edges, wheel racks, undercarriage washes and hand held wands are shown in a and d, and the artificially created mud bog used to evaluate VWU effectiveness is shown b and c. Vehicle types are as follows: 4WD (Humvee in a and truck in c), large 4WD in b, tracked - M1A1 tank in d.

each successive wash. This portion of the experiment was replicated four times at the Orchard Training Area site.

2.3. Statistical analysis

Our metrics of interest for both the ATV and different vehicle type seed accrual studies were seed accrual rate (1 or 100 km^{-1}), total abundance and species richness. For seed accrual rate and seed abundance (both log transformed) linear (ATV study) or general linear mixed effects models (vehicle type study) were employed. Species richness was analyzed using generalized linear models with a Poisson error distribution. We assessed the normality and heteroskedasticity of our data and transformed as necessary prior to performing the analyses.

For the ATV study, our fixed effects were surface (on- and off-trail), season (summer or fall), and nativity (native or non-native). The fixed effects for the vehicle study were vehicle type (ATV, 4WD, large 4WD, tracked) and nativity (native or non-native), with exercise and replicates nested within site as random effects. For the vehicle study, all but one exercise were performed under dry conditions so we restricted our main analyses to these data, unless otherwise stated. Tukey comparison of means was utilized to analyze differences between the different vehicle types. We also evaluated mean seeds accrued 100 km^{-1} for 4WD and tracked vehicles under wet and dry conditions (exercise 4 and 5) at Limestone Hills Training Area, but there was insufficient data for statistical analysis.

Finally, we performed additional analysis to evaluate richness by

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life history (annual, biennial, perennial), life form (grass, forb, shrub/tree) and seed characteristics (length was the only characteristic consistently available, though not for all species) among the different vehicle types and seed bank samples, from the Limestone Hills Training Area. Generalized linear models with poisson distribution, or quasipoisson distribution due to overdispersion, were used.

The mitigation experiments, including the amount of soil removed by the VWU contractors and the effect of the VWU filtration and containment process on seed survival, were both examined with analysis of variance. The proportion of soil and seed removed by successive washes was analyzed using general linear mixed effects models: using logit transformation to address normality and heteroscedasticity issues. The fixed effect in the model was vehicle type, while the random effect of wash number was nested within replicate and site. Tukey comparison of means was once again used to compare between the individual washes.

All analyses were completed using the statistical analysis program 'R', version 3.3.1.

3. Results

3.1. Seed accrual experiments

3.1.1. All-terrain vehicle study

All terrain vehicles driven off-trail accrued seeds at a higher rate per km driven (km^{-1}) than on-trail ($F_{(1,20)} = 113.20$; $p = 1.10$ E-09), with a higher rate of accumulation on drives during the fall than the summer ($F_{(1,20)} = 39.24$; $p = 4.08$ E-06), and more non-native seeds than native seeds ($F_{(1,20)} = 61.20$; $p = 1.64$ E-07; Fig. 2). The same pattern was observed for total seed abundance: more seeds were accrued off-trail than on-trail ($F_{(1,20)} = 113.05$; $p = 1.12$ E-09), and more non-native than native seeds were accrued ($F_{(1,20)} = 62.43$; $p = 1.47$ E-07).

Mean species richness accrual on the ATVs did not differ between summer (21) and fall (25), although more non-native (12.6) than native species (7.9) accrued on the ATVs ($X^2_{(1,20)} = 12.86$; $p = 0.0003$). Overall 87 species were observed from the ATV washes, most species were rare.

3.2. Seed accrual on wheeled and tracked vehicle types

The small 4WD vehicles were driven on two different road surfaces, the mean number of seeds accrued was higher on unpaved (361 seeds 100 km^{-1}) than paved (68 seeds 100 km^{-1}) dry surfaces ($F_{(1,5)} = 22.97$; $p = 0.004$). All vehicle types were driven primarily on dry unpaved roads and there were differences between vehicle types ($F_{(3,11)} = 4.84$, $p = 0.021$): 4WD accrued seeds at a rate of 420 seeds 100 km^{-1}, significantly more than on large 4WD (151 seeds 100 km^{-1}) and less than on the tracked vehicles (887 seeds 100 km^{-1}), ATVs did not differ from other vehicles. Further, results of Tukey post hoc comparison of means demonstrated that tracked vehicles accrued seeds at a higher rate than large 4WD ($p < 0.001$) but did not differ from the ATV (Fig. 3). The rate of seed accrual nor the abundance differed with nativity.

During our sampling of the military exercises there was a period of high precipitation. This provided us with the opportunity to compare seed accrual on 4WD and tracked vehicle types under wet versus dry conditions; we compared one wet and one dry exercise performed a week apart, in which multiple vehicles of each type were used. Unsurprisingly, more seeds were accrued under wet conditions for both tracked and the wheeled vehicles: the rate of accrual 100 km^{-1} increased under wet conditions 11.2 and 19.6-fold for tracked and wheeled vehicles, respectively.

Total species richness accrued on the different vehicle types was high for the two vehicle study sites (61 and 77 total species; Supplemental Table 1). Overall, total richness, native and non-

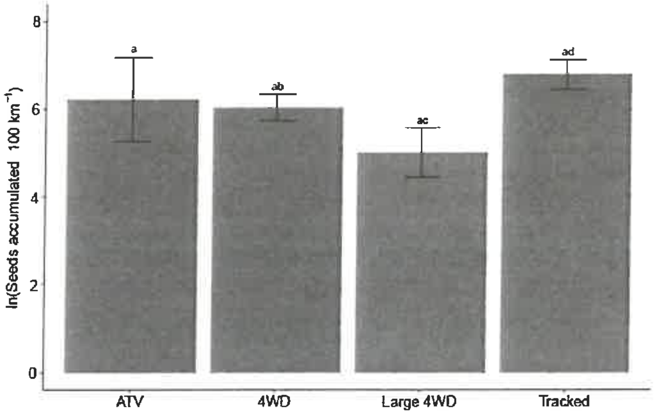

Fig. 3. Rate of seed accrual on four different vehicle types driven on unpaved roads. The bars represent standard errors, letters indicated differences ($p < 0.05$).

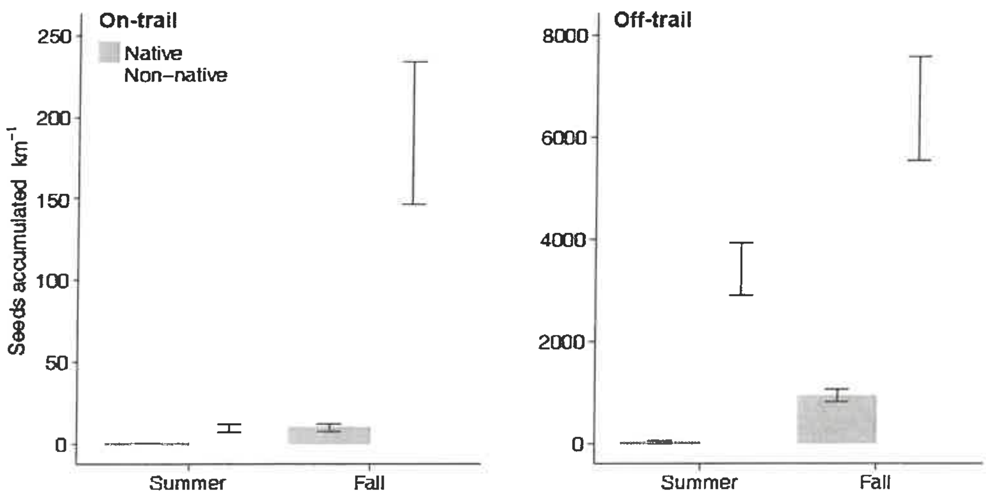

Fig. 2. Mean number of native and non-native seeds accumulated per kilometer for all terrain vehicles driven on- and off-trail in both summer and fall. Bars represent standard errors from three replicates of 24 vehicle laps (76.8 km). Note the different scales of the y-axis for the on- and off-trail data.

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native richness did not differ among vehicle types nor the seed bank, at either site. Furthermore, the species accrued demonstrated different life history attributes (annual, biennial, perennial), forms (grass, forb, shrub) and seed lengths; and we evaluated differences with seed bank samples from the Limestone Hills Training Area. Annual and biennial richness did not differ among vehicle types and the seed bank, however, perennial richness did differ ($X^2_{(4,10)} = 16.82$; $p = 0.002$) with all vehicle types having lower richness than the seed bank. Forb and shrub richness did not differ either, but grass richness did ($X^2_{(4,10)} = 9.51$; $p = 0.049$) and was lower for 4WD ($p = 0.02$) and large 4WD ($p = 0.001$) than the seed bank. It should be noted that three-quarters of the grasses observed were perennial. Finally, we observed no difference in the length of the seeds accrued by the different vehicle types and the seed bank.

3.3. Vehicle wash unit studies

The mean soil waste removed by the VWU was 79% (±9.9%), with no differences among the vehicle types or wash units (Fig. 4). The percentage of seeds surviving the VWU containment and filtering procedure did not differ among the five VWU either, nor was there any difference among species. Overall seed survival was low (23% ± 9%).

3.3.1. Wash duration

The results of the five successive three-minute washes of a 4WD using our primary VWU demonstrated that 59% of the total soil waste was removed during the first three-minute wash, a further 19% during the second wash, and much less during the following three washes (11%, 7%, and 4% respectively; Fig. 5). The number of successive washes made the vehicle cleaner ($F_{(4,25)} = 90.61$; $p = 1.14$ E-14). Results of Tukey post hoc comparison of means demonstrated that the first three washes made the vehicle significantly cleaner ($p < 0.001$), however there was no difference in the mean cumulative percentage removed between the third and fourth consecutive washes ($p = 0.11$; Fig. 5).

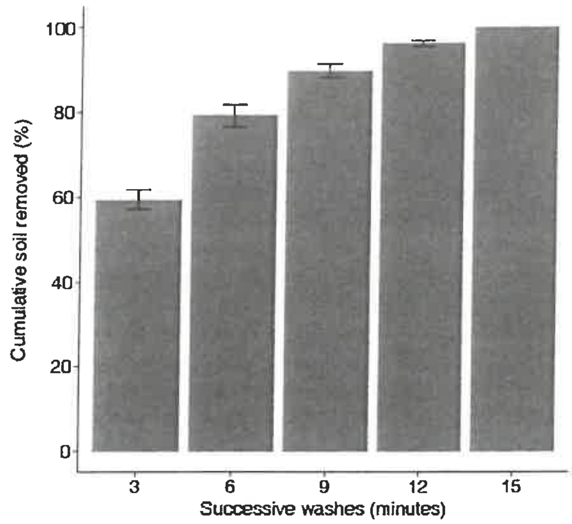

Fig. 5. Cumulative percentage of soil waste removed from a 4-wheel drive vehicle with five successive 3 min duration washes, using the primary vehicle wash unit.

4. Discussion

This is the first study to quantify the rate and magnitude of seed accrual by vehicles, adding critical data to the emerging research on the role of vehicles as dispersal vectors. Vehicles accrued seeds at higher rates than we expected, especially under dry conditions before the peak of seed shed, a period we expected to be relatively low risk. We demonstrate that vehicle accrual of plant propagules is

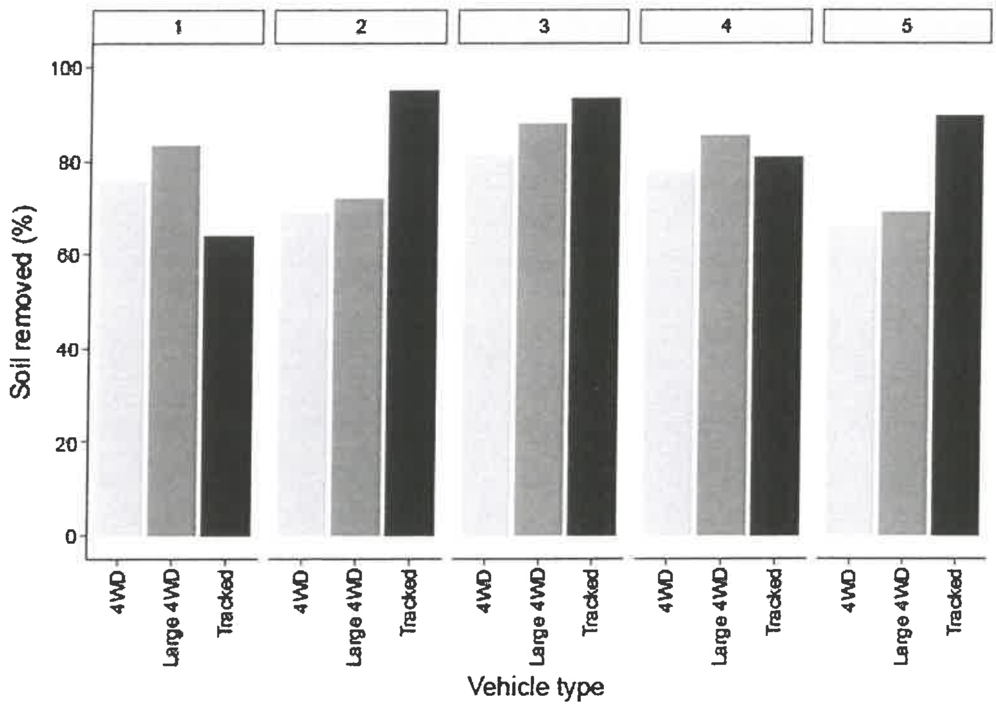

Fig. 4. The percentage of soil removed by the different vehicle wash units (1–5) for each vehicle type, assessed through our additional cleaning procedures. The data for the wheeled vehicle types (4WD, large 4WD) for each wash unit represents the combined wash total after driving a 1.4 km variable surface course 18 times; results of the tracked vehicle are from one drive over the unpaved section of the course.

affected by different driving surfaces (paved versus unpaved, and on-trail vs. off-trail), under different road conditions (wet and dry), and seasons (summer versus fall). The plant propagules accrued by vehicles are representative of a site's vegetation. This pattern of indiscriminate accrual demonstrates vehicles pose both a risk for dispersing non-native and invasive species but also play a role in moving native species into new areas. Spread of native species by vehicles may be beneficial to help address range shifts resulting from global climate change; especially with recent research demonstrating that not all ranges are poleward or upwards in elevation (Lenoir and Svenning, 2015). In addition, our evaluation of portable vehicle washing techniques demonstrates that we have existing technological solutions that can mitigate the threat of vehicle dispersal of problematic invasive plant species.

The ATV study highlights the importance of both driving surface and season for seed accumulation rates, with significantly greater accrual off-trail and in the fall compared with on-trail and in the summer. Previous studies have found that off-trail travel of various types (e.g. walking, horse-riding, camping, mountain biking, and vehicles) cause changes to the amount of litter, bare-ground, and soil conditions (e.g. erosion and altered nutrient levels) (Pickering and Hill, 2007). This has often resulted in changes to plant community composition (see reviews by: (Liddle, 1991; Pickering and Hill, 2007). By quantifying significant seed accrual by off-trail vehicles, our study has identified one mechanism through which off-trail driving results in altered plant community composition: vehicles driving off-trail/road scarify the soil, providing microsites favorable for plant establishment, while concurrently providing an abundance of seed, potentially non-native in origin. Pickering and Hill (2007) in their review demonstrated an increase in non-native invasive plant species associated with off-road travel in Australia.

Plants differ in their phenology and previous studies evaluating seed abundance from mud samples taken from vehicles (Clifford, 1959; Schmidt, 1989; Zwaenepoel et al., 2006) and seed accrual on different vectors (see Pickering and Hill (2007) for review) have found differences in the seasonality of seed accrual. Consistent with these studies and our expectations, we found seed accrual to be significantly higher in the fall than in the summer. This finding was exaggerated when seed accrual of the on- or off-road trials were compared; the most significant seed accrual occurred off-road during the fall. These findings would support travel restriction regulations that correspond to times (seasons) of seed set for species of concern (e.g. species considered especially invasive in the region), particularly for off-trail travel.

The importance of driving surface was also demonstrated in the vehicle type study, with higher seed accrual rates on unpaved than paved roads for 4WD (36 vs 7 km^{-1}, respectively) the only type driven on both surfaces. Furthermore, our study shows vehicle type matters. When comparing the rate of seed accrual of vehicles driven primarily on unpaved roads, seed accrual was higher for 4WD than large 4WD, and tracked vehicles accrued more than twice that of either 4WD or large 4WD. Overall, the rates of seed accrual were surprisingly high given the exercises were performed before yearly seed production began at our sites, when we would expect seed accrual to be at its lowest. As such, they represent a conservative estimate of seed accrual. Previous studies have estimated between 0.9 and 3 seeds per vehicle (Hodkinson and Thompson, 1997; Lonsdale and Lane, 1994; Zwaenepoel et al., 2006) but these studies did not wash entire vehicles; they sampled from the exterior of the vehicle and sometimes within it, and the distance driven prior to sampling was unknown. Our results indicate that vehicles driven primarily on unpaved roads pose a higher risk of gaining and dispersing non-native seeds than those driven on paved roads. Thus, all vehicles, tracked particularly, driven frequently on unpaved roads and more so off-road should be cleaned frequently, and especially before being driven into a new region or area of conservation value.

Unsurprisingly, we found that seed accrual was greater under wet conditions. Climate zone and seasonality are environmental factors that can affect the amount of damage done to vegetation by recreation (see Pickering and Hill, 2007). Our results empirically demonstrate that another consequence of driving in wet conditions is the accrual and subsequent dispersal of seeds. Again, this highlights the importance of restricting and regulating travel during sensitive time-periods and conditions. Taylor et al. (2012) observed more rapid seed loss from vehicles under wet conditions on paved than unpaved roads, and Zwaenepoel et al. (2006) observed less mud on vehicles as precipitation increased. Our results suggest that vehicles driven in muddy conditions will rapidly accrue seeds and, combined with Taylor et al.'s (2012) study, when these vehicles are then driven on paved roads they will disperse seeds over shorter distances than those vehicles driven on unpaved roads. Such information could be used to inform roadside vegetation monitoring programs after road construction and road improvement projects.

Species richness did not differ between vehicle types nor seed bank samples, suggesting it was representative of the surrounding vegetation. This was also true at our ATV sites, where we observed higher non-native than native species richness in both our vegetation survey and ATV samples (data not presented). Previous studies have observed similar richness between vehicle samples and the roadside and regional flora (Clifford, 1959; Schmidt, 1989; Zwaenepoel et al., 2006).

Our study and Schmidt's (1989) conclude that all types and sizes of seed are accrued on vehicles. We observed similar number of species with annual and biennial life histories, and forb and shrub functional forms, among vehicle types and the seed bank samples. We did observe less perennials from our vehicle samples, and less grass species (N.B. three-quarters of our grass species were perennial) on the two 4WD vehicle types, but we have no explanation for this pattern. Seed length did not differ among vehicle type samples nor the seed bank. Similarly, seed length didn't differ between vehicle samples and local roadside flora in previous studies (Clifford, 1959; Zwaenepoel et al., 2006), though it did differ from the regional flora (Zwaenepoel et al., 2006).

4.1. Using information on seed accrual to develop interception programs

In the USA, vehicle recreation (ATVs and others) on unpaved forest roads and off-road driving is increasing (Switalski et al., 2004), thus, developing land management policies to address dispersal of plant propagules via vehicles is important. Vehicle seed accrual can inform land management policies in two different ways. First, as suggested by Auffret and Cousins (2013), in areas where the roadside vegetation is native, vehicles can be valued for their ability to transport native seeds between fragmented habitats and mitigate global climate change. As the seed richness accrued by the vehicles in our study generally matched the surrounding flora, our results demonstrate the viability of such an endeavor provided appropriate steps are taken to ensure non-native species are not introduced and spread.

Second, if a goal of public land management, especially in conservation areas, is to limit the introduction of non-native plant species, an approach that takes into consideration the ability of vehicles to transport seeds should be considered. An approach such as this could be modelled on current programs that address the problem of invasive aquatic species being spread anthropogenically (Elwell and Phillips, 2016). The invasion of aquatic nuisance species, such as Dreissenid (quagga and zebra) mussels, into western USA

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has resulted in a watercraft interception program (Elwell and Phillips, 2016). This program has protocols and standards, which include random check points, screening interviews and assessments based on the history of the watercrafts, followed by inspections by trained professionals (Elwell and Phillips, 2016; Zook and Phillips, 2009). While the program isn't perfect and improvements are being made (Zook and Phillips, 2009), it demonstrates that approaches can be taken to mitigate invasion.

The portable vehicle wash units (VWUs) we tested removed ~80% of soil and other matter from dirty vehicles. While ~20% of seeds remain for dispersal, this is still a considerable reduction in the risk of seed dispersal and new invasions. We would recommend that fair to moderately muddy 4WD and large 4WD be washed for 6–9 min. Vehicle inspections, including screening interviews and assessments, and subsequent washing by VWUs in high risk areas (i.e. those with a high amount of known off-road/unpaved road travel or those with a high level of soil disturbance) and key conservation areas (e.g. National Parks and Monuments) would be a way to decrease seed spread. Given the effects of environmental factors on seed accrual, the VWU use should be linked with season and surface conditions. Another factor affecting the risk of vehicles introducing non-native plants is the distance that they have travelled and the type of road: wide, paved national roads with high traffic intensity have more non-native species than narrower, unpaved local roads with lower traffic intensity and local traffic (Vakhlamova et al., 2016). Thus, vehicles travelling longer distances between regions are more likely to introduce species that are non-native to the new area. Therefore, washing stations should be prioritized near conservation areas that people travel widely to visit and, during the screening process, vehicles that have driven greater distances should be prioritized for washing.

Consistent strategies to remove waste water and material is an issue for the watercraft interception programs (Zook and Phillips, 2009). Our findings demonstrate that the vehicle wash unit process of soil and seed containment, filtering, and removal, damages seeds. Evaluation of seed survival from the five vehicle wash units demonstrated that this process destroys ~77 percent of seeds. While containment and disposal strategies for soil and seed waste were not part of this study, it is apparent that storing the soil and seed waste prior to removal could destroy most of the seeds; one of the vehicle wash unit contractors placed their soil and seed waste in double wrapped black plastic before disposing at a landfill and ad hoc sampling from bags left on site for 3–4 weeks generated no seedlings in the greenhouse (Rew, unpublished). Thus, while further experimentation is needed, our findings suggest that if an invasive plant seed interception program is to be employed, the chance of soil and seed waste causing further risk of invasion can be minimized by storage in anaerobic conditions, on site or at public washing/inspection stations, prior to disposal.

5. Conclusions

Plant propagules accrue indiscriminately on all vehicles types. These results support the long-held paradigm of vehicles as seed dispersal vectors. Therefore, as universal plant dispersal vectors, vehicles provide a potential risk for new invasions or, conversely, a conservation technique for native species in exceptional situations. Seed accrual is affected by environmental factors (driving surface, surface conditions, and season), thus mitigating seed accrual and subsequent dispersal should vary temporally and spatially according to conditions. Finally, portable vehicle wash units are effective in the removal of soil and seed waste from dirty vehicles, provided the wash is of sufficient length (≥6–9 min), very muddy vehicles will need longer washes. Similar to the watercraft interception programs, we recommend that non-native plant interception programs be employed during high risk times, in high risk areas, on high risk vehicles: consequently, vehicle wash units should be employed during wet times of year or after storms, especially when plants are shedding seeds, and near activities with high levels of soil disturbance (e.g. during wildfire control operations, utility installation) and surrounding areas of conservation interest (e.g. National Parks), and washing should focus on vehicles that have recently driven great distances, on unpaved surfaces, or off-road.

Acknowledgements

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jenvman.2017.10.060.

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Invasive Species Account

Brief Overview

- Governing statute: M.S. 84D.15
- Year established: 2007 (program established in 1991)
- Primary Division: Ecological and Water Resources

Sources and Uses of the Funds

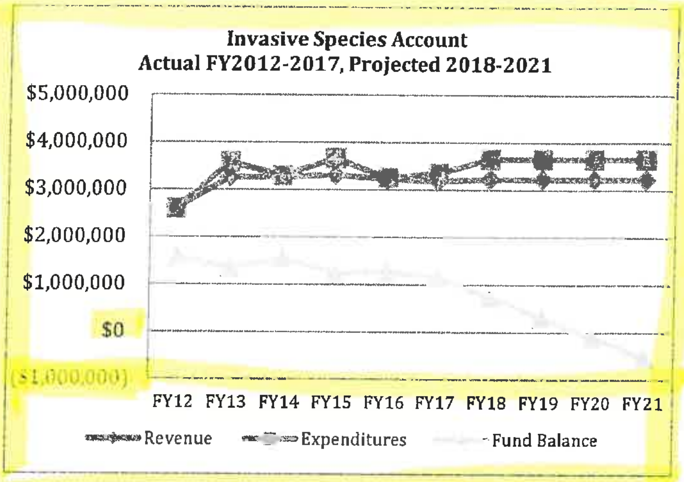
A surcharge on watercraft licenses under M.S. 86B.415, subd. 7, and civil penalties for violations of the law related to prohibited invasive species under M.S. 84D.13 are deposited into the account. Receipts from an annual $5 surcharge on nonresident fishing licenses under M.S. 97A.475, subd. 7 are transferred each year from the Game & Fish Fund to the Invasive Species Account. The watercraft surcharge accounts for 42 percent of total revenues while the non-resident fishing surcharge accounts for 35 percent.

Funds from the Invasive Species Account are used for management of invasive species and implementation of Chapter 84D. Major activities include control of invasive species, watercraft inspection, public awareness, law enforcement, assessment and monitoring, management planning, and research.

FY17 Financial Summary	
Beginning fund balance	**$1,258,993**
Prior year adjustments	$49,225
Revenues	
Watercraft Surcharge	$1,325,445
Misc Receipts	7,490
Non Res Fishing Lic Surcharge, Water Rec Account	1,848,589
Total Revenues	$3,181,524
Expenditures	
Ecological and Water Resources Mgmt	$2,958,783
Enforcement	359,976
Conservations Corps Minnesota	25,000
Total Expenditures	$3,343,759
Ending fund balance	**$1,145,983**
Net change	($113,010)

Forecast

The fund balance has been declining for many years due to appropriations exceeding revenues. Each year DNR ensures a positive balance by reducing expenditures.



Expenditure projections are based on spending authorized in law for the current biennium and carried out through 2021. The department will manage levels of spending to ensure the account does not go negative as shown above

FY2017 Accomplishments

- Worked with other DNR partners to standardize and optimize field data collection, leading to field trials of iPads for data collection and the DNR AIS Survey Manual is being developed.
- Starry stonewort pilot project was developed to enable successful applicants to use multiple techniques to manage new or existing infestations and evaluate the active management.
- A series of four informal Aquatic Invasive Species (AIS) learning sessions (76 participants from 30 counties) and a series of five regional AIS prevention workshops (64 participants from 43 counties) brought together local government staff to actively share and learn from one another's collective experiences, initiate regional and statewide collaborative efforts, gain knowledge on AIS topics of concern, and build stronger inter-county relationships.
- Trained over 900 local government units on watercraft inspections.
- Tested, developed and implemented online lake service provider training.

Additional Resources

Invasive species program

Aquatic invasive species grants and partnerships

Invasive Species of Aquatic Plants and Wild Animals in Minnesota, Annual Report 2010

Summary Report

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Cirsium arvense - Canada thistle

Family Asteraceae

For more images, click here.

Introduction

Canada thistle (*Cirsium arvense*) is extremely difficult to kill. However, September is one of the best times to start your assault. This article will describe Canada thistle and how to eradicate it.

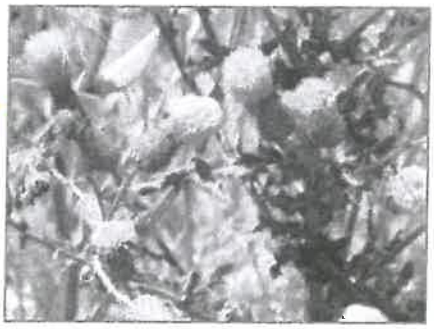
Canada thistle is a serious weed in nursery crops. Not only does it compete with crops, but it will infest fields and landscapes of customers who purchase your plants (very bad news).

Canada thistle (note that it's NOT 'Canadian' thistle) is in the family Asteraceae. It is an invasive weed native to Europe and Asia. The generic name *Cirsium* is derived from the Greek word kirsos which means 'swollen vein' (Clark, 1998). Plants of this genus were used as an herbal remedy to relax swollen veins. *Arvense* means 'of cultivated fields', a word you will notice that is used in the name of many of our most problematic weeds (*Cerastium arvense*, *Anagallis arvensis*, *Convolvulus arvensis*, etc.). The specific name is appropriate since Canada thistle is so common and problematic in cultivated fields. Canada thistle is not native to Canada, I don't know how the common name came about.

Physical description

Flowers are pink and bristly.

Canada thistle is a perennial that spreads by seed and an underground system of vertical and horizontal roots. Canada thistle is diecious, which means male and female flowers occur on separate plants. Flowers are pink, bristly, 1/2 inch long and wide. Characteristics of Canada thistle are extremely variable when examining populations from different regions. Although, my observation within the northern Willamette Valley is that most plants are similar. They are 3 to 5 feet tall, with glossy foliage on the upper surface and woolly on the lower leaf surface (this is reportedly one of the more variable characteristics). Leaves are alternately arranged, lobed, and armed with stiff spines.



Flowers fade in late summer to pale brown seed heads. The brown color is the color of the pappus (hairs attached to seed) that aids in wind dispersal.

Seed are attached to a cotton-like pappus that aids in wind dispersal. Seed can survive in soil for up to 20 years (Ross and Lembi, 1999). A seedling can reproduce vegetatively in as little as 6 weeks after germination, and a single plant can develop a lateral root system with a 20 foot spread in a single season. Severed roots can produce new plants, thus tillage and/or cultivation spread the weed throughout the field. Vegetative reproduction, through a spreading root system and/or dissemination via tillage equipment, are the primary methods of Canada thistle infestation.

Canada thistle control

Control can be accomplished mechanically by tilling every 3 weeks for an entire growing season. If this option is not feasible, herbicides are effective when used properly. Roundup and Basagran are effective when applied at bud to early bloom stage, but more than one application will be necessary for controlling established colonies. Herbicides containing the active ingredients clopyralid (Stinger or Lontrel) are reported to be the most effective, and should be applied as soon as plants have emerged from the soil. Arnold Appleby, a retired OSU weed scientist, reports that the most effective control is achieved by applications of Lontrel in late September with 2/3 pint/acre followed by

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application in spring with 1/3 pint/acre (Appleby, 1999). So mark your calendars, and as soon as the Farwest Show is over, get after that thistle!

Clopyralid can cause severe injury to some crops. Always use directed applications to avoid injury on nursery crops. When making applications in nursery or landscape sites, Lontrel is the labeled product (Stinger is labeled for ag crops).

Note: Due to issues surrounding residual clopyralid in compost, the ODA developed new restrictions for using the herbicide in turf areas. Generally this does not apply to agricultural sites, but first read the ODA rules or check with your local Dow Agrosciences rep to be sure you are permitted to use these products.

Small plants that have just emerged from the soil are connected by underground system of horizontal roots.

Literature cited

- Appleby, A. 1999. Canada thistle (Cirsium arvense). http://www.css.orst.edu/newsnotes/9903/weed.html#Canada thistle.
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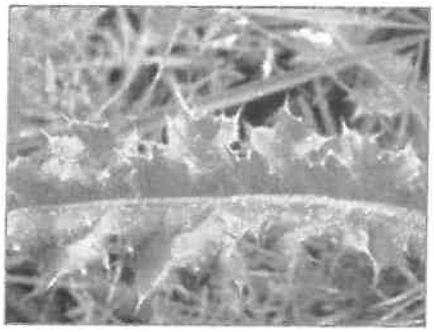
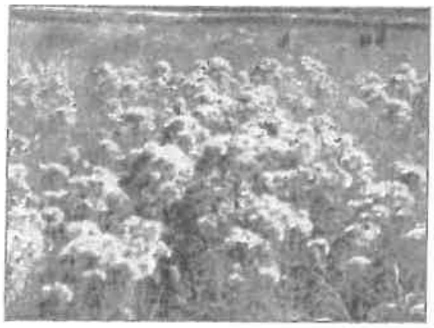


Foliage is lobed, dark glossy green on the top, and woolly on the underside. Leaves are clearly painful to touch.

For more images, click here.



Seed plumes develop in large numbers in a local field. Canada thistle will continue to send up new plants from roots after setting seed.

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Email comments to James Altland

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Garlic Mustard

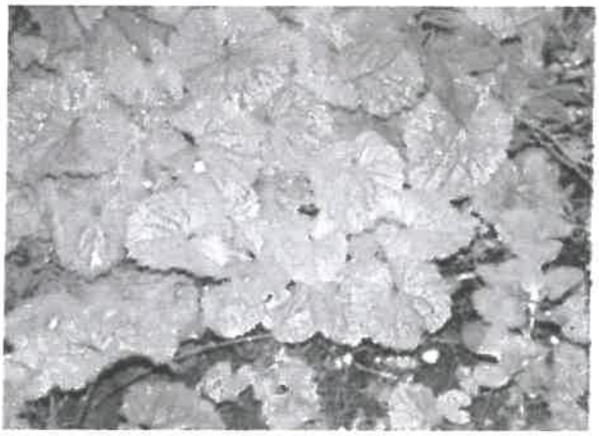
Biology Identification Impacts Prevention & Control New York Distribution Map

Background

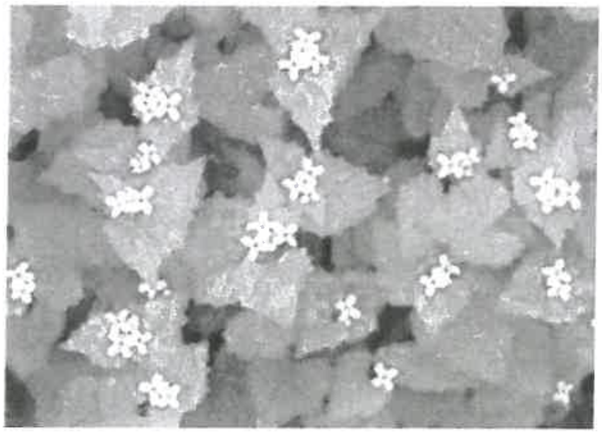
Garlic mustard (*Alliaria petiolata*) is an invasive herb that has spread throughout much of the United States over the past 150 years, becoming one of the worst invaders of forests in the American Northeast and Midwest. While it is usually found in the undergrowth of disturbed woodlots and forest edges, recent findings have shown that garlic mustard has the ability to establish and spread even in pristine areas. This spread has allowed it to become the dominant plant in the undergrowth of some forests, greatly reducing the diversity of all species. Garlic mustard is one of very few non-native plants to be able to successfully invade forest understories.

Origin and Expansion

Garlic mustard is a non-native species originating from Europe and parts of Asia. It is believed that garlic mustard was introduced into North America for medicinal purposes and food. The earliest known report of it growing in the United States dates back to 1868 on Long Island, NY. It has since spread throughout the eastern United States and Canada as far west as Washington, Utah, and British Columbia.



First year garlic mustard basal flower rosette – Jil M. Swearingen, USDI National Park Service, Bugwood.org



Second year flowers – David Cappaert, Michigan State University, Bugwood.org

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Biology

Garlic mustard has a biennial life cycle, that is, it takes two years to fully mature and produce seeds. Seeds germinate in February to early March of the first year and grow into a short rosette by the middle of the summer. In the plant's second year, a stalk develops, flowers form, and the plant dies by June. Siliques, four-sided seedpods, develop in May, containing small black seeds lined up in a row. On average, a garlic mustard plant will produce 22 siliques, each of which can contain as many as 28 seeds. A particularly vigorous plant may produce as many as 7,900 seeds (Nuzzo, 1993) although the average is more likely to be in the 600 seed range. The seeds generally germinate within one to two years, but may remain viable for up to five years in the seed bank. Seed dispersal is mainly by humans or wildlife carrying the seeds.

Characteristics and Identification

Identification of first year plants can be difficult; the task is made easier by smelling the garlic odor produced when the leaves of the plant are crushed. The basal leaves of an immature plant are dark-green and kidney shaped with round teeth (scalloped) along the edges; average size of the leaves is 6 to 10 cm in diameter. The petiole, or leaf stalk, of first year plants are 1 to 5 cm long. In its second year, the alternating stem leaves become more triangular shaped, 1 to 5 cm long, and have sharper teeth, with leaves becoming gradually smaller towards the top of the stalk. Leaf stalks of mature plants are hairy. As with the younger plants, second year plants have a garlic odor when crushed but the odor is less obvious with increasing age.

Garlic mustard flowers arrive in early April and die by June. Flowers develop on an unbranched (occasionally weakly branched) stalk and have 4 small white petals arranged symmetrically. Flowers are approximately 6 to 7 mm in diameter with 3 to 6 mm petals. Individual flowers contains six stamens, two shorter and four longer. Mature flowering plants reach 3.5 feet tall, although shorter flowering specimens may be found.

Impacts

Garlic mustard has the potential to form dense stands that choke out native plants in the understory by controlling light, water, and nutrient resources. Plants most affected by these dense stands are herbaceous species that occur in similar moist soil forest habitats and grow during the spring and early summer season. Although unsupported by the lack of long-term research into garlic mustard impacts, the plant has been circumstantially tied to decreased native herbaceous species richness in invaded forests. Researchers have found that garlic mustard is allelopathic (it releases chemicals that hinder the growth of other plant species) and has inhibited growth of both grasses and herbs in laboratory settings (Michigan State University, 2008). Some researchers also believe that these compounds may hinder the beneficial relationships some plant species have with soil fungi (Roberts and Anderson, 2001). Experimental trials have shown that removal of garlic mustard leads to increased diversity of other species, including annuals and tree seedlings (MSU, 2008).

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Garlic mustard is one of the few invasive plants able to dominate the understory of forests in the Northeast and Midwest – Victoria Nuzzo, Natural Area Consultants, Bugwood.org

Other aspects of the forest ecosystem may be altered due to the change in the vegetative community tied to garlic mustard invasion. While the impacts to wildlife are not completely understood, altering the plant diversity can cause a change in leaf litter availability, potentially impacting salamanders and mollusks (MSU, 2008). Insects, including some butterflies, may be affected through the lost diversity in plants and loss of suitable egg-laying substrate (MSU, 2008). Garlic mustard may also affect the tree composition by creating a selective barrier that some seedlings, such as the chestnut oak (Quercus prinus), may not be able to overcome (MSU, 2008). These changes in tree composition could have significant long-term effects.

Prevention, Control and Management

There are few effective natural enemies of garlic mustard in North America. Herbivores, or animals that eat plant material, such as deer (*Odocoileus virginianus*) and woodchucks (*Marmota monax*) only remove up to 2% of the leaf area in a stand of garlic mustard (Evans et al. 2005). This level of herbivory is ineffective in controlling reproduction or survival of garlic mustard. Although 69 herbivorous insects have been found to be associated with garlic mustard in Europe, less than a dozen have been found on North American infestations of the species (Hinz and Gerber, 1998).

Manual removal of plant has been shown to prevent the spread of garlic mustard. Pulling by hand must remove at least the upper half of the root to prevent a new stalk from forming; this is most easily accomplished in the spring when the soil is soft. Hand-pulling should be performed before seeds are formed and needs to be continued for up to five years in order to deplete any established seed bank. This method works best in smaller pockets of invasion or in areas recently invaded to help prevent the development of a seed bank.

Chemical applications can also be effective for controlling garlic mustard, particularly in areas too large for removal by hand. In dense stands where other plant species are not present, a glyphosate-based herbicide such as Roundup® can be an effective method for removal. Glyphosate herbicides are non-selective, so caution must be used when non-target species are in the area. Chemical applications are most affective during the spring (March-April) when garlic mustard is one of the few plants actively growing. Fall applications may be used; however other plant species still in their growing season may be harmed. Readers are advised to check with local regulatory agencies to determine the regulations involved with chemical treatments.

The best method for controlling garlic mustard, or any other invasive plant, is to prevent its establishment. Disturbances in the forest understory that would allow for rapid invasion should be minimized. This would include limiting foot traffic, grazing, and erosion-causing activities. Monitoring the forest understory and removing any

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https://www.mda.state.mn.us/plants/pestmanagement/weedcontrol/noxiouslist/purpleloosestrife

Purple Loosestrife

Common Name: Purple Loosestrife
Scientific Name: *Lythrum salicaria* L.
Legal Status: Prohibited - Control

Efforts must be made to prevent seed maturation and dispersal of plants into new areas. Additionally, no transportation, propagation, or sale of these plants is allowed. Failure to comply may result in enforcement action by the county or local municipality. Minnesota Noxious Weed Law.

Background

Purple loosestrife is native to Europe and Asia. It was introduced to North America in the early 1800s in ship ballast and as a medicinal herb. It is now found in 40 US states.

Description

- A semi-aquatic perennial species that typically forms a dense bushy growth of many erect stems reaching heights of approximately 4- 7 feet tall. It is highly visible from July through September because of its robust purple flowering spikes.
- Leaves are smooth-edged, slender, pointed and arranged in opposite pairs along ridged stems.
- Showy spikes of flowers develop at the tops of each stem consisting of many individual 5- 7 petaled purple flowers.
- Large roots develop over time and store high levels of nutrients providing the plant with reserves of energy early in the spring or during stressful periods.

Habitat

Purple loosestrife prefers wet soils or standing water. Loosestrife plants are typically found in poorly drained soils of road right-of-ways and trails, drainage ditches, culverts, lake shores, stream banks, and a variety of wetland habitats.

Means of spread and distribution

Purple loosestrife reproduces both by seed and vegetative propagation which allows it to quickly invade new landscapes. Each flower spike can produce thousands of tiny seeds that are easily dispersed by wind, water, snow, animals, and humans. Purple loosestrife is found throughout Minnesota. The Minnesota Department of Natural Resources estimates that infestations have been recorded in 77 of Minnesota's 87 counties, covering 58,000 acres of lake, river, and wetland habitats.

page one

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Impact

Purple loosestrife aggressively invades lakes, rivers, and wetlands, creates large monocultures, and significantly decreases the biological diversity of native plant and wildlife populations.

Prevention and management

- A sound management plan will take several years of commitment, especially on older stands that have an established seed bank. Regular follow-up is critical to ensure the population is decreasing.
- Hand pulling or digging is only recommended when a few plants are discovered on a property. To successfully control purple loosestrife in this manner, the entire root system has to be removed from the soil to prevent re-sprouting of new stems. Checking the site periodically for several years is recommended to ensure that new seedlings or re-sprouts can be destroyed.
- Mowing or cutting is not practical for sites where loosestrife is growing in an aquatic or semi-aquatic environment. However, if conditions permit, and if executed prior to flowering, mowing or cutting can reduce seed production. Re-sprouts will vigorously appear following mowing, so follow-up cutting will be necessary to prevent seed production during the growing season. Make sure to wash equipment thoroughly following mowing to prevent spread of seeds to new areas.
- Various herbicides have been used successfully against purple loosestrife in Minnesota. Due to the fact that purple loosestrife is a semi-aquatic to aquatic species, it is IMPORTANT to use only herbicides that are labeled and approved for use in or around water. If treating plants near water with herbicide, please be aware of the state pesticide laws and use only products labeled for aquatic use. If using herbicide treatments, check with your local University of Minnesota Extension agent, co-op, or certified landscape care expert for assistance and recommendations. There are several businesses throughout the state with certified herbicide applicators that can be hired to perform chemical applications.
- Biological control, using host-specific natural enemies of purple loosestrife, is a popular form of management for this species in Minnesota. Biological control agents feed specifically on purple loosestrife plants and have been shown to provide a long-term sustainable management solution. The Minnesota Department of Natural Resources, in cooperation with the Minnesota Association of County Agricultural Inspectors, oversees a statewide biological control program for this noxious weed.
- Purple loosestrife lifecycle and treatment timing graphic

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ENVIRONMENTAL Fact Sheet

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

29 Hazen Drive, Concord, New Hampshire 03301 • (603) 271-3503 • www.des.nh.gov

WD-BB-45 2019

Purple Loosestrife

See pgs. 2+3

Purple Loosestrife
(Lythrum salicaria)

Purple loosestrife is an erect perennial herb standing 3 to 10 feet tall. Its average height is 5 feet. The plant blossoms every July through September with purple flowers that are located in long spikes at the tip of its branches. Its leaves are opposite or whorled on a square, sometimes woody stem. One purple loosestrife plant may grow as an individual stalk or as several stalks clumped together. As beautiful as this plant may appear, its beauty is deceptive, as purple loosestrife is gradually altering our nation's wetlands. Native look-alikes of this plant are swamp loosestrife and blue vervain.

Species Range and Distribution
Purple loosestrife is a problem in New Hampshire and throughout North America and Canada. The northeastern United States and southern Canada are the areas experiencing the greatest impact of purple loosestrife. The distribution of purple loosestrife ranges from being common to abundant, and many areas have been found to support dense stands of this plant.

How Was Purple Loosestrife Introduced?
Purple loosestrife is native to Eurasia. It was originally introduced to eastern North America in the early to mid-1800s. This invasive plant was either accidentally introduced via ship ballasts, deliberately brought over as an ornamental plant or its seeds were transported by imported raw wool and sheep.

Where Does Purple Loosestrife Invade?
Optimum habitats for purple loosestrife include freshwater marshes, open stream margins and alluvial floodplains. Purple loosestrife also invades wet meadows, pasture wetlands, cattail marshes, stream and river banks, lake shores, irrigation ditches, drainage ditches and stormwater retention basins. Purple loosestrife is often associated with cattail, reed canary grass and other moist soil plants.

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What Makes Purple Loosestrife a Good Invader?

Purple loosestrife prefers moist organic soils, fluctuating water levels and full sunlight, which are conditions that can stress many native plants. However, this plant can survive in many conditions associated with disturbed sites, such as construction sites. It can tolerate a wide range of environmental conditions (temperature, sunlight, pH, nutrient levels) and can establish itself on a variety of substrates (gravel, sand, clay, and organic soil). Purple loosestrife has no natural predators, such as disease or insects on this continent; therefore, it has an incredible ability to out-compete native vegetation and to form dense stands.

How Does Purple Loosestrife Spread?

Purple loosestrife's ability to spread contributes to its success as an invader. One adult purple loosestrife plant can produce 2.5 million to 2.7 million seeds annually. Seeds are roughly the size of ground pepper grains, and are viable for many years. They may remain dormant in the soil until conditions are right for germination. These seeds are easily dispersed and transported by water, wind, bird feathers, animal fur, footwear, boats, boat trailers and car tires. Purple loosestrife is also capable of resprouting from broken stems, underground roots and plant fragments. If mowed, the cut stem pieces will send out new roots and form new plants. The once commercial sale of purple loosestrife also increased the spread of this plant by introducing it to various wetlands and home gardens. It has been illegal to sell, purchase, propagate, import, distribute and transport *Lythrum* species in New Hampshire since 1999.

Why Is Purple Loosestrife a Problem?

Purple loosestrife negatively affects both wildlife and agriculture. It displaces and replaces native flora and fauna, eliminating food, nesting and shelter for wildlife. Purple loosestrife forms a single-species stand that no bird, mammal, or fish depends upon, and germinates faster than many native wetland species. If wildlife species are displaced, those that cannot move into new areas may be lost. By reducing habitat size, purple loosestrife has a negative impact of fish spawning and waterfowl habitat. The plant also diminishes wetland recreational values such as boating, fishing and hunting. This, in turn, may hurt local economies. Purple loosestrife affects agriculture by blocking flow in drainage and irrigation ditches and decreasing crop yield and quality.

What Are Some Solutions to the Purple Loosestrife Problem?

Three possible control methods exist for purple loosestrife. These include physical, biological and chemical means. None of these methods will completely eliminate purple loosestrife, but they will control the populations within ecologically acceptable limits.

Physical Control of purple loosestrife is possible for smaller stands of plants (fewer than about 100 plants). It involves physically removing the plant from the soil. Removal should ensure that all root and plant pieces are dug out of the soil. The best time to remove purple loosestrife from the soil is prior to seeding time (August/September). Removal after this time will not eliminate the seeds that

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have already been produced by the plant. Once the plants are removed they should be burned or tightly bagged to prevent the spread of seeds or resprouting. Composting is not an alternative as the plants may regenerate in the compost pile. Many local conservation commissions, garden clubs and other specialty groups throughout New Hampshire are initiating their own purple loosestrife monitoring programs involving mapping, hand-pulling and disposal of this nuisance plant. If hand-pulling during flowering time, cut off the flower stalk and bag it before removing the plant and roots to minimize seed dispersal.

Biological Control is a method of control involving the release of predators to attack the pest species. Three different species have been used in North America to attempt to control purple loosestrife: two species of beetles and one weevil. These three species are common in Europe where they combine to act on the leaves and roots, thereby controlling its populations. The insects were proven "safe" to our natural environment as a result of extensive research conducted at Cornell University.

In the late 1990s, the New Hampshire Departments of Agriculture and Transportation initiated a joint project to introduce beetles into areas infested with purple loosestrife. The beetles feed on the plants, curbing their growth within a five-year period, depending on the size of the infestation. There are now over 20 such sites in New Hampshire, with each showing signs of success with thinning purple loosestrife populations. The beetles appear to be migrating to nearby purple loosestrife sites, controlling growth there. Their population is regulated by the purple loosestrife growth, and the beetles have been making good headway at reducing populations of this particular invasive plant in the state.

Chemical Control: In dry areas, Round-Up can be used for control. In wetlands or areas with standing water, only a licensed applicator working under a special permit can conduct an herbicide treatment.

What Can I Do to Help?

There are many things you can do to help prevent the spread of purple loosestrife. The first step is to ***recognize it***. Purple loosestrife is most easily identified when in bloom (July and August), before it goes to seed. The second step is to ***report it***. If a large infestation is identified, you can contact the departments of Agriculture, Transportation or Environmental Services. Mapping the infestation is helpful as well. The third step is to ***remove it***. Check with authorities prior to removal to determine what permits may be needed and how best to proceed.

For more information about exotic aquatic plants, please contact the Exotic Species Program at (603) 271-2248, or go to www.des.nh.gov and search "Exotic Species."

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Off-road vehicle best management practices for forestlands: A review of scientific literature and guidance for managers

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ABSTRACT: Management of off-road vehicles (ORVs) on forestlands has become increasingly challenging as various user groups compete for a finite amount of land on which to recreate. Additionally, no uniform methods exist for managing ORVs in forests to reduce their impacts to the environment and lessen conflicts with other user groups. The objectives of this paper are to review recent research on the environmental and social effects of ORVs in forested landscapes, and based upon the best available science, propose Best Management Practices (BMPs) for forestlands to help minimize ORV impacts. We found extensive scientific literature documenting the physical and ecological effects of ORVs in forestlands, ranging from soil compaction to non-native plant dispersal. Many species of wildlife are also affected by ORV use through direct and indirect mortality, disturbance and cumulative loss of habitat. Conflict with non-motorized users has been documented as well, resulting in diminished recreational experience and displacement of quiet users. The BMPs presented here for ORV management and monitoring in forestlands should help managers provide opportunity for motorized recreation while protecting natural resources and reducing user conflicts.

Keywords: Off-road vehicle, ORV, Best Management Practices, BMPs, erosion, stream sedimentation, invasive species, wildlife disturbance, user conflicts

INTRODUCTION

Management of outdoor recreation including off-road vehicles (ORVs) use is becoming increasingly challenging as more people recreate on public and private forestlands. Technological advances have given ORVs more power and control, allowing even beginners to access remote wildlands. This has increased the popularity of riding ORVs, and the potential for impacts on natural resources and conflicts between off-roaders and non-motorized forest visitors. The environmental and social impacts of their use have been well documented in hundreds of research articles, extensive literature reviews (e.g., Joslin and Youmans 1999, Schubert and Associates 1999, Gaines et al. 2003, Davenport and Switalski 2006, Ouren et al. 2008) and books (e.g., Knight and Gutzwiller 1995, Liddle 1997, Havlick 2002). While the majority of research on this topic has focused on arid locations (e.g., Webb and Wilshire 1983) and more recently beach environments (e.g., Lucrezi and Schlacher 2010), many recent studies have also addressed ORV use in forested landscapes.

Best Management Practices (BMPs) provide science-based criteria and standards that land managers follow in making and implementing decisions about human uses and projects that affect natural resources. BMPs are usually developed for a particular land use and are based on ecological considerations, legal obligations and pragmatic experience, and should be supported by the best available scientific knowledge. Several states have adopted ORV management plans, policies or strategic plans (e.g., Michigan Department of Natural Resources 2008, California State Parks 2009, Arizona State Parks 2010) and trail design, and construction and maintenance manuals have been written (e.g., Wernex 1994, Meyer 2002, Crimmins 2006). Unfortunately, no consistent broad-based guidelines have been developed for planning, implementing and monitoring off-road vehicle use on forestlands based on ecological considerations. In addition, most of the state plans and policies, and design and construction manuals, tend to consider ORV trail and forest road design, management, maintenance and monitoring from a viewpoint centered around legal and administrative stipulations, user needs and desires, and avoiding soil erosion. It is very seldom that such state plans or design and construction manuals take a more ecological or holistic viewpoint in deciding where to site trails, or one that stresses consideration of multiple natural resources.

This paper reviews recent scientific literature on ORV effects on forestlands, and based upon the best available science, proposes Best Management Practices (BMPs) to aid land managers in travel planning or in any decision-making process related to off-road vehicle management on forested lands. Each section reviews research on a key resource impact of ORVs, and is followed by a list of BMPs for planning and decision-making, implementation and monitoring to mitigate the impact. These BMPs will help transportation managers place ORV routes in areas where they can be enjoyed by motorized recreationists while minimizing harm to the environment and reducing user conflicts.

Off-road vehicle BMPs can be easily used by a manager who wants to incorporate science into creating an ecologically and socially sustainable route system. For example, research has found that the risk of stream sedimentation and negative impacts on aquatic habitat are highest at stream crossings. Thus, we propose the BMP to choose route locations with the fewest number of stream crossings when planning a route. In another example, research found that ORVs cause disturbance in a number of wildlife species. Accordingly, our BMP recommends setting levels of acceptable disturbance that are compatible with maintaining species viability. Furthermore, studies have found that closing routes benefits plant and wildlife populations. We further recommend that routes be closed and restored if there is an unacceptable impact to the resource.

This paper is an abridged and updated version of our original report, *"Best Management Practices for Off-Road Vehicle Use on Forestlands,"* available online at: http://www.wildlandscpr.org/ORV-BMPs. These BMPs have already been used during environmental analyses for travel management planning on many national forests (e.g., USDA FS 2009, USDA FS 2010, USDI BLM and USDA FS 2010). For example, the Ashley National Forest found them to be useful to fill information gaps and supplement existing direction (USDA FS 2009). Additionally, the Forest Service has recently included these Best Management Practices for reference in its report, *"Comprehensive Framework for Off-Highway Vehicle Trail Management"* (Meyer 2011). This official Forest Service document will be widely used in all future efforts to manage off-road vehicle use on national forest lands.

METHODS

To identify the most current research on off-road vehicles, we searched an online bibliographic database of over 20,000 citations documenting the physical and ecological effects of roads and off-road vehicles (http://www.wildlandscpr.org/bibliographic-database-search). First completed in 1995, this database is updated every two years by Wildlands CPR by systematically searching for literature related to roads and motorized recreation. The database contains a variety of scientific and "grey" literature including journal articles, conference proceedings, books, lawsuits, and agency reports. The database was most recently updated in 2010 using an established protocol that systematically searches 13 ecological and scientific databases. Seventeen primary keywords/descriptors were used to identify research on any road, highway, or ORV effect (positive or negative) on ecosystems, wildlife, and natural resources. Each primary keyword was used alone and in Boulian combination with 89 descriptor words and phrases. Each secondary keyword was used alone and in Boulian combination with primary keywords and other descriptor words and phrases (for a list of keywords please contact lead author).

Review of the Literature and Best Management Practices

We found extensive research on the effects of off-road vehicles (ORVs) on natural resources. Several studies published in the 1970s first documented the effects of ORVs on soils in the California desert. A flurry of studies followed resulting in the first book dedicated to this topic, *Environmental Effects of Off-Road Vehicles – Impacts and Management in Arid Regions* (Webb and Wilshire 1983). As ORV popularity expanded beyond the California deserts, so did research examining its effects around the globe. Impacts on streams, vegetation, and wildlife have come to the forefront of research, as have other ecosystems such as beach environments and forestlands - the primary focus of this review.

Soil Compaction and Erosion Research

Weighing several hundred pounds, ORVs compress and compact soil, reducing the absorption of water into the soil, resulting in increased flow of water across the ground (Sack and da Luz 2003, Meadows et al. 2008). This surface flow increases erosion of soils and can also add sediment to streams (Chin et al. 2004, Ayala et al. 2005, Welsh 2008), which degrades water quality, buries fish eggs, and generally reduces the amount and quality of aquatic habitat (Newcombe and MacDonald 1991).

In ORV use areas, soil erosion is accelerated directly by the vehicles, and indirectly by increased runoff of precipitation and by creating conditions favorable to wind erosion. Knobby and cup-shaped tires that help ORVs climb steep slopes are responsible for major direct erosional losses of soil. As the tire protrusions dig into the soil, forces far exceeding the strength of the soil are exerted, resulting in a "rooster tail" of soil and small plants thrown behind the vehicle. In an Ohio forest, Sack and da Luz (2003) measured erosional losses in high-use ORV areas as high as 209 kg/m^2. Meadows et al. (2008) found that ATV trails on U.S. Forest Service lands on average produced 10 times more sediment that undisturbed soils. It has also been demonstrated experimentally that sediment loss increases with increased ORV traffic (Foltz 2006), and the greatest sediment yields occur when trails are wet (Wilson and Seney 1994).

Most soils are vulnerable to compaction and erosion due to several factors. An analysis of more than 500 soils at more than 200 sites found that virtually all types of soils are susceptible to ORV damage (Schubert and Associates 1999). Clay-rich soils, while less sensitive to direct mechanical displacement by ORVs, have higher rates of erosion than most other soil types, and when compacted, produce a strong surface seal that increases rainwater runoff and gullying. Sandy and gravelly soils are susceptible to direct excavation by ORVs, and when stripped of vegetation, are susceptible to rapid erosion – usually by rill and gully erosion.

ORV impacts on forest soils are compounded by the loss of vegetation following ORV use. Stable vegetation keeps soil in place; once anchoring vegetation is removed, soil erosion increases. When vehicles damage or uproot plants, exposed soils easily become wind-blown or washed away by water. Wilshire et al. (1978) first described the direct effects of ORVs on vegetation, such as crushing and uprooting of foliage and root systems, as well as the indirect effects caused by the concomitant erosion. The indirect

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effects include undercutting of root systems as vehicle paths are enlarged by erosion, creation of new erosion channels on land adjacent to vehicle-destabilized areas due to accelerated runoff or wind erosion, burial of plants by debris eroded from areas used by vehicles, and reduction of biological capability of the soil by physical modification and stripping of the more fertile upper soil layers. Biological soil crusts (commonly found in deserts, but also present in some forestlands) are particularly sensitive to wind erosion following ORV use and take decades to recover (Belnap 2003).

Stream Sedimentation Research

While driving on roads has long been identified as a major contributor to stream sedimentation (for review see Trombulak and Frissell 2000), recent studies have found ORV use on trails to be a significant source of fine sediment in streams (Chin et al. 2004, Ayala et al. 2005, Welsh 2008). Stream sedimentation greatly degrades aquatic habitat (Newcomb and MacDonald 1991). For example, Chin et al. (2004) found that in watersheds with ORV use streams contained higher percentages of sands and fine sediment, lower depths and lower volume – all characteristics of degraded stream quality.

While forest roads often have greater erosion potential, ORV routes often lack culverts or bridges at stream crossings, and users often simply drive across creeks. By fording creeks, sediment is released into the water by several mechanisms including: 1) concentration of surface runoff through the creation of wheel ruts, 2) exposed surfaces from the existence of tracks, 3) increased runoff from soil compaction, 4) vehicle backwash, and 5) undercutting of banks from waves (Brown 1994). A modeling exercise found that the average annual sediment yield from one ORV stream crossing in Alabama could reach 126.8 tons/ha (Ayala et al. 2005). Another study in Colorado found that ORV trails produced six times more sediment than unpaved roads and delivered 0.8 mg/km^2 of sediment to the stream network each year (Welsh 2008). Coe and Hartzell (2009) recently reported that the well-traveled Rubicon jeep trail in California's Sierra Nevada Mountains had rates of stream sedimentation 50 times higher than adjacent forest roads.

Best Management Practices for soils

PLANNING AND DECISION-MAKING BMPS FOR FOREST SOILS

- Do not locate routes in areas with highly erodible soils.
- Locate routes only in areas with stable soils; avoid locating routes in areas with biological crusts.
- Do not locate routes to climb directly up hillslopes. Route grades should be kept to a minimum and not exceed an eight degree (15 %) grade.
- Do not locate routes above treeline or in other high elevation areas that are ecologically significant and/or especially prone to erosion.
- Locate routes a minimum distance (as listed below) from waterbodies and wetlands:
    - Fish-bearing streams and lakes – 91 m (300 ft)
    - Permanently flowing non-fish-bearing streams – 46 m (150 ft)
    - Ponds, reservoirs, and wetlands greater than one acre – 46 m (150 ft)
- Do not designate new routes requiring stream crossings and prioritize closure, re-routing or creating bridge crossings for existing routes that have stream crossings.
- Do not locate routes in areas with soils contaminated by mine tailings, or mine tailings reclamation sites, at least until they are recovered, fully stable and able to sustain safe ORV usage. If route construction is necessary, reclamation activities should be completed prior to route construction.
- Close and restore routes that cause high levels of erosion (e.g., raise sedimentation above Total Maximum Daily Loads (TMDL) and reduce native fish population potential).
- Require all motorized camping to occur in designated campsites. Reclaim undesignated motorized camping sites.

IMPLEMENTATION BMPS FOR FOREST SOILS

- Identify the type or types of soil and steepness in the area that is being affected by ORVs and use this information to prioritize mitigation efforts and create target management objectives to minimize erosion.

- Identify where waterbodies and wetlands are located, where routes cross them, and whether fish are present.
    - Prioritize stream crossing closures and route relocations, and if necessary, determine appropriate sites for upgrades and/or bridge crossings.
- Ensure adequate maintenance of bridges and culverts on routes to help prevent unauthorized stream crossings that might damage soils, streambanks, riparian vegetation, or other aquatic resources.
- Estimate the average soil loss for areas that are currently and obviously negatively affected by ORVs using the Universal Soil Loss Equation. Close and restore routes if the soils are determined to exceed standards for tolerable soil loss.
- If closing or moving a particularly damaging route is not possible, mitigate erosion with waterbars or other erosion control measures.
- Close and restore areas that have become "mud bogging areas," or are prone to "mud bogging."
- Close and restore routes where it has been determined, through analysis, that cumulative impacts of erosive activities (e.g., ORVs combined with fire, livestock grazing or other erosive stressors) are leading to a stream failing to meet erosion standards.
- Prioritize for closure renegade routes going directly up hillslopes, into wetland areas (including wet meadows), or adjacent to designated routes.
- Adaptively manage by closing or mitigating a damaging route if monitoring identifies that forest soil conditions are no longer in compliance with planning and decision-making BMPs.

MONITORING BMPS FOR FOREST SOILS

- Monitor for the amount of erosion occurring on all routes (designated and renegade). Gather data needed for the Universal Erosion Soil Loss Equation.
- Regularly survey for and identify renegade off-route spurs.
- Map stream crossings without culverts or bridges and note stream sedimentation levels and visible soil/channel impacts in these areas.
- Identify areas of significant amounts of bare soil or route-widening along routes using photographs and route width measurements.
- Monitor closed and restored routes to ensure the measures taken are effectively mitigating impacts to forest soils.

Trampling Impacts on Vegetation and the Spread of Invasive Plants Research

Riding a several hundred pound ORV off-route or cross-country can crush, break, and ultimately reduce overall vegetative cover. Vehicular impacts on vegetation range from selective kill-off of the most sensitive plants to complete loss of vegetation in large "staging areas." Plants that do survive are weakened, malformed, and more susceptible to disease and insect predation. Trampling by ORVs can also damage germinating seeds – even those in the soil. A study that examined ORV use on several U.S. National Forests found at least a 40 percent reduction in vegetation following ORV traffic (Meadows et al. 2008). Similarly, in a desert example in southern California, Groom et al. (2007) found 4-5 times fewer plants in an ORV use area than a protected area. However, when one of the study areas was closed to motorized use (and experienced a year of high rainfall), there appeared to be a recovery of that population.

In addition to trampling effects, ORVs are a major vector for non-native invasive plant species. With knobby tires and large undercarriages, ORVs can unintentionally transport invasive non-native species deep into forestlands. For example, one study found that in a single trip on a 16.1 km (10 mi) course in Montana, an ORV dispersed 2,000 spotted knapweed (*Centaurea stoebe*) seeds (Montana State University 1992). In Wisconsin, a survey of seven invasive plant species along ORV routes found at least one of these exotic plant species on 88% of segments examined (Rooney 2005). ORVs in roadless areas pose a particular risk of spreading invasive non-native species because roadless areas often have less weeds present. Gelbard and Harrison (2003) found that ORVs are the chief vector for invasive species infestation in California roadless areas, which were shown to be very important refuges for native plants. Furthermore, as a result of ORV use, the size and abundance of native plants may be reduced, which in turn permits invasive or nonnative plants to spread and dominate the plant community (GAO 2009).

Impacts to vegetation can have cascading effects throughout an ecosystem. For example, on an intensively used ORV route in Idaho, native shrubs, bunch grasses, and biological crust were greatly reduced close to the route and replaced with rabbitbrush (*Chrysothamnus* spp.) and non-native cheat grass (*Bromus tectorum.*; Munger et al. 2003). Because of these habitat changes, fewer reptiles were found alongside the route than were found 100 m away (328 ft). In another example of cascading impacts, Waddle (2006) found that three out of four species of ground-dwelling anurans in Florida were negatively influenced by ORVs due to trampling of vegetation and altered hydrology.

Best Management Practices for vegetation

PLANNING AND DECISION-MAKING BMPS FOR VEGETATION

- Locate routes in areas that do not have sensitive, threatened or endangered plant species.
- Locate routes where there are no unique plant communities such as aspen stands, bogs, wetlands, riparian areas and alpine habitat types.

IMPLEMENTATION BMPS FOR VEGETATION

- Identify sensitive, threatened, and/or endangered plants present in ORV use areas, as well as rare, fragile and/or unique plant communities (i.e., aspen stands, bogs, wetlands, riparian, alpine areas). Record the survey information into a GIS (Geographic Information System) database.
- Close areas where sensitive, threatened and/or endangered plant species are at risk.
- Remove invasive non-native plants from routes when feasible.
- Prohibit motorized camping in areas where invasive plants are a problem.
- Control invasive plants in staging areas to avoid their spread onto routes.
- Identify areas where invasive plants present a problem and require that all ORVs using such areas wash vehicles when exiting such areas.
- Close and restore routes documented as contributing to the spread of non-native invasive plants into relatively weed-free areas.
- Use native species when revegetating a closed route.
- Modify livestock grazing practices or halt grazing in newly restored areas where routes have been closed.

MONITORING BMPS FOR VEGETATION

- Monitor routes for sensitive, threatened, and/or endangered plants in ORV use areas, as well as rare, fragile and/or unique plant communities.
- Monitor for unauthorized spur routes into areas with sensitive, threatened, and endangered plant species.
- Monitor routes for presence and spread of non-native species or the decline of native species.
- Monitor closed and restored routes to ensure effective mitigation for damaged vegetation is occurring.
- Monitor the success of revegetation projects.
- Adaptively manage by closing or mitigating a route if monitoring identifies that vegetation conditions are no longer in compliance with planning and decision-making BMPs.

Wildlife Mortality, Disturbance, and Habitat Loss Research

Driving ORVs in forested environments has led to direct and indirect impacts on wildlife. When driven at high speeds, ORVs can collide with small animals and cause direct mortality. However, there are also many indirect impacts that can increase wildlife mortality. For example, in a review of research on mesocarnivores in the U.S., Weaver (1993) reported that ORV access increases the trapping vulnerability of American marten (*Martes americana*), fisher (*Martes pennanti*), and wolverine (*Gulo gulo*). Lynx (*Lynx lynx*) are also thought to be sensitive to road density due to increased trapping pressure (Singleton et al. 2002).

ORV use also increases access for illegal harvest of wildlife in areas that are difficult for game wardens to patrol. For wolves (*Canis lupus*), one study found that 21 of 25 human-caused mortalities in the US Northern Rockies occurred within 200 m (656 ft) of a motorized

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gle how do invasive species affect biodiversity

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Invasive species can change the food web in an ecosystem by destroying or replacing native food sources. The **invasive species** may provide little to no food value for wildlife. **Invasive species** can also alter the abundance or diversity of **species** that are important habitat for native wildlife.

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Videos

DNR

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Terrestrial Invasive Species Program

GOALS

- Improve or enhance the ability of DNR staff to effectively manage terrestrial (land-based) invasive species on DNR-managed lands through prevention, management and inventory, outreach and communication, and research.
- Prevent or limit the negative impacts on Minnesota's ecology, economy and human health that can result from terrestrial invasive species such as Oriental bittersweet, wild parsnip, buckthorn, garlic mustard, earthworms, emerald ash borer and gypsy moth.
- Prevent and manage terrestrial invasive species to protect and/or restore habitats for wildlife species, especially those species in greatest conservation need.

HIGHLIGHTS

PREVENTION

- Worked with DNR staff to ensure that they had the equipment needed to prevent invasive species spread and follow DNR's Invasive Species Operational Order 113. The Operational Order went through a full departmental review in 2017 and was updated and signed by the commissioner.
- Through outreach and education with the public, worked to prevent the introduction of terrestrial invasive species to state-managed lands. The photo shows the new educational display at the State Fair.

MANAGEMENT AND INVENTORY

The Invasive Species Program initiated a funding program in 2006 for the management and inventory of terrestrial invasive plant species on state-managed lands. Funds are dispersed to DNR divisions and regions. Funding for this program has decreased from its high in 2009.

Fiscal Year 2018: Thirty-seven proposals totaling $389,695 were received; $217,620 was awarded for 26 projects.

Fiscal Year/s	Dollars Awarded	Acres	Number of Projects
2006-2007	$365,000	27,375	31
2008	$435,660	26,523	32
2009	$610,807	40,000 est.	47
2010	$606,777	27,955 + 40,000 from aerial survey	42
2011	$438,000	18,258	33
2012	$178,340	24,989 + 13,500 from aerial survey	26
2013	$160,000	7,547	22
2014	$144,249	11,860	18
2015	$270,674	12,994	26
2016	$192,339	5,501	23
2017	$219,834	5,755	21
2018	$217,620	In progress	26

FISCAL 2017 FUNDING DISTRIBUTION

Total $219,834 • 21 projects • 3,633 acres inventoried • 2,122 acres managed

Species inventoried and managed in various projects:

Bird's foot trefoil, black locust, bull thistle, butter and eggs, Canada thistle, chicory, common buckthorn, common burdock, common teasel, cow vetch, crown vetch, cut-leaved teasel, garlic mustard, glossy buckthorn, Japanese hops, Japanese/Bohemian knotweed, leafy spurge, meadow knapweed, moth mullein, must thistle, non-native bush honeysuckles, Oriental bittersweet, poison hemlock, Queen Anne's lace, reed canarygrass, Siberian elm, Siberian peashrub, spotted knapweed, tansy, wild parsnip, wooly cupgrass.

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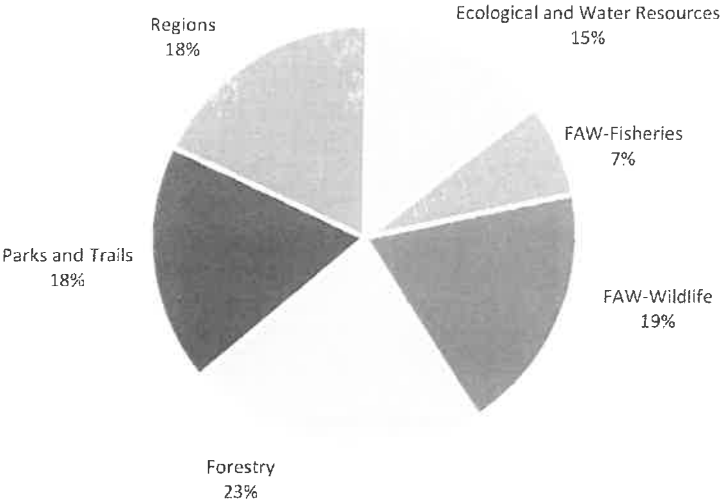
FISCAL YEAR 2017 FUNDING DISTRIBUTION



DNR CONTINUES TO USE EDDMAPS AS INVENTORY TOOL FOR INVASIVE SPECIES

EDDMapS (Early Detection and Distribution Mapping System) is a national website for collecting and sharing invasive species inventory information (www.eddmaps.org). In 2016, the DNR adopted EDDMapS for invasive species location information. The EDDMapS Midwest (www.eddmaps.org/midwest) webpage was created as a central source of information on invasive species in the Midwest.

The EDDMapS Midwest webpage and the associated Great Lakes Early Detection Network (GLEDN) app allows people to make reports of invasive species, collect photos associated with the locations, send reports through a system of verifiers, and view verified reports.

EDDMapS Midwest modernizes invasive species inventory collection and provides a centralized place for organizations to share data. EDDMapS collects data on aquatic and terrestrial invasive species including plants, diseases, insects, fish and other animals. In fiscal year 2017, DNR staff and contractors made 12,606 reports of invasive species locations covering 101,569 acres.

OUTREACH AND COMMUNICATION

The State Fair Invasive Species Display brought invasive species prevention messages to many State Fair visitors.

A new interactive screen exhibit debuted at the State Fair. Attendees could practice the actions of *PlayCleanGo: Stop Invasive Species in Your Tracks* through a hiking scene and ATV scene.

RESEARCH

Garlic mustard biological control took a big step forward in 2017. Garlic mustard *(Alliaria petiolata)* is an invasive biennial plant of forest understories. It is a challenging and expensive species to manage, so research to find a biological control insect began in 1998.

The Technical Advisory Group for Biological Control Agents of Weeds (TAG) recommended in February of 2017 that the root-mining weevil, *Ceutorhynchus scrobicollis* be released for biological control of garlic mustard in North America. This panel of 19 scientists from across the United States and Canada advises USDA APHIS-PPQ (the United States Department of Agriculture - Animal and Plant Health Inspection Service, Plant Protection and Quarantine program) on whether new biological control agents should or should not be released in North America. This is a major milestone culminating of over 18 years of research.

The next steps are for review by USDA-APHIS staff who oversee permitting of biological control agents of weeds to determine if they agree with the TAG review panel recommendations. That will be followed by U.S. Fish and Wildlife Service review to ensure compliance with the Endangered Species Act, and additional APHIS staff review to ensure compliance with the National Environmental Policy Act and with executive orders related to tribal coordination. In

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DNR RESPONSE TO COVID-19: For details on adjustments to DNR services, visit this webpage (https://www.dnr.state.mn.us/covid-19.html). For information on the state's response, visit the Department of Health website (https://www.health.state.mn.us/diseases/coronavirus/index.html) .

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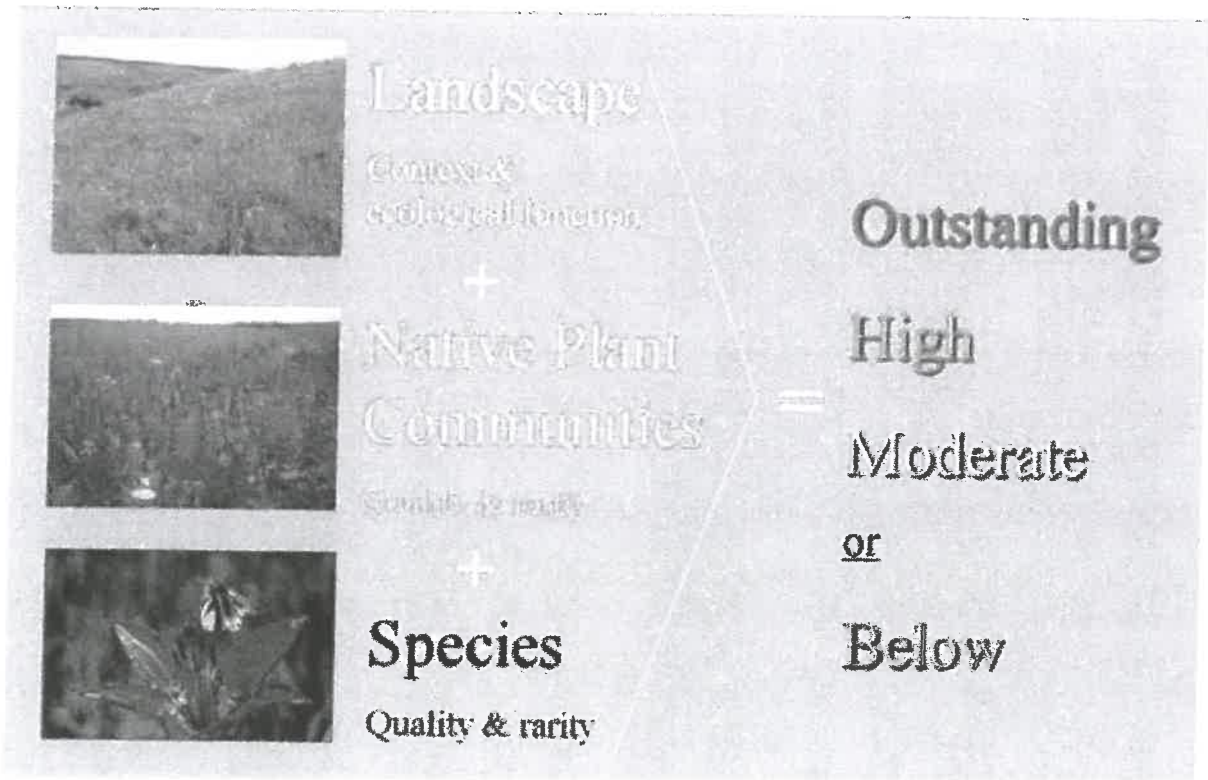
MBS Site Biodiversity Significance Ranks

At the conclusion of work in a geographic region, Minnesota Biological Survey (MBS) ecologists assign a biodiversity significance rank to each survey site. These ranks are used to communicate the statewide native biological diversity significance of each site to natural resource professionals, state and local government officials, and the public. The biodiversity ranks help to guide conservation and management.

A site's biodiversity significance rank is based on the presence of rare species populations, the size and condition of native plant communities within the site, and the landscape context of the site (for example, whether the site is isolated in a landscape dominated by cropland or developed land, or whether it is connected or close to other areas with intact native plant communities).



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There are four biodiversity significance ranks, outstanding, high, moderate, and below:

- "**Outstanding**" sites contain the best occurrences of the rarest species, the most outstanding examples of the rarest native plant communities, and/or the largest, most ecologically intact or functional landscapes.
- "**High**" sites contain very good quality occurrences of the rarest species, high-quality examples of rare native plant communities, and/or important functional landscapes.
- "**Moderate**" sites contain occurrences of rare species, moderately disturbed native plant communities, and/or landscapes that have strong potential for recovery of native plant communities and characteristic ecological processes.
- "**Below**" sites lack occurrences of rare species and natural features or do not meet MBS standards for outstanding, high, or moderate rank. These sites may include areas of conservation value at the local level, such as habitat for native plants and animals, corridors for animal movement, buffers surrounding higher-quality natural areas, areas with high potential for restoration of native habitat, or open space.

More information is available in the Guidelines for Assigning Biodiversity Significance Ranks (https://files.dnr.state.mn.us/eco/mcbs/biodiversity_significance_ranking.pdf) PDF (170Kb)

(https://files.dnr.state.mn.us

Draft Map of Areas of Biodiversity Significance in Minnesota

This map displays areas of biodiversity significance in Minnesota, including sites across the state that have been determined by the Minnesota Biological Survey (MBS) to have outstanding, high, or moderate biodiversity significance according to the criteria described above, and several large wilderness or protected areas in the northern part of the state.

Sites of biodiversity significance mapped by MBS

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DNR RESPONSE TO COVID-19: For details on adjustments to DNR services, visit this webpage (https://www.dnr.state.mn.us/covid-19.html). For information on the state's response, visit the Department of Health website (https://www.health.state.mn.us/diseases/coronavirus /index.html) .

Page Menu

Minnesota Scientific and Natural Areas Program Biodiversity

Determining the best candidates for Natural Area protection is a complex process. Natural area conservation planning focuses on areas of high biodiversity. We use the following tools, concepts and resources to evaluate and manage sites.

The value of biodiversity (the variety of life and its processes)

Minnesota's biodiversity has evolved over millennia into complex ecosystems. A myriad of species interact with each other and environmental factors such as soils, topography, hydrology and climate within these ecosystems.

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Preserving biodiversity has benefits (ecosystem services) such as:

- Maintaining healthy, stable plant and animal populations
- Protecting genetic diversity
- Protecting water and soil resources
- Filtering pollution and nutrient recycling
- Contributing to climate stability and carbon storage
- Recovering from catastrophic events
- Providing sources for food, medicine and other products
- Research, education and monitoring
- Recreation, tourism and inspiration

In areas where biodiversity is threatened, losing species can affect the ecosystem's ability to function properly and provide these services. Maintaining biodiversity reduces voids and the entire ecosystem maintains a higher degree of resilience.

Conservation planning for natural areas focuses on areas of high biodiversity as well as habitats for rare species.

Resilience as a strategy

Resilience is the capacity of an ecosystem to cope with disturbance. Resilience is critical to reducing climate change and fragmentation from land development. As climate change affects ecosystems they will face increasing vulnerability. An effective strategy at easing these negative impacts is to build resilience into native communities by:

- Creating large protected areas and corridors to provide pathways for species to migrate to more suitable habitats
- Preserving a greater variety of habitats for desirable species

The SNA program is using both strategies for resilience to maintain Minnesota's biodiversity.

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Biodiversity significance (/eco/mcbs/biodiversity_guidelines.html) is a ranking based on the size and condition of native plant communities and how they fit in an ecological landscape. It also includes the presence or absence of rare species populations. The rankings are 'outstanding', 'high', 'moderate' and 'below'. Ecologists with the Minnesota Biological Survey (/mbs/index.html) determine this status. This ranking is used to help prioritize Natural Area protection efforts.

Minnesota's Ecological Classification System (ECS)

Ecological landscape classifications are used to identify, describe, and map progressively smaller areas of land with increasingly uniform ecological features. Minnesota's Ecological Classification System (ECS) (/ecs/index.html) uses biotic and environmental factors, including climate, geology, topography, soils, hydrology and vegetation.

The largest units of the ECS are provinces and are defined primarily by climate. Minnesota has four provinces. Provinces are divided into 10 sections based on glacial deposits, topography and plant distributions. The 26 subsections of the ECS are further refined by local vegetation, especially trees, among other factors. Individual Scientific and Natural Areas (/snas/index.html) note the subsection in which they are located. Native plant communities are a finer grading of the classification system.

Minnesota's Native Plant Communities

Local groupings of trees, shrubs, grasses and forbs that interact with each other and their environment are called native plant communities (/npc/index.html) and are characterized by the kinds and quantities of species they contain. They form recognizable units, such as oak savannas, pine forests, cattail marshes and other communities that tend to repeat over space and time.

Plant communities are subject to change. They form in response to climate and nutrients, as well as catastrophic flooding and fires. In the absence of change, they can be fairly stable over time. However they can also develop into something complete new. For example, a beaver dam can cause significant flooding and as a result, over a period of time, a new community will form in the flooded area. Places where native species have been largely replaced are no longer considered native plant communities.

Native plant communities serve as the basis for evaluating Scientific and Natural Area priorities. The Minnesota Biological Survey (/mbs/index.html) has identified, surveyed, and prioritized communities and rare species for research and conservation. Minnesota's Native Plant Community Classification (/npc/classification.html) serves as

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minnesota's forest INVADERS

A Guide to Invasive Species

The Minnesota Sustainable Forestry Initiative® (SFI) Implementation Committee

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AMUR MAPLE

Originating in Asia, the Amur maples was first introduced to the U.S. in the mid 1800s. Planted as an ornamental, it is common in suburban landscapes. Seeds from Amur maples may take hold as invasives, spreading into areas where it displaces trees and shrubs in the forest understory or becomes established in open savannas.

IDENTIFICATION Reaching an average height of 20 feet, the Amur maple is a deciduous tree that grows best in full sun with well-drained soil, but can tolerate shade and poor soils. The four-inch leaves have three lobes (maple-shaped), with deeply toothed edges. The bark and twigs are smooth and light-colored. Clusters of fragrant white flowers appear in May and June, followed by two-winged fruit (seeds) that ripen in late summer. The prolific seeds can scatter widely when they drop from the tree. The foliage becomes bright red in the fall.

WHAT CAN YOU DO? Once established, Amur maple is not easily removed. The tree resprouts from stumps and may survive a prescribed burn. The best removal method is to pull up the root system. You can apply herbicides to cut stumps or the bark at the base of the tree.

BUCKTHORN

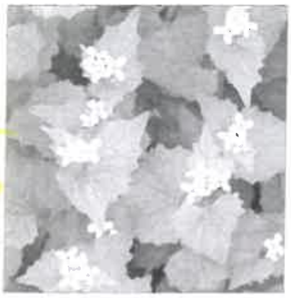
Two species of buckthorn were introduced to Minnesota by the nursery trade. Once popular for hedges and as ornamentals, common (European) and glossy (alder) buckthorn invade forests and wetlands, out compete native plants, and degrade wildlife habitat. The buckthorns are listed as noxious plants and are illegal to import, sell, or transport in Minnesota.

IDENTIFICATION Common buckthorn is a tall shrub, often with multiple stems at the base. Dark, glossy leaves are egg-shaped with fine-toothed edges and pointed tips. The leaves stay green late into the fall. Clusters of black, berrylike fruit ripen in August and September. The twigs have stout thorns.

Glossy buckthorn also is a tall understory shrub. Dark, glossy leaves are oval-shaped with smooth edges. Berry-like fruit clusters ripen from red-brown to dark purple in the fall.

WHAT CAN YOU DO? Remove buckthorn by cutting stems at ground level or pulling them up. Cut stems must be treated with an herbicide or covered with black plastic to prevent resprouting. Removing established buckthorn requires ongoing treatments to destroy new sprouts.

GARLIC MUSTARD



Garlic mustard is a European plant that spreads from gardens to the woods, where it may quickly take over the forest floor. Overwhelming native plant species, garlic mustard alters habitat for insects utilized as food by birds and small mammals. The tiny seeds are easily spread by birds or through human vectors such as logging equipment or recreational vehicles. Garlic mustard is classified as a prohibited noxious weed in Minnesota.

IDENTIFICATION Thriving in areas of forest disturbance, garlic mustard prefers moist, shaded deciduous woods or floodplain forests. It is a biennial plant that blooms with white, four-petal flowers in May of its second year. In the first year, dark green, leaves form rosettes. In the second year, the leaves are on alternate stems. When crushed, stems and leaves smell like garlic.

WHAT CAN YOU DO? If you find just a few garlic mustard plants, you can pull them up, remove them from the site, and dispose of them. A larger patch may be treated with prescribed burning. Spring or fall herbicide treatments can be used, too. The seeds remain viable for several years, so your boots and mechanical equipment must be washed thoroughly after being used where garlic mustard is found.

HONEYSUCKLE

Three species of exotic honeysuckle, Tartarian, Morrow's and Bell's, are considered invasives in Minnesota. Honeysuckles are popular ornamental shrubs readily available from nurseries. Birds feed upon honeysuckle berries and may transfer the shrub into the wild. Honeysuckles may become established in disturbed areas, abandoned fields, open woodlands, or other forest habitat, preferring drier soils.

IDENTIFICATION Honeysuckle shrubs are five to 15 feet high. They have multiple stems and may form dense thickets. Older stems have shaggy bark and a pithy interior. The simple leaves may be smooth or downy, depending upon the species. The shrubs are easily identified during the summer by their distinctive paired berries, which are red or yellow in color. Small, paired flowers bloom in May or June and are usually pink, but may be white or red.

WHAT CAN YOU DO? Honeysuckle can be pulled up, but pulling will expose the seedbed so it may resprout. Prescribed burning will kill seedlings and the living tops of mature plants, but repeated burns are necessary. You can apply herbicide to the foliage in the spring or treat cut stumps.

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REED CANARY GRASS

Common in Minnesota wetlands and low lying areas, reed canary grass forms a mat of vegetation that eliminates other plants and has minimal wildlife value. It has been widely planted for forage and erosion control. Reed canary grass may become established following wetland disturbances such as ditching, stream channeling or sedimentation.

IDENTIFICATION Reed canary grass is among the first to green up in the spring. Growing two to six feet high on erect, hairless stems, reed canary grass has long, tapering leaves up to 10 inches in length and up to a half-inch in width. Blooming in May and June, the densely clustered florets go from green to purple and become beige as summer progresses. Horizontal stems, called rhizomes, grow beneath the soil and sprout to form new plants.

WHAT CAN YOU DO? Reed canary grass is difficult to control. Prescribed burns may give native species a better advantage. Mowing in mid June and October reduces seed production. In some situations, reed canary grass can be plowed up and reseeded with favorable species. Herbicide applications are most effective in the fall.

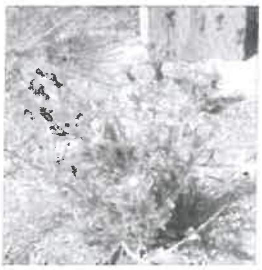
SIBERIAN PEA SHRUB

Commonly used in hedges and as an ornamental, the Siberian pea shrub may become established along woodland edges, in savannahs, or in disturbed areas. This native of Siberia and Manchuria out competes native shrubs and stubbornly resists removal. It is sold in nurseries for landscaping, as well as for shelterbelts and wildlife cover.

IDENTIFICATION The bean-like seed pods, up to 2 inches long, are a distinctive identifying trait. Compound leaves contain eight to 12 pairs of elliptic leaflets. Yellow flowers bloom in May and June. The plant has narrow branches with gray bark or yellowish green bark on new shoots. Siberian pea shrub may grow to about 20 feet in height.

WHAT CAN YOU DO? Repeated prescribed burns will set back Siberian pea shrub, though it may continue to resprout. You may pull up individual shrubs. Treat cut stumps or spray around the stem with herbicide.

SPOTTED KNAPWEED



This Eurasian immigrant is thought to have invaded North America via contaminated alfalfa in the 1890s. It is a serious problem for rangeland in western states and is spreading in Minnesota. The seeds may hitch a ride in loads of hay or in the undercarriage of vehicles or mechanical equipment. It prefers dry sandy soils and may take hold in disturbed or undisturbed areas. Spotted knapweed is phytotoxic, which means it is poisonous to neighboring plants. In Minnesota, it is classified as a secondary noxious weed.

IDENTIFICATION Look for thistle-like pink to purple flowers at the tips of wiry stems two to three feet in height. Blooms appear from July through September. The plant is a biennial or short-lived perennial that reproduces with brown seeds topped with a tuft of bristles.

WHAT CAN YOU DO? Be sure to wear long sleeves and gloves when working with spotted knapweed, because it is a skin irritant for some people. You may pull up individual plants or mow them often to prevent seed production. Very hot, prescribed burns are necessary to kill spotted knapweed. Early summer herbicide treatment may be effective. Biological controls are used in Minnesota with some effectiveness.

(30)-469-

COMMON TANSY

Common tansy was once cultivated for medicinal purposes and is still planted by gardeners. In the wild, it primarily grows along roadsides or in similar disturbed areas where it crowds out other vegetation. Widely established across northern Minnesota, common tansy is classified as a secondary noxious weed in the state. Most grazing animals avoid common tansy.

IDENTIFICATION Common tansy is a perennial typically growing in dense patches. From July through September, you can identify common tansy by the clusters of bright yellow, button-like flowers topping stiff, three foot high stalks. Compound leaves projecting from the stalk are fern-like in appearance. When crushed, the leaves are strongly aromatic. After the foliage dies back for the season, stiff, brittle stalks remain. Numerous, tufted seeds are dispersed from the flower heads by wind and water. The plant also spreads from the roots and may grow from small root pieces

WHAT CAN YOU DO? Common tansy can be spot-sprayed with herbicide. Repeated treatments may be needed to eliminate infestations. You can pull up individual plants, but they may resprout from remaining roots.

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THISTLE

Several non native thistles are found in Minnesota, including Canada, musk, bull, sow, and plumeless. They may be difficult to tell apart unless they are in bloom. Thistles generally become established in disturbed areas. Prickly leaves and stems make them unsuitable for grazing and uncomfortable for human contact. Some thistles are classified as prohibited noxious weeds in Minnesota.

IDENTIFICATION Thistles are easy to identify. A rosette-shaped plant with a deep tap root forms, then tall, flowering stems grow two to five feet. Small, purplish flowers bloom throughout the summer, creating clusters of tufted seeds distributed by winds and birds. Thistle seeds remain viable for many years. The plants can spread from shoots on the root system.

WHAT CAN YOU DO? Thistles are persistent and difficult to remove. You can try to pull them up, but they will resprout from pieces of roots remaining in the ground. Spring prescribed burning will set thistles back, but may trigger the plants to produce more seeds. You can follow up with spot-spraying with herbicides, preferably during the bud stage . Thistle-eating weevils are available, but have been known to eat native thistles, too.

WILD PARSNIP

Primarily found in southeastern Minnesota, wild parsnip becomes established in disturbed prairies and oak openings. A native of Europe and Asia, this is the same parsnip gardeners plant as a root crop. The sap from wild parsnip may cause skin rashes, irritation, and blistering.

IDENTIFICATION A perennial, wild parsnip may spend more than one year in the rosette stage. Blooming under favorable conditions from June to late summer, the plants produce flowerings up to four feet in height. Clusters of yellow flowers two to six inches wide appear at the top of the stem. After blooming, the plant dies. Small, straw-colored seeds remain viable up to four years. Although it slowly moves into new habitat, wild parsnip may spread rapidly once it becomes established.

WHAT CAN YOU DO? Whenever you are handling wild parsnip, wear long-sleeved shirts and pants, as well as gloves to avoid skin contact. You can pull up plants or cut them off below the root crown. Prescribed fire can be followed up with spot applications of herbicide, because wild parsnip is one of the first plants to green up after a burn. In undisturbed habitat, try leaving wild parsnip alone, because it may not out compete native vegetation.

ASIAN LONGHORNED BEETLE

The Asian longhorned beetle hasn't been found in Minnesota, but has infested trees in New York City and Chicago. The beetle, native to China and Korea, was transported to the U.S. in wood shipping crates. Aggressively attacking living trees, the beetle prefers maples but may infest other deciduous trees. Federal regulations requiring solid wood packing material from China to be treated to kill insects hopefully will prevent more introductions of this pest.

IDENTIFICATION The Asian longhorned beetles are ¾ to 1¼ inch in length. The adults are black with white markings and have long antennae. They chew holes into tree bark, especially maples, to lay eggs. Look for round and oval holes 3/8 inch in diameter. You may find coarse sawdust around infested trees.

WHAT CAN YOU DO? Early detection of this pest is essential to the eradication of a beetle infestation. Trees attacked by the beetle must be removed. Any discovery of Asian longhorned beetle should be immediately reported to the Minnesota Department of Agriculture, a local state forestry office or your county extension agent.

COMMON PINE SHOOT BEETLE

The common pine shoot beetle is a Eurasian immigrant first discovered in Ohio in 1992. It has since been found in other states, including Minnesota in the Twin Cities metropolitan area. The beetle prefers Scotch pine, but may infest eastern white pine, red pine, and jack pine. Feeding on new shoots, the beetles may inhibit tree growth.

IDENTIFICATION Adult beetles are ¼ inch long, cylinder-shaped, and range in coloration from reddish brown to black. Larvae are the same length with legless, white bodies and a brown head. Eggs are laid in pine stumps and logs, with larvae emerging as adults in June. The beetles fly to living pine trees to feed on new and one-year old shoots, which are destroyed. In fall, the beetles burrow into thick bark at the base of the host tree to over winter.

WHAT CAN YOU DO? Minnesota is under a USDA quarantine for pine trees (including Christmas trees) and pine products with the bark attached. Pines and pine products being moved to a no quarantine area must be inspected and certified free from pine shoot beetles. Look for the beetles in dead or dying pine shoots. Chip or burn pine slash and downed logs. When harvesting pine, cut the stumps as close as possible to the ground.

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WILDLIFE REFERENCES

Ref 1 – Ref 35

Note: Ref 1- Ref 35 are printed out

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Reference Index for Wildlife Impacts Section
Marked as (Ref #) in report

Ref 01- Modeling anthropogenic noise impacts on animals in natural areas

Ref 01-01 (Francis, Paritsis, Ortega, & Cruz, 2011), Ref 01-02 (Shannon et al., 2015), Refe 01-03 (Ware, McClure, Carlisle, & Barber, 2015), Ref 01-04 (Francis et al., 2011),

Ref 01-05 (Kight & Swaddle, 2011),
Ref 01-06 (Schroeder, Nakagawa, Cleasby, & Burke, 2012).
Ref 01-07 (Ware et al. 2015),
Ref 01-08 Francis, Ortega, & Cruz, 2009)
Ref 01-09 (Francis, Kleist, Ortega, & Cruz, 2012).
Ref 01-10 (Bowles et al., 1999)
Ref 01-11 (Bunkley, McClure, Kawahara, Francis, & Barber, 2017) Ref 01-12 (Morley, Jones, & Radford, 2014)
Ref 01-13 (Mullet, Gage, Morton, & Huettmann, 2016)

Ref 02 Environmental Effects of Off-Highway Vehicles on Bureau of Land Management Lands

Ref 02-01 (Lyren, 2001) Link never opened
Ref 02-02 (Lovich and Bainbridge, 1999)
Ref 02-03 (Brattstrom and Bondello, 1983) Must purchase Ref 02-04 (Havlick 2002) This is a book for purchase

Ref 03 All-terrain Vehicles in the Adirondacks

Ref 03-01 (Formann and Alexander 1998)
Ref 03-02 (Bluewater Network 2002) ATV Noise levels - couldn't locate Ref 03-03 (Wildlands Center for Preventing Roads 2001) - Couldn't locate

Ref 05 Cumulative and Universal: ATV Impacts on the landscape and Wildlife Ref 05-01 (Bury et al. 1977) Could not locate
Ref 05-02 (Bury et al. 2002) Could not locate
Ref 05-03 (Ouren et al. 2007)

Ref 05-04 (Reed et al. 1996) Must pay for full article Ref 05-05 (Forman et al. 2003) Must pay for full article Ref 05-06 (Canfield et al. 1999) Couldn't locate
Ref 05-07 (Rowland et al. 2000) Could not locate
Ref 05-08 (Wisdom et al. 2004a).
Ref 05-11 (Geist 1978) Could not locate
Ref 05-12 (Hershey 2011).

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Ref 06 Superior National Forest Regional Forester Sensitive Species (RFSS List)
DELETED

Ref 07 Minnesota's List of Endangered, Threatened, and Special Concern

Species

- no sub references

- no sub references

Ref 09 Lynx Critical Habitat in Minnesota

- no sub references

- no sub references

Ref 11-01 (Hostetter and Gardner 2016) - Could not locate

Ref 12-01 (Moen et al. 2008)
Ref 12-02 (Moen et.al 2010) - See Ref 10

Ref 08 Endangered Species in Minnesota County Distribution of Federally- Listed Threatened and Endangered Species

Ref 10 Habitat and road use by Canada lynx making long-distance movements

Ref 11 Summary of the Superior National Forest's 2018 Canada lynx DNA database and monitoring

Ref 12 Canada lynx in Minnesota: Road Use and Movements within the Home Range

Ref 13 Canada Lynx, Gray Wolf, and Northern Long-eared Bat From the Proposed NorthMet Project and Land Exchange

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Ref 13-01 (Hoving 2001)
Ref 13-02 (Moen et al. 2008b) - See ref 12-01

Ref 14: Biological Assessment For Federally-Listed species: Gray wolf, Canada Lynx, and their Critical Habitats for the Superior National Forest

https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5351554.pdf

Ref 14-01 (Burdett 2007)
Ref 14-02 (Moen et al. 2008) - See Ref 12-01

Ref 15 https://westernlaw.org/protecting-wildlife/canada-lynx/

Ref 16 https://www.dnr.state.mn.us/mammals/wolves/mgmt.html

Ref 17
https://www.howlingforwolves.org/sites/default/files/Wolf+Analysis+Threats+To+Wolves.pdf

Ref 18 https://www.biologicaldiversity.org/campaigns/gray_wolves/index.html

Ref 19 https://files.dnr.state.mn.us/fish_wildlife/wildlife/wolves/wolf_comments19.pdf

Ref 20 https://www.dnr.state.mn.us/eco/nongame/projects/wood_surveys.html

Ref 21 https://www.dnr.state.mn.us/reptiles_amphibians/helping-turtles-roads.html

Ref 22 https://www.dnr.state.mn.us/eco/nongame/projects/a-list.html

Ref 23
https://www.dnr.state.mn.us/rsg/profile.html?action=elementDetail&selectedElement=ARAAD02020#

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Ref 25 https://www.dnr.state.mn.us/birds/eagles/summer.html

Ref 26
https://www.fws.gov/southdakotafieldoffice/NationalBaldEagleManagementGuidelines.pdf

Ref 27 https://explorer.natureserve.org/AboutTheData/Statuses

Ref 28 https://explorer.natureserve.org/Search

Ref 29 https://www.fws.gov/midwest/endangered/insects/rpbb/factsheetrpbb.html.
Ref 30 https://www.registrelep sararegistry.gc.ca/virtual_sara/files/plans/rs_rusty_patched_bumble_bee_e_proposed.pdf

Ref 31
https://www.dnr.state.mn.us/rsg/profile.html?action=elementDetail&selectedElement=AMACC01150#

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Contents lists available at ScienceDirect

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Research Paper

Modeling anthropogenic noise impacts on animals in natural areas

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ABSTRACT

Noise is a globally pervasive pollutant that can be detrimental to a range of animal species, with cascading effects on ecosystem functioning. As a result, concern about the impacts and expanding footprint of anthropogenic noise is increasing along with interest in approaches for how to mitigate its negative effects. A variety of modeling tools have been developed to quantify the spatial distribution and intensity of noise across landscapes, but these tools are under-utilized in landscape planning and noise mitigation. Here, we apply the Sound Mapping Tools toolbox to evaluate mitigation approaches to reduce the anthropogenic noise footprint of gas development, summer all-terrain vehicle recreation, and winter snowmobile use. Sound Mapping Tools uses models of the physics of noise propagation to convert measured source levels to landscape predictions of relevant sound levels. We found that relatively minor changes to the location of noise-producing activities could dramatically reduce the extent and intensity of noise in focal areas, indicating that site planning can be a cost-effective approach to noise mitigation. In addition, our snowmobile results, which focus on a specific frequency band important to the focal species, are consistent with previous research demonstrating that source noise level reductions are an effective means to reduce noise footprints. We recommend the use of quantitative, spatially-explicit maps of expected noise levels that include alternative options for noise source placement. These maps can be used to guide management decisions, allow for species-specific insights, and to reduce noise impacts on animals and ecosystems.

1. Introduction

Anthropogenic noise affects species' occupancy (Francis, Paritsis, Ortega, & Cruz, 2011), behavior (Shannon et al., 2015), distribution (Ware, McClure, Carlisle, & Barber, 2015), reproduction (Francis et al., 2011), physiology (Kight & Swaddle, 2011), and ultimately fitness (Schroeder, Nakagawa, Cleasby, & Burke, 2012). Noise can be an invisible source of habitat degradation (Ware et al. 2015), influence trophic interactions (e.g., predator-prey dynamics, Francis, Ortega, & Cruz, 2009), and change the provision of ecosystem services (Francis, Kleist, Ortega, & Cruz, 2012). Although most noise studies have focused on birds, terrestrial noise has been shown to affect a wide variety of taxa, including mammals, reptiles, amphibians, and invertebrates (Bowles et al., 1999; Bunkley, McClure, Kawahara, Francis, & Barber, 2017; Morley, Jones, & Radford, 2014; Shannon et al., 2015). Consequently, there is increasing interest in describing and mitigating the impacts of noise pollution on biodiversity (e.g., Mullet, Gage, Morton, & Huettmann, 2016).

With increased awareness of the threats posed to ecological systems by noise, several approaches to model noise propagation across landscapes have been developed (e.g., Ikelheimer & Plotkin, 2005; Kragh et al., 2002; Reed, Boggs, & Mann, 2012). Sound propagation models provide a means of assessing current and predicted noise levels and evaluating noise propagation under alternative management options (Harrison, Clark, & Stankey, 1980; Reed et al., 2012) or future scenarios (Dumyahn & Pijanowski, 2011). As such, the application of propagation modeling can provide rapid and cost-effective insights for planning or management decisions to mitigate potential noise impacts (e.g., management of snowmobile noise in Yellowstone National Park, Jacobson, 2013).

Energy development and motorized recreation are noise sources of particular concern, as they are widespread and can substantially

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increase sound levels in natural areas (e.g., Harrison et al., 1980; Ramirez and Mosley, 2015). Noise from natural gas extraction has been shown to reduce species' abundance in large areas of habitat (Bayne, Habib, & Boutin, 2008), change patterns of habitat selection (Kleist, Guralnick, Cruz, & Francis, 2017), interfere with species' hunting behavior (Mason, McClure, & Barber, 2016), alter species' physiology (Blickley et al., 2012), and influence trophic interactions (Francis et al., 2011).

Recreational noise, too, has been shown to directly, negatively affect species' behavior (Brattstrom & Bondello, 1983; Karp & Root, 2009). A recent review of recreational impacts found that ~45% of studies of summer-season motorized recreation and ~80% of snow-based, winter motorized recreation had negative effects on species (Larson, Reed, Merenlender, & Crooks, 2016). Noise is hypothesized to be an important factor driving the negative effect of motorized recreation on species (Harrison et al., 1980; but see Reimers, Eftestøl, & Colman, 2003). Among other effects, species may avoid noise sources (Bradshaw, Boutin, & Hebert, 1997), and the resulting displacements may be energetically costly (Bradshaw, Boutin, & Hebert, 1998). Noise may also mask species' communication (Lohr, Wright, & Dooling, 2003), which may cause species to compensate using a variety of potentially costly strategies (Brumm & Slabbekoorn, 2005).

Our study aims to develop approaches that allow a spatially-explicit evaluation of the benefits of different mitigation approaches to reduce the amount of area exposed to noise. We applied noise propagation models to assess noise-related impacts of gas development, off-highway vehicle use, and snowmobile use and examined the potential to reduce noise impacts through relocating noise-producing activities or, in the case of snowmobiles, by reducing noise levels at the source. A variety of acoustic metrics are available, including sound pressure levels, thresholds, audibility, and potential for masking. We demonstrate the utility of summarizing noise propagation data in these various manners, highlighting the applicability of these different metrics to different types of questions. We predicted that small changes at the planning stage could greatly reduce noise levels, especially in sensitive areas. We used threshold-, audibility-, and masking-based metrics (see Methods) as different indices of noise impacts for different ecological situations. Finally, we discuss modeling decisions to consider when developing and applying sound propagation model outputs to management questions.

2. Methods

2.1. Study area

We examined noise impacts from energy development or motorized recreation in three study locations: gas extraction in Shale Ridges Management Area, CO (39.3 N 108.3 W; BLM, 2015), all-terrain vehicle recreation in Bangs Canyon, CO (38.93 N 108.5 W), and snowmobile use in the Stanislaus National Forest, CA (38.514 N, 119.92 W). These sites were selected to represent a variety of anthropogenic noise sources relevant to land managers, and to illustrate sources with different spatial arrangements (point-, line-, and area-based noise sources). We used site-specific approaches to incorporate specific situation of each location in the noise propagation models.

The Shale Ridges Management Area has recently been the subject of a Master Leasing Plan (BLM, 2015), which included the potential for new natural gas extraction in the area. This management area also contained lands designated as Areas of Critical Environmental Concern (ACEC) for wildlife. The study landscape was comprised of ridges and valleys, with a mean elevation of 1906 m (1382–2723 m min-max, USGS, 2013), and was comprised of a variety of vegetation types, with pinyon-juniper (*Pinus edulis* and/or *Juniperus osteosperma*) woodland (30%) and big sagebrush (*Artemisia tridentata*) scrubland (21%) accounting for over half the land cover. No other land cover type accounted for more than 10% of the total land area (LANDFIRE, 2012). One of the most iconic species in the region is the mule deer (*Odocoileus hemionus*), and previous research has suggested that mule deer are sensitive to natural gas development (Johnson et al., 2016; Northrup, Anderson, & Wittemyer, 2015; Sawyer, Kauffman, & Nielson, 2009; Sawyer, Nielson, Lindzey, & McDonald, 2006). Consequently, we examined the potential for drilling and operating new wells to affect mule deer.

Bangs Canyon, adjacent to Colorado National Monument and located near Grand Junction, CO, is managed by the BLM for motorized recreation, non-motorized recreation, and wildlife. Bangs Canyon is also topographically diverse (mean: 1902 m, min-max: 1362–2955 m USGS, 2013), with a similar vegetation composition to the Shale Ridge Management Area: 30% Pinyon-Juniper Woodland, 11% Big Sagebrush Shrubland, and no other land cover > 10% of the landscape (LANDFIRE, 2012). Motorized recreation can be disruptive to non-motorized recreationists and wildlife (e.g., Rapoza, Sudderth, & Lewis, 2015; Seip, Johnson, & Watts, 2007); consequently, we tested the degree to which motorized recreation would be audible along non-motorized trails. We chose to use a single all-terrain vehicle (ATV) as our motorized source (although model results could be scaled to represent any number of ATVs), and evaluated human audibility (ISO 389-7). In addition to evaluating effects on other recreational visitors, humans are a useful proxy for many species because human hearing is similar to or better than that of many wild animals (e.g. see audiograms in Fay, 1988; Buxton et al., 2017).

Finally, we considered snowmobile use in a recreation area within Stanislaus National Forest proposed by the USDA Forest Service (hereafter 'snowmobile area'). In contrast to the other two study regions, Stanislaus National Forest was higher in elevation (mean: 2459 m, min-max: 1675–3328 USGS, 2013), but predominantly wooded (49% Red Fir Forest, no other landcove > 10% of the landscape, LANDFIRE, 2012). The potential for avian communication to be masked by anthropogenic noise has been a topic of considerable research (e.g., Brumm & Slabbekoorn, 2005; Hu & Cardoso, 2010; Lohr et al., 2003), and winter may be a time when masking of alarm and other social calls of birds place these animals in particular risk due to weather extremes and limited food (e.g., Jansson, Ekman, & von Brömssen, 1981; Robel & Kemp, 1997). Therefore, we chose to evaluate the potential for snowmobiles to mask species-specific vocalizations in a recreation area. We focused on vocalizations by White-breasted Nuthatches (*Sitta carolinensis*), as this species is present in the Stanislaus National Forest year round, vocalizes in winter, and quality recordings of the species' vocalizations are available (Nelson, 2015a, 2015b).

2.2. Modeling approach

2.2.1. Modeling approach overview

We used Sound Mapping Tools V4.4 (SMT, Keyel, Reed, McKenna, & Wittemyer, 2017 http://purl.oclc.org/soundmappingtools) with ArcGIS (10.3, 10.4, ESRI, Redlands, CA) to evaluate potential acoustic impacts using publicly-available data sets (see Table 1, code used to run the analyses given in Appendix 1). SMT provides an easy-to-use ArcGIS interface for several existing sound models: SPreAD-GIS (Harrison et al., 1980; Reed et al., 2012), NMSIMGIS (Ikelheimer & Plotkin, 2005), and a GIS implementation of ISO 9613-2 (ISO 9613-2). These sound models make spatially-explicit quantitative predictions of sound levels based on distance from a sound source, land cover, topography, and environmental conditions, and they have been used previously to address natural resource-related questions (e.g., Barber et al., 2011; Sunder, 2003).

We represented line and polygon noise sources as arrays of points to meet the point input requirement of the models. Each point source had the same starting sound level. All decibel values reported here are A-weighted sound pressure levels re: 20 μPa (dBA) unless otherwise noted. One-third octave band ranges used in the weightings are given in Table 1. We used weather data from a nearby weather station using seasonally appropriate weather conditions. Our goal was not a precise

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Table 1
Data used for the study sites.

Variable	Shale Ridge	Bangs Canyon	Stanislaus National Forest
Nearest weather station	Grand Junction	Grand Junction	South Lake Tahoe[8]
Weather station WBAN	23066[2]	23066[2]	93230[2]
Year used for weather conditions	2014	2014	2014
Months used for weather conditions[1]	September	July	January
Mean temperature (°C)	19.8	26.4	2.5
Mean relative humidity (%)	44.3[3]	29.7[3]	50.0[3]
Mean wind speed (kph)	12.0	13.6	5.5
Modal wind direction (°)	120	45	30
Land Cover	LANDFIRE[4,5]	LANDFIRE[4,5]	SNOW
Elevation	NED[5,6]	NED[5,6]	NED[5,6]
Source data	Drill rig[7], gas compressor[7]	All-terrain vehicle[7]	Snowmobiles[7]
1/3 octave band range	125-2000 Hz	125-2000 Hz	2500 Hz

[1] Months were chosen to be representative of the activity under consideration, with exception of drilling, which could potentially happen at any time. The exact time is not critical, as the research objective is focused on identifying large, relative, differences.
[2] Weather data acquired from QCLCD files (NOAA, 2015).
[3] Relative humidity was calculated using the August-Roche-Magnus approximation (Alduchov & Eskridge, 1996; McNoldy, 2017), and a single average value was computed for the focal month.
[4] (LANDFIRE, 2012).
[5] Resampled to 30 × 30 m cell size and converted to the appropriate UTM zone.
[6] National Elevation Data, 1 arc-second resolution, (USGS, 2013).
[7] Drill rig measurements provided by E. Brown, National Park Service, gas compressor measurements made by XXX, (masked for blind review), all-terrain vehicle source data from Harrison et al. (1980), snowmobile data provided by D. Joyce, National Park Service Natural Sounds and Night Skies Division.
[8] The closest weather station was Bridgeport Sonora Junction (WBAN 433) but this had no data for the year and month of interest.

instantaneous sound level for one given point in time, but a relative assessment of the different options under equivalent conditions (see Appendix 2 for a broader discussion of weather-related model considerations). To facilitate the modeling process, sound sources were assumed to be omni-directional (but note this assumption may be inappropriate for some sources; e.g., helicopters, Conner & Page, 2002).

2.2.2. Modeling energy development using thresholds

We selected SPreAD-GIS (Reed et al., 2012) to model the noise impact from proposed wells on mule deer within the ACEC. While several models could have been chosen, the SPreAD-GIS model executes more quickly, and our goal was to compare alternative management scenarios using a consistent model. We made spatially-explicit predictions of noise from active drilling of a well and from a hypothetical onsite gas compressor station at four proposed well sites. We modeled drilling and compressor stations at each site, as these represent two substantial noise sources associated with wells. We assessed where mule deer might be displaced within the ACEC by gas exploration activities using a threshold-based approach to provide a discrete value that could be used for interpreting relative area impacts among well locations. A weakness of thresholds is that they can be somewhat arbitrary (e.g., a mule deer could respond similarly to values immediately below and above the selected threshold), however, the threshold approach provided a clear basis for comparing the relative footprints of the different well locations. We used a 45 dBA 1 s L_{eq} threshold as the level at which mule deer would be displaced. As hearing among ungulates is similar (Heffner & Heffner, 2010), the threshold was empirically estimated for a proxy species, caribou (*Rangifer tarandus caribou*; see Appendix 3 for derivation; [Bradshaw et al., 1997]). Finally, we repeated the procedure with a systematic grid of points spaced 500 m apart to evaluate the potential impact of alternative well placement locations. Potential impacts were quantified by the area that would be raised above a 45 dBA 1 s L_{eq} by drilling or placement of a compressor station at that location. Well locations were compared on the basis of their predicted noise footprints.

2.2.3. Modeling summer recreation and audibility

In Bangs Canyon, we examined where motorized recreation (represented by an all-terrain vehicle, ATV) could be audible above natural background sound levels. Audibility may serve as an estimate of the minimum potential impact, as inaudible decibel levels are not expected to have negative effects (but see studies on infrasonic effects, e.g., Landstrøm, 1987). Audibility only assesses *potential* impact, as a sound may be audible without necessarily causing any negative effects (Rapoza et al., 2015). While audibility will depend on species, individual, and even the degree of attention paid by an individual animal to the noise source (Fay, 1988; Rapoza et al., 2015), an international standard has been developed for calculating human audibility (ISO 389-7). We used this standard, as humans often have better hearing than many mammals and birds (Fay, 1988) in the low-frequency bands that travel the furthest. Audibility was calculated using the audibility statistic d', calculated by comparing background sound levels taken from Harrison et al. (1980) to ATV sound levels for each 1/3 octave frequency band, accounting for human hearing (ISO 389-7). Values of $10 * \log_{10}(d')$ greater than 7.3 were considered audible, based on empirical results (Fidell et al., 1994). We excluded trails within 200 m of highways from the analysis based on the assumption that the highway would be the dominant source of noise in these areas.

To characterize the noise along the motorized route, the route was broken into a series of points to simulate a single ATV traveling at $\sim 6\,\mathrm{m\,s^{-1}}$ sampled every 20 s, which resulted in an approximately 120 m point spacing along the line. We chose a spacing that gave sufficient coverage to examine relative impacts of different sections of the motorized trail and assumed a single ATV traveling the route. This spacing may not adequately represent sound propagation from line sources, as sound levels drop by 6 dB per doubling of distance for point sources compared to 3 dB per doubling of distance for line sources (Bies & Hansen, 2009). To model line sources, one must check that when sound levels are summed across points, the spacing is adequate to show the 3 dB reduction per doubling of distance. The SPreAD-GIS model was run for each point using source levels reported by Harrison et al. (1980).

We considered the audibility impact in two ways. First, we looked at where on the non-motorized trails an ATV would be audible by calculating audibility based on a single ATV for each point along the motorized trail. Second, we examined which locations along the motorized trail were most responsible for this impact on the non-motorized trail, to prioritize any mitigation measures or development of alternative routes. To accomplish this, the length of non-motorized trail where each motorized point was audible was computed (length was

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approximated by examining the area affected for a 1 m wide trail). Points with more than 1 m of affected non-motorized trail were classified as points having a greater impact; the remaining points were classified as lower impact.

2.2.4. *Modeling winter recreation and masking*

In Stanislaus National Forest, we chose to examine the potential for masking the peak frequency of White-breasted Nuthatch calls and songs. Peak frequency of nuthatch vocalizations was extracted using Raven Pro (Bioacoustics Research Program, 2014) and was found to be in the 2.5 kHz 1/3 octave band. Potential noise levels within a snowmobile area (polygon) were assessed using a systematic grid of points spaced 30 m apart (to match the land cover and elevation cell sizes). We modeled standard and next-generation four-stroke snowmobiles, running at a speed of $13.4\,m\,s^{-1}$ ($48.3\,km\,h^{-1}$, source data provided by D. Joyce, National Park Service). Model predictions were first made for a single snowmobile of each type at every grid point. Then, the maximum sound level from any grid point was used to evaluate the potential impact of the snowmobile area. Finally, the maximum sound level results for a single snowmobile were compared to the results from a group of snowmobiles by scaling the single snowmobile results by a factor corresponding to the number of snowmobiles in the group (on an energy basis, not a decibel basis). We used a group count of eight snowmobiles; this corresponds to the low number of snowmobiles per group in a study of snowmobile impacts (Eckstein, O'Brien, Rongstad, & Bollinger, 1979). The results are intended to demonstrate the relative increase in noise level with an increase in the number of snowmobiles, and could be rescaled to accommodate additional scenarios. We used the NMSIMGIS model (Ikelheimer & Plotkin, 2005) from Sound Mapping Tools due to its ability to model snow-covered ground and its greater frequency range than SPreAD-GIS. Number and type of snowmobiles were compared on the basis of predicted sound levels where a 90% or more reduction in listening area might occur for White-breasted Nuthatches.

Listening area is defined as an area where a receiver could detect a signal. For example, the area where one White-breasted Nuthatch could hear another White-breasted Nuthatch calling. Barber, Crooks, and Fristrup (2010) showed that a 3 dB increase above ambient leads to a 50% reduction in listening area, and by the same logic a 10 dB increase corresponds to a 90% reduction in listening area. Harrison et al. (1980) estimate the maximum ambient sound levels in conifers for the 2 kHz band (the closest spectrum to 2.5 kHz with data) to be 27 dB (minimum 9 dB). Therefore, we considered areas in excess of 37 dB to represent 90% or greater reduction in listening area to provide a minimum estimate, to account for the uncertainty in the ambient dB levels. We measured the minimum and maximum distance outside the snowmobile area where a 90% or more reduction in listening distance would occur using the measure tool in ArcGIS.

3. Results

For natural gas development in the Shale Ridges Management Area, the four proposed wells were predicted to raise sound levels above 45 dBA for 0, 11.6, 69.1, 76.3 ha during drilling and 0, 6.9, 39.0, 43.0 ha during operation of a compressor station (Fig. 1, for wells 1, 2, 3, 4, respectively). When alternative locations were considered, potential acoustic impacts varied across the landscape. Most areas outside the ACEC would raise the dBA level within the ACEC above 45 dBA for less than 1 ha. Wells 3 and 4 were among the locations with the greatest potential acoustic footprint. For these wells, alternative locations within 1 km would substantially reduce the area expected to exceed 45 dBA (Fig. 2). Moving well 3 by less than 1 km could reduce the area above 45 dBA by 27.7% during drilling and 17.7% during operation of a compressor station. For well 4, the potential reduction in affected area for a move of 1 km or less was even greater: 64.9% for drilling and 34.8% for a compressor station. These differences within the ACEC were primarily due to terrain effects.

For summer motorized recreation in Bangs Canyon, ATVs were predicted to be audible to humans on over 16% of the non-motorized trails (Fig. 3a). For most locations along the non-motorized trails, a single ATV would be inaudible due primarily to the barrier effects of intervening terrain and distance from the motorized trail (Fig. 3a). Similar to reported results for the Shale Ridges site, not all points along the motorized trail were equal in their acoustic impacts, with seven point locations having a much larger acoustic impact on the non-motorized trail than the others (i.e., affecting at least 1 m of the non-motorized trail, Fig. 3b) due to a combination of proximity and topography.

For winter motorized recreation in Stanislaus National Forest, snowmobiles differed in their potential to mask White-breasted Nuthatch vocalizations (Fig. 4). The next-generation snowmobiles produced lower sound levels in the 2.5 kHz one-third octave band used by White-breasted Nuthatches than did the standard snowmobiles, as well as having reduced noise footprints. In all cases, the presence of a snowmobile was expected to reduce the listening area (for a conspecific cue) for White-breasted Nuthatches by more than 90% within the snowmobile-exposed area. The exact distance at which a 90% or greater reduction was no longer expected varied spatially. For a single next-generation snowmobile, this distance ranged from 13 to 86 m outside the snowmobile area while for eight next-generation snowmobiles, it ranged from 83 to 210 m. For one and eight standard snowmobiles, these distances were 64–137 m and 158–286 m respectively.

4. Discussion

As noise pollution expands and threatens natural systems, approaches to plan for and mitigate negative effects of noise sources are increasingly needed. We demonstrated the application of noise propagation models in three systems with differently structured noise sources and areas of concern. We applied sound propagation models to these systems to identify critical locations where noise sources had disproportionate impacts on landscapes and where alternative locations of noise sources could reduce the area of the landscape exposed to noise. This information can provide targeted guidance for noise mitigation efforts of existing activities or for proactive planning to reduce undesirable noise impacts. As has been previously noted (e.g., Embleton, 1996), our results demonstrated the key role topography can play in sound propagation. Properly planning around topographical barriers can help to mitigate noise impacts. As has been shown previously (Bies & Hansen, 2009), reduction of noise levels at the source also reduced noise impacts. While our approaches were varied to match the characteristics of our three systems, they demonstrated the capacity of sound propagation models to produce spatially-explicit maps identifying areas of concern (e.g., threshold exceedance) and comparative noise footprints (e.g., between two types of noise sources) to inform noise management. The resulting maps demonstrate the capacity to greatly reduce noise impacts in ecologically sensitive areas through fine-scaled (i.e., within 1 km) site selection.

Topography was identified as a major factor because spherical spreading loss (a reduction in sound pressure levels as sound waves spread out over an increasing area) and atmospheric absorption are not expected to differ for equidistant points, while acoustic losses due to land cover are relatively small (Embleton, 1996). Consequently, the large differences observed for equidistant locations were due to topographical features acting as natural barriers. This was evident across all three examples: in Shale Ridges, nearby alternate locations were expected to have large reductions in noise footprints, in Bangs Canyon, proximity to the motorized trail was important, but the points with the greatest effect were those that were not shielded by topographical barriers. Similarly, in Stanislaus National Forest, the distance from the snowmobile area where a 90% or greater reduction in listening area was expected to vary by more than 100 m, despite relatively

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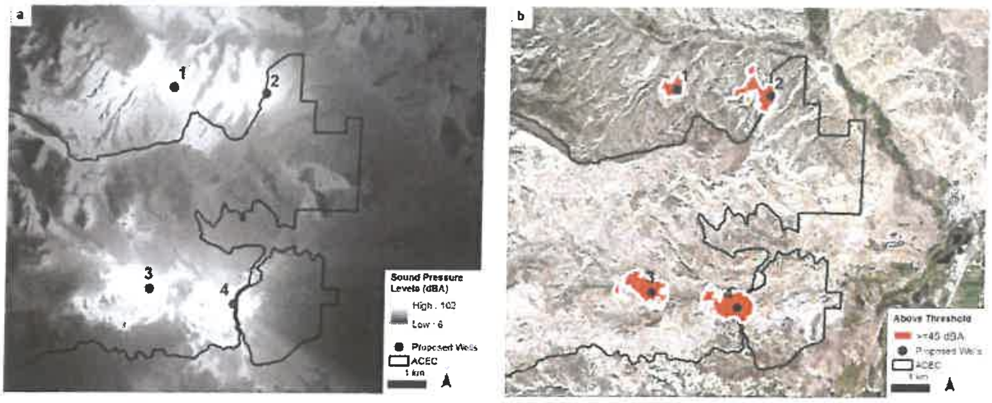

Fig. 1. The predicted acoustic impact of drilling four new wells (1–4). (a) The predicted sound pressure levels of drilling the well sites are displayed, while in (b) only the areas where sound pressure levels would meet or exceed a 45 dBA threshold (derived for mule deer, *Odocoileus hemionus*) are shown. The Area of Critical Environmental Concern (ACEC) is outlined in black.

homogeneous vegetation cover.

4.1. Using sound propagation to explore mitigation impacts

In the Shale Ridges Management Area, we demonstrated the strong differences between well locations in their potential noise impacts (Fig. 1), and the potential for a reduction in noise impacts with changes to well placement (Fig. 2). Use of a systematic grid greatly increased the rigor of the consideration of alternative locations, and was computationally feasible for our study area. Similarly, we found that consideration of the spatially explicit audibility of noise may help guide route planning decisions. Some locations on the motorized trail in Bangs Canyon contributed substantially more noise to the non-motorized trail than other locations (Fig. 3). The predicted noise levels in Bangs Canyon were anticipated to be inaudible over most of the non-motorized recreation trail, suggesting that noise management at this location may be of limited value. Were noise management to occur, the maps identify the points where the greatest reductions could be achieved. These maps could also be used to identify areas that would need to be closed in order to protect particularly sensitive areas.

General model predictions may be used to identify locations on the landscape more susceptible to noise intrusions. These locations are expected to remain the same, even if source type and source number are varied. For example, the locations most affected by drilling were the same locations as those identified in the compressor station analysis. In some cases, the source with the lowest overall sound level may not be the quietest with respect to a particular frequency band. By modeling just the noise expected to interfere with White-breasted Nuthatch vocalizations, we demonstrated how models could be used to focus on noise that is expected to be most disruptive to specific species' detection of conspecific cues.

With recognition of the problems created by noise exposure, emphasis on developing quieter technologies has created options for noise mitigation efforts. We only assessed the change in impact using quieter snowmobile technology in the Stanislaus National Forest site. As expected, quieter snowmobiles led to lower noise impacts (Fig. 4), but even noise from these next-generation snowmobiles greatly reduced White-breasted Nuthatch listening area. The potential to use quieter technology for gas extraction (e.g., noise-dampening walls) has been addressed and can provide substantial reduction in noise levels (Bayne et al., 2008; Francis et al., 2011), consequently, we did not examine it explicitly here. Additionally, management based on total noise levels may be more desirable than by focusing on particular mixtures of noise sources. Total noise level management was done in the winter travel management plan for Yellowstone National Park (Jacobson, 2013). This travel management plan used the NMSim model to determine restrictions on the number and types of snowmobiles allowed in an area based on total anticipated noise levels.

4.2. Modeling decisions and limitations

The analyses required several modeling decisions, and the appropriate decision depended on the specific question being asked in each case study. These included the choice of acoustic metric, sound propagation model, source level data and number of sources, resolution and extent of the analysis, weather data and season, and alternatives for evaluation of planning and mitigation options. The choice of sound propagation model can be guided by empirical data (e.g., see Appendix 4), consideration of the model capabilities (e.g. frequency range, land cover), and applicable standards (e.g., Sunder, 2003). When reporting acoustic results, it is critical to report details, such as the timeframe of the acoustic measure, which weightings were used, and what frequency range was considered (reviewed by McKenna, Shannon, & Fristrup, 2016). An important next step would be to use field measurements to evaluate and refine the sound propagation models. The analyses presented here could be further refined in the future, especially in cases where absolute sound levels are more important than relative differences between locations. When absolute levels are required, identifying the sensitivity of the analysis to model choice and selection of input conditions may be useful. When multiple models make the same prediction, more confidence can be placed in the model results. Where the models make differing predictions, careful consideration of the model assumptions or field measurements may be necessary.

4.3. Potential applications

Available modeling tools, including the ones employed here, can facilitate studies of animal behavior and fitness. These tools make it easier to include sound levels as ecological covariates. While all of the approaches employed here used a single sound level per noise source, many noise sources vary in decibel level over time. More sophisticated examples could be developed to use more than one source level (e.g. for multiple speeds or for sources that vary in sound level over time). In the case of Bangs Canyon, while a single ATV was not audible over the majority of the trail, multiple ATVs or different models might be audible. Additional summary information could be extracted such as maximum sound level, duration of the noise source, time audible, and whether the noise source is impulsive (such as a gunshot) or continuous. These different noise attributes can have different degrees of influence on animals' behavior and fitness (Shannon et al., 2015), and additional studies examining these noise components could be valuable.

Further model applications could include characterization of other sound sources in the areas. In the Shale Ridges analysis we considered only the noise impacts of the well site itself, and not those of any associated infrastructure (e.g., roads, well pad construction). A quiet well location that would require a noisy access road through sensitive areas may be worse than an alternative well location with quieter access. As such, it is critical to consider the potential noise impacts of all noise sources to inform well site selection. Further research quantifying these

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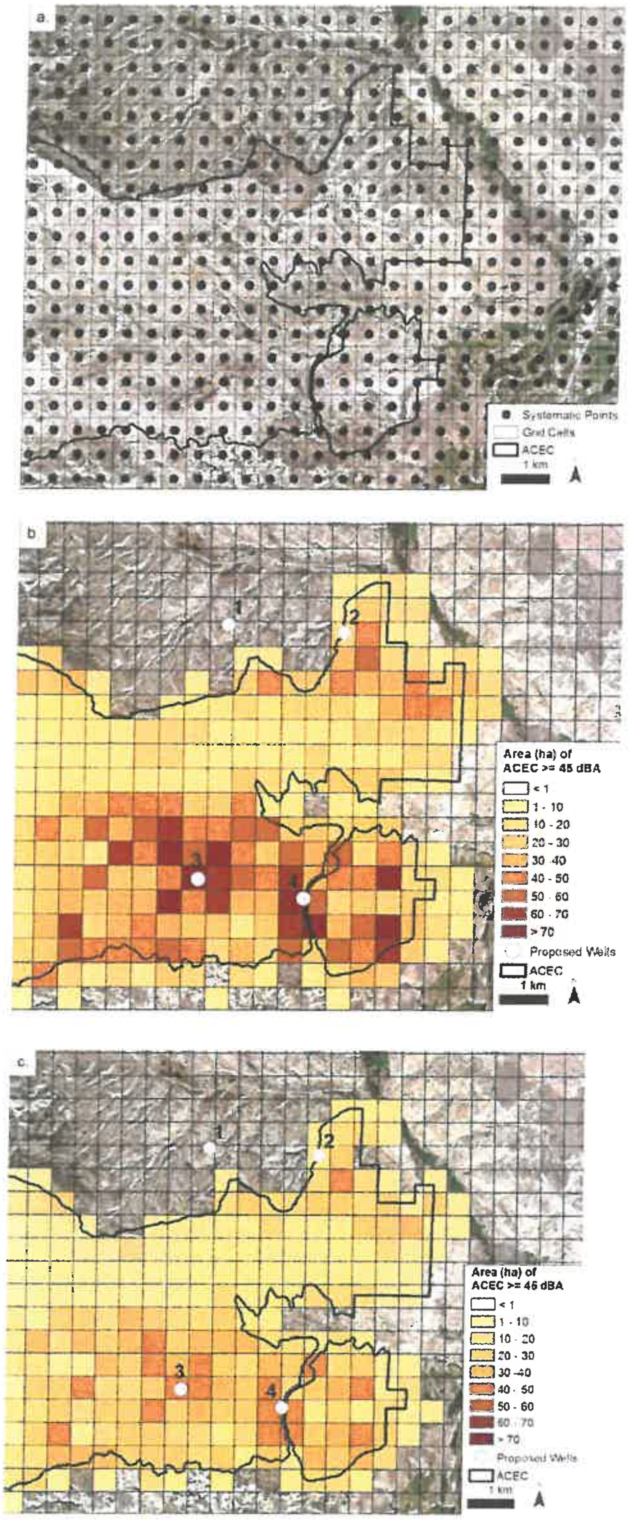

Fig. 2. The potential impact on mule deer within the Area of Critical Environmental Concern (ACEC) was evaluated for (a) systematic points across the landscape. The impact of each systematic point was extrapolated to the entire grid cell, and each cell was color-coded according to the area of the ACEC that would be elevated above 45 dBA during (b) drilling and (c) by operation of a hypothetical on-site compressor station at that point. Note that the actual spatial extent above a 45 dBA threshold of each systematic point (as was shown in Fig. 1b) is not shown, rather the color coding provides an index to the spatial extent that would be affected by drilling or compressor operation at that point (the darker the shading the greater the area affected). The locations (but not the sound levels) of the four proposed well sites (1–4) are included for context.

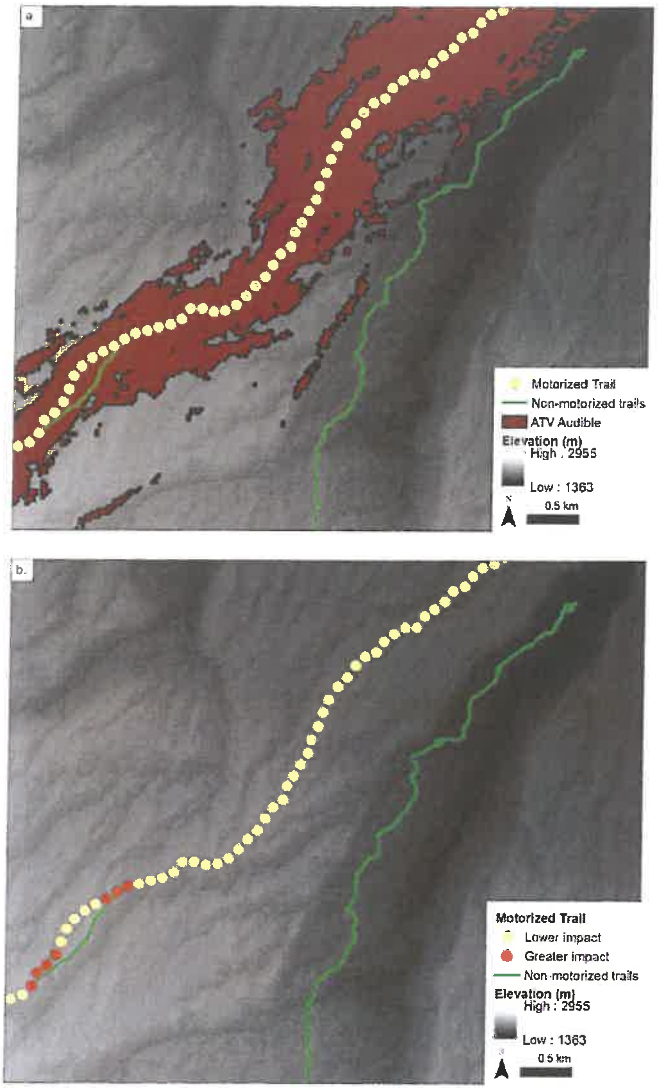

Fig. 3. (a) Audibility of a single ATV traveling a motorized vehicle trail in Bangs Canyon, CO. Audibility was defined based on human hearing abilities (ISO 389-7), and was defined as a cumulative d' statistic at or above 7.3. (b) The relative impact of individual sections of the motorized trail on the non-motorized trail highlight potential targets for management action. Lower impact points affected < 1 m of the non-motorized trail, while greater impact points affected ≥ 1 m. Elevation is from a hillshaded 1 arc-second digital elevation model (USGS, 2013).

potential noise sources is an important next step. Similarly, the Bangs Canyon analysis did not include other nearby anthropogenic noise sources, such as a nearby highway. Importantly, management decisions would need to consider information beyond just noise (e.g., presence of sensitive species, wilderness characteristics, access to the resource of interest, sensitivity of the habitat to disturbance, etc.).

A focus on the percentage reduction in listening area, while including simplifying assumptions, bypasses many of the limitations associated with studying masking. Masking depends on signal sound level (i.e. how loud a nuthatch vocalizes), noise level, how well an animal can hear during noise events (e.g., critical ratios, Lohr, et al., 2003), and how the animal behaviorally adjusts for the noise (e.g., by shifting vocalization amplitude, frequency or timing, Brumm & Slabbekoorn, 2005; Slabbekoorn, 2013). While critical ratio data exist for some animals, the data are lacking for the majority of species (Dooling, Lohr, & Dent, 2000; Fay, 1988). However, the percent reduction in listening area, in contrast to the size of the listening area, is determined by the

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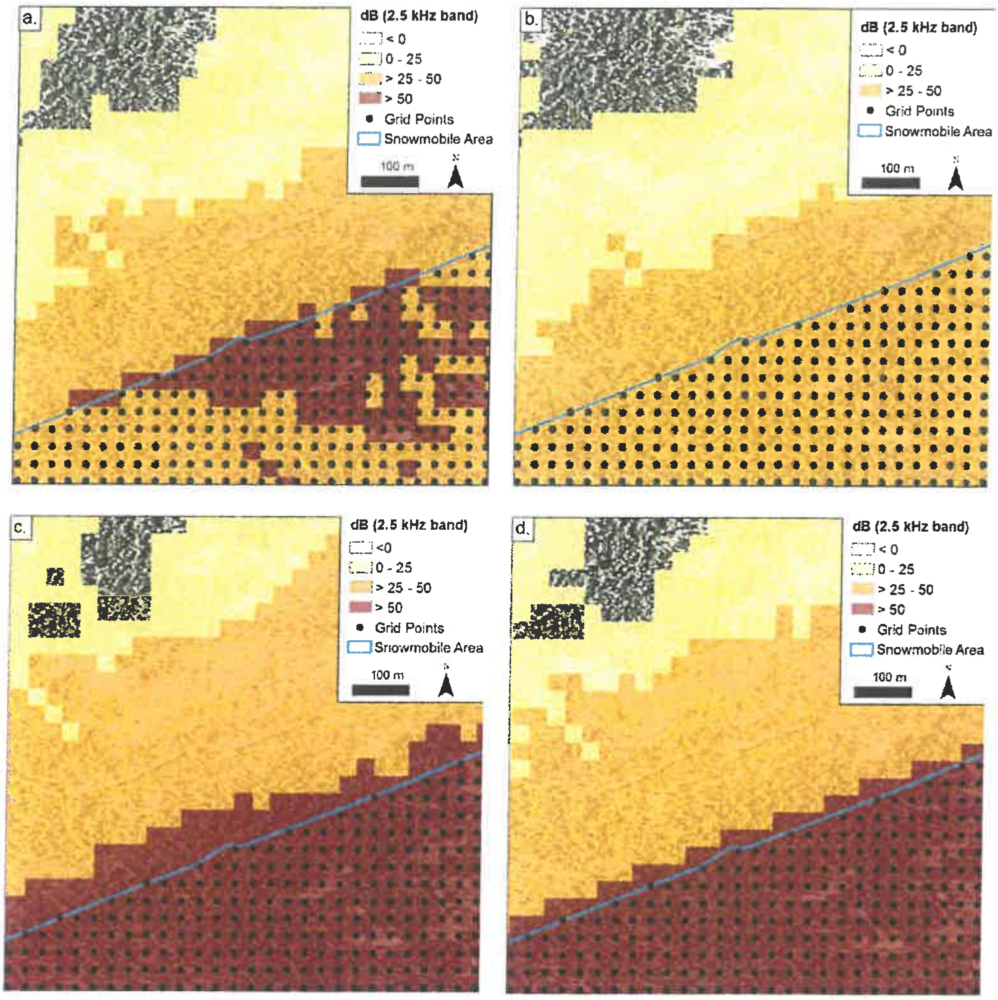

Fig. 4. The potential for snowmobiles to mask White-breasted Nuthatch vocalizations in the 2.5 kHz band differed by snowmobile type and number. Standard four-stroke snowmobiles (a, c) produce more acoustic energy in the 2.5 kHz one-third octave frequency band than snowmobiles utilizing next-generation technology (b, c). Increasing the number of snowmobiles from one (a, b) to eight (c, d) raises the maximum sound level within the snowmobile area to above 50 dB for both snowmobile types (aerial photo from USDA-FSA-APFO, 2016).

sound level relative to ambient, and not by species-specific hearing abilities. Thus, while it may be possible to model species-specific listening areas (e.g., US8223980B2, 2009), an approach based reduction in listening area may be sufficient and more feasible for many management questions.

5. Conclusions

In three empirical examples, we demonstrated a modeling approach for evaluating the potential noise exposure to animals. This approach can be used to evaluate alternative management scenarios with respect to noise source locations, such as designation of quiet areas, where noise intrusion would likely be harmful to ecological systems. Similarly, areas could be identified where noise impacts should be mitigated (e.g., through use of quieter technology, Bayne et al., 2008), and those where additional noise sources are unlikely to contribute an appreciable increase above background levels or negatively impact critical resources. We recommend the use of quantitative, spatially-explicit maps of expected noise levels that include evaluation of alternative options. These maps can be used to guide management decisions, allow for species-specific insights, and to reduce noise impacts on animals and ecosystems.

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Acknowledgements

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.landurbplan.2018.08.011.

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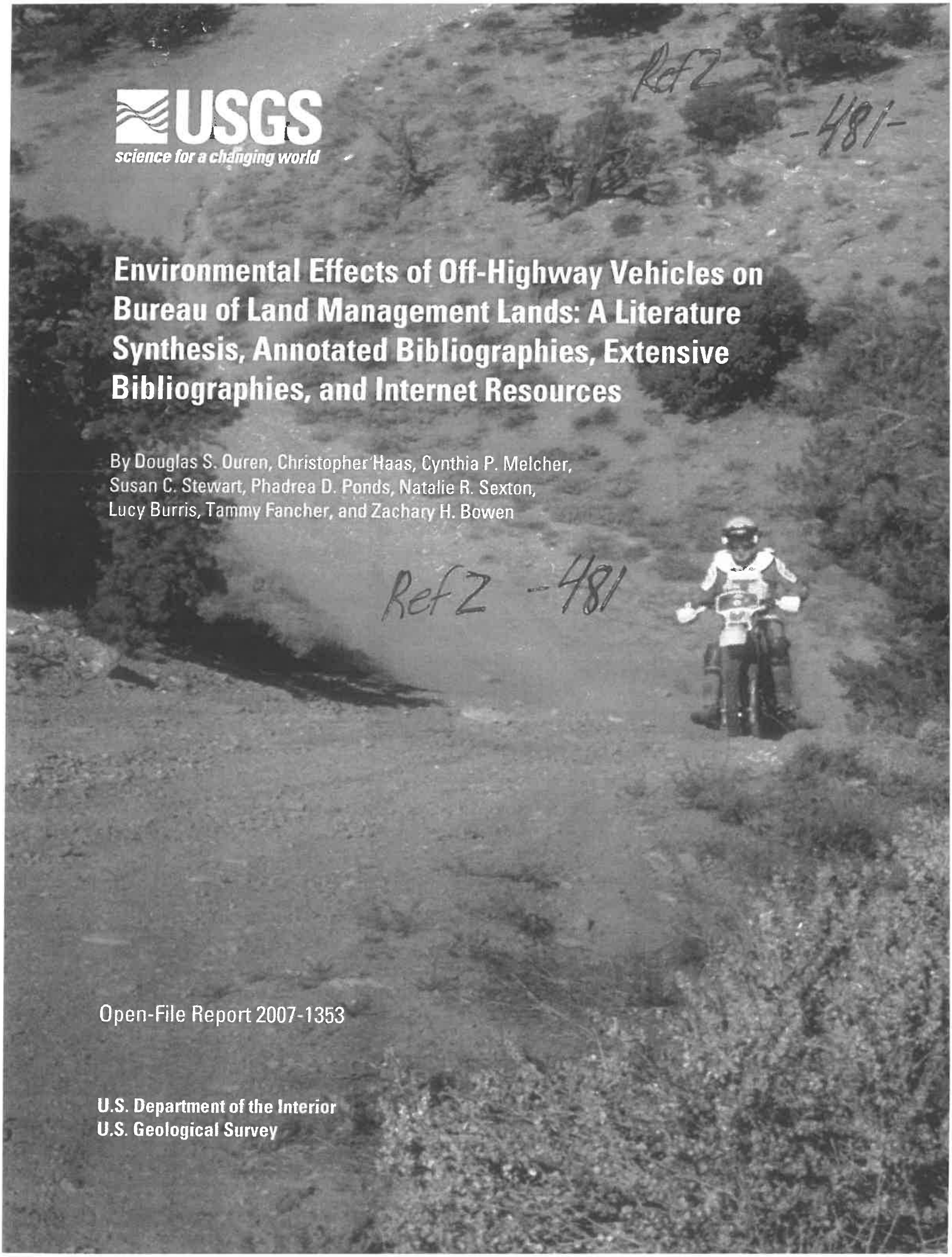

RefZ -481

science for a changing world

Environmental Effects of Off-Highway Vehicles on Bureau of Land Management Lands: A Literature Synthesis, Annotated Bibliographies, Extensive Bibliographies, and Internet Resources

By Douglas S. Ouren, Christopher Haas, Cynthia P. Melcher, Susan C. Stewart, Phadrea D. Ponds, Natalie R. Sexton, Lucy Burris, Tammy Fancher, and Zachary H. Bowen

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Open-File Report 2007-1353

U.S. Department of the Interior
U.S. Geological Survey

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along roads can alter or preclude the seasonal movements of amphibians to their breeding pools (Gibbs, 1998; Vos and Chardon, 1998).

In the same ways that travel routes promote increased dispersal of non-native and invasive plant species, they also promote increased distributions of wildlife species otherwise unlikely to be common in a given area; in turn, this exerts additional competitive pressures on native species. Huey (1941) documented pocket gophers (*Thomomys umbrinus*) extending their ranges across the Mojave Desert via roads and canal systems. Although much of the surrounding desert landscape contained soils unsuitable for gophers, the attractive habitat (greater cover of vegetation resulting from increased moisture availability) along roadsides and canals facilitated the spread of these animals (Huey, 1941). An additional important edge effect associated with roads of many types is the presence of utility infrastructures, which can contribute to significantly altered predator-prey relationships along roads. For example, raven species (*Corvus* spp.) have increased their distribution throughout the Mojave Desert, primarily due to the fact that they can perch along utility structures to scan for carcasses on adjacent roads (paved and unpaved) (Knight and Kawashima, 1993), a significant concern in light of the fact that Berry and others (1986) reported ravens as being responsible for 68 and 75 percent of mortality among juvenile desert tortoises on two study plots.

2.4.4 OHV Disturbance and Noise

Vehicular traffic is also a source of noise and other stimuli that have the potential for disturbing wildlife along any type of road or trail (Singer, 1978; van der Zande, 1980; Brattstrom and Bondello, 1983; Bowles, 1995; Reijnen and others, 1995, 1996; Bowles, 1995; Kaseloo and Tyson, 2004). Veen (1973; as interpreted and translated by van der Zande, 1980) found that four shorebird species inhabiting open grassland areas were disturbed within 500–600 m of a "quiet rural road" and within 1600–1800 m of a "busy highway;" van der Zande (1980) reanalyzed Veen's data and yielded similar results for three of the four species, and went on to conclude that populations of these birds were diminished by as much as 60 percent over those distances. Forman and Alexander (1998) found that noise levels generally increase with traffic intensity, and Reijnen and others (1995, 1997) concluded that traffic noise can lead to significant reductions in breeding bird densities. Larger animals also exhibit responses to the intensity of traffic and traffic noise. Lyren (2001) found that coyotes changed their road-crossing periods in response to changes in traffic intensity throughout the day, and Singer (1978) reported that, in response to the shifting of truck gears, mountain goats ran away from a road edge when the truck was 1 km (0.6 mi) away from them, and they ran away from a lick that was 400 m (437.4 yd) from the road.

Noise emitted from certain types of OHVs can be as high as 110 decibels, which is near the threshold of human pain (Lovich and Bainbridge, 1999). Although sounds from OHV motors are not the loudest anthropogenic sounds, in wildlife habitats they are emitted more frequently than other high-intensity sounds (Brattstrom and Bondello, 1983), and the effect on animals can be significant. For example, sand lizards (*Uma scoparia*) and kangaroo rats (*Dipodomys deserti*) experienced hearing loss that lasted for weeks after being exposed to less than 10 minutes of dune buggy playback recordings played intermittently at lower decibel levels than the animals would have been exposed to in the actual presence of a dune buggy (Brattstrom and Bondello, 1983); subsequently, both species were unresponsive to recordings of predator sounds. In two other studies, kangaroo rats (*Dipodomys spectabilis*) experienced inner ear bleeding when subjected to OHV noise (Berry, 1980b; Bury, 1980). Another issue is the way in which OHV noise (sound pressure) may simulate that of natural sounds (thunder, for example) to which many

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animals may be adapted to respond. For example, in response to 30 minutes of taped motorcycle sounds, Brattstrom and Bondello (1983) documented a spadefoot toad (*Scaphiopus couchii*) emerging prematurely (wrong season, absence of rain) from its burrow, most likely because the sound mimicked that of thunder, to which the species would normally respond.

Noise, lights, and other disturbances associated with OHV activities also have the potential for eliciting stress responses from a broad spectrum of wildlife taxa. Indeed, studies have shown that ungulates, birds, and reptiles all experience accelerated heart rates and metabolic function during disturbance events; in turn, animals may be displaced and experience reproductive failure and reduced survivorship (see review in Havlick, 2002). For example, radio-collared mule deer disturbed by ATVs altered their patterns of foraging and spatial use of habitat; deer in undisturbed areas, however, exhibited no such changes (Yarmoloy and others, 1988). In addition, Yarmoloy and others (1988) found that harassment of deer resulted in diminished reproductive output in the following fawning season, whereas deer that were not harassed experienced no change in reproduction.

2.4.5 Wildlife Mortality and Related Issues

Direct wildlife mortality can result from vehicular impact (Harris and Gallagher, 1989; Beier, 1993; Bruinderink and Hazebrook, 1996; Moore and Mangel, 1996), thus removing individuals from populations (Harris and Gallagher, 1989; Forman and Alexander, 1998); thus, habitats containing roads may represent population sinks for any species that commonly attempts to move from one habitat fragment to another by crossing roads (Kline and Swann, 1998). If mortality rates exceed rates of reproduction and immigration, wildlife populations decline (Beier, 1993; Bruinderink and Hazebrook, 1996; Moore and Mangel, 1996; Forman and Alexander, 1998). Previous studies indicate that mortality rates vary widely according to habitat and road or route characteristics (for example, road width, traffic density and speed, adjacent habitat) (Ward, 1982; Bashore and others, 1985; Foster and Humphrey, 1995; Evink and others, 1996, 1998), as well as taxa studied—invertebrates: Seibert and Conover (1991), Munguira and Thomas (1992); reptiles and amphibians: Rosen and Lowe (1994), Ashley and Robinson (1996), Boarman and others (1998), Rudolph and others (1998), Means (1999); birds: Dhindsa and others (1988), Moore and Mangel (1996), Mumme and others (2000); and mammals: Gilbert and Wooding (1996), Romin and Bissonette (1996), Lehnert and Bissonette (1997), Gunter and others (1998), Lyren (2001). Even where the frequency of wildlife mortality is relatively low most of the year, it may increase during certain seasons (Feldhammer and others, 1986; Bruinderink and Hazebrook, 1996) or when traffic frequency increases (McCaffery, 1973). Furthermore, population dynamics can be altered if low mortality rates nonetheless cause disproportionate mortality among specific sex and/or age classes (Beier, 1993; Moore and Mangel, 1996; Mumme and others, 2000).

Several researchers have conducted extensive monitoring at desert OHV sites and undisturbed sites to compare direct effects of OHV activity on mortality and abundance of certain reptile species (Bury and others, 1977; Berry, 1980a; Bury, 1980; Luckenbach and Bury, 1983; Brooks, 1999; Grant, 2005). Of important concern is the susceptibility of desert tortoises to mortality on all types of roads. Berry (1980a) found a link between OHV activity and population declines of the desert tortoise and Couch's spadefoot toad (*Scaphiopus couchii*); numbers of tortoises and active burrows in a 25-ha control plot were significantly greater than in a similar plot exposed to OHV activity, presumably the result of direct mortality from vehicles or the collapsing of burrows caused by OHV traffic (Lovich and Bainbridge, 1999). Additionally, the body masses of subadult and adult tortoises in the control plot were greater than those of

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WCS WORKING PAPER NO. 21
APRIL, 2003

ALL-TERRAIN VEHICLES IN THE ADIRONDACKS

Issues and Options

By Leslie N. Karasin

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etative cover can all adversely affect wildlife. Additionally, the creation or widening of trails or roads to accommodate ATV use can be detrimental to wildlife because of the resulting fragmentation of habitat, increased human access to backcountry areas, and displacement of interior species by edge species. Habitat fragmentation is widely regarded as a major threat to species diversity. A good deal of research has also been done on the impact of trails and roads on the behavior patterns of wildlife, demonstrating that many wildlife species shift their home ranges or movement patterns in response to the presence of roads or trails, whether to avoid humans or to take advantage of travel corridors (Bennett 1991; Formann and Alexander 1998). These shifts have consequences for population dynamics and predator-prey relationships. Additionally, the introduction of exotic plant species, discussed above, can be damaging to native wildlife populations. All of these impacts are exacerbated if ATV users widen trails or create new trails. Another habitat modification impact pertains to the micro-habitats that are sometimes created when pools form in rutted trails. Particularly if this happens in the wet spring season, amphibians may be attracted to the area for breeding, despite the fact that their chances of survival in an ATV trail are poor (Defenders of Wildlife 2003).

Pollution, another threat listed above as having an impact on wildlife, includes both water and air pollution. The example cited above involving water pollution and its effect on fish populations illustrates one type of potential consequences posed by ATV emissions.

The final category of impact on wildlife is disturbance, which is less tangible than the other effects. Disturbance includes the myriad ways in which wildlife suffer from the noise pollution and human presence which results from ATV use. The average ATV with a muffler produces noise at a level of 81-111 dB (Bluewater Network 2002). Being in the vicinity of this volume of noise can cause direct damage to wildlife; they can suffer auditory damage just as humans can, and the noise can also directly affect predator-prey relationships by masking the sounds that generally have an important role in those interactions. High levels of background noise can have a number of indirect effects as well. Noise can cause wildlife to be stressed, and it can affect their balance of energy expenditures, cause an increase in animals' heart rates, and affect behavior patterns such as nesting and reproduction or feeding and foraging. These impacts may or may not be devastating to an animal depending on the season, its energy budget, and the extent of the disturbance. One study of disturbance by ATVs involved mule deer; the researcher disturbed a mule deer population and tracked its feeding and travel patterns. The disturbed group altered its behavior and had a lower reproductive rate the following season than the control group. (1995) Another study looked at birds' travel patterns and found that birds traveled away from areas where ORVs were in use to areas where there was little or no ORV activity (Wildlands Center for Preventing Roads 2001).

Noise Pollution

Analyses of the noise produced by an ATV vary slightly, but an average estimate is that a single ATV produces 80 decibels at 50 feet (Blumberg 2003). For purposes of comparison, this is slightly quieter than a tractor-trailer driving on a highway, and considerably louder than a diesel delivery truck idling. The pre-

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cise noise level of a particular ATV varies according to the type of engine and muffler, the ground surface, and whether the machine is accelerating or not, among other factors. For general purposes, though, it is possible to model the soundscape produced by one or more ATVs with rough accuracy. If an ATV produces 80 decibels at 50 feet, and there is not dense vegetation to attenuate its noise, it will be at a volume of 56 decibels 800 feet away. This is loud enough to interfere with conversations. If two such machines are together, and again assuming that there is not vegetation or other factors that directly interfere with the sound waves, they could be audible from two miles away. Noise has an impact on wildlife, as discussed above, and on non-motorized users.

Impacts on Non-motorized Users

ATVs' impacts on non-motorized users are not, strictly speaking, ecological factors, but they are included here because of the general effect that they have on the character of wild areas and on the natural environment as it is perceived by other humans. This is a complex subject that could easily extend far into the realms of recreation management and human psychology. Simply put, however, ATVs interfere with the resource of silence that many non-motorized users go into wild areas expecting to find. One study of recreationists' responses to noise suggested that backcountry users are much more sensitive to man-made noise than front-country (road-accessible campground) users.[7] These same backcountry users rated off-road vehicles as the most irritating noise sources in the study (Kariel 1991). It is worth mentioning that a broad group of backcountry users find motorized uses irritating. In addition to the reactions of hikers and backpackers mentioned above, several studies of sportsmen have documented that a majority of hunters feel that the presence of motorized recreational vehicles detracts from their recreational experience (The Wilderness Society 2001).

ATVs interfere with the resource of silence that many non-motorized users go into wild areas expecting to find

ATVs may also leave physical evidence of their presence (obvious erosion, for example), which is a reminder to other users about the presence of motorized use, and therefore a statement about the natural character of the area. As a result of these factors, motorized use is often seen as being incompatible with some other types of recreational use. In the Adirondacks, where 70 million people live within a day's drive of an enormous resource of public land, there is considerable pressure to balance incompatible uses.

Impacts and Implications for Management

It should be emphasized that the impacts detailed above do not occur in a vacuum. There are many complex relationships between the systems of a wild area, and damage to any element of the system many have serious effects on the area's overall ecological health.

Some of the impacts detailed above can be mitigated with good management. Trail siting and appropriate trail management, for example, are critical factors in determining whether an ATV-used trail is particularly susceptible to erosion. Some of the impacts, however, cannot be mitigated other than by limiting or restricting use. Nothing else, for example, will curb impacts on wildlife.

Where decisions like trail routing, trail maintenance, or amount of permitted use can have an effect on environmental impacts, the goal of management is to halt undesirable change, a process which involves both establishing limits

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Cumulative and Universal: ATV Impacts on the Landscape and Wildlife

A Review of the Literature on the Subject

Prepared by: Backcountry Hunters and Anglers

Summer, 2011

Ref 5-487-

Section 2. Effects of ATV use on Wildlife

All-terrain vehicle travel can have a profound effect on all forms of wildlife. Concerns about the effect of off-highway travel on wildlife include: direct mortality (Bury et al. 1977; Bury et al. 2002), habitat fragmentation (Ouren et al. 2007) and reductions in habitat patch size (the size of an unfragmented "patch" of land that supports at least one population of wildlife) (Reed et al. 1996; Forman et al. 2003), increases in the edge: interior habitat ratio (reductions in animal populations at the edge of forest habitats referred to as the "edge effect"), and alteration of animal behavior (Canfield et al. 1999; Rowland et al. 2000; Wisdom et al. 2004a). Although direct mortality of ungulates resulting from collisions with ATV's is low, mortality of several species of reptiles have been documented due to off-highway travel (Brooks 1999; Grant 2005).

Habitat fragmentation results from the development of barriers that divide areas of continuous habitat into smaller, disconnected parcels or "patches". **Although roads may be the largest source of habitat fragmentation in North America (Harris and Lopez 1992), ATV trails can have a greater cumulative impact due to the density of trails on previously continuous habitats (Gaines et al. 2003; Gilbert 2003)**. Habitat fragmentation can disrupt wildlife movements between and within habitats (Forman and Alexander 1998; Jackson and Griffin 1998), which can have negative consequences for endemic species and may encourage non-native and invasive species propagation (Lovallo and Anderson 1996; Jackson and Griffin 1998). When ATV use results in habitat fragmentation and the disruption of wildlife movement, subpopulations of wildlife can become isolated (Dobson et al. 1999); which promotes inbreeding within the population and results in the loss of genetic diversity (Hanski 1999). Habitat fragmentation can reduce reproductive success among nesting birds and is believed to be the main culprit in population reductions in some species of forest birds (Robinson et al. 1995).

northwestern Wyoming was not significantly altered by the presence of off-road tracks that received minimal traffic in summer months, but were avoided by elk as traffic increased on the same tracks during the hunting season.

Alteration of animal behavior resulting from disturbance (motorized or non-motorized) ranges from immediate, short term temporary displacement to permanent abandonment of favored feeding areas (Geist 1978). According to Trombulak and Frissel (2000), animal behavior is modified through five mechanisms:

1. altered movement patterns
2. changes in home range
3. altered reproductive success
4. altered escape response
5. altered physiological state

Geist (1978) (quoted from Hershey 2011) asserts that these modifications to behavior result in three primary consequences:

1. Elevates metabolism at the cost of energy resources and reserves needed for the animal's normal growth and reproductive potential.
2. Can cause death, illness or reduced reproduction due to secondary effects from physical exertion and temporary confusion.
3. Can lead to avoidance or abandonment of areas and to reduction in a population's range and, ultimately, to reductions of the populations due to loss of access to resources, increased predation or increased energy cost for existence.

Geist (1978) is supported by Yarmoloy et al. (1988) who suggest that over time these consequences can result in lost productivity for a population when physiological responses to northwestern Wyoming was not significantly altered by the presence of off-road tracks that received minimal traffic in summer months, but were avoided by elk as traffic increased on the same tracks during the hunting season.

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DEPARTMENT OF NATURAL RESOURCES

Ref 7-490-

MINNESOTA'S LIST OF ENDANGERED, THREATENED, AND SPECIAL CONCERN SPECIES

see pgs. 2,3,4

PURPOSE, SCOPE, AND RELATIONSHIP TO FEDERAL LAWS

Minnesota's Endangered Species Statute (Minnesota Statutes, Section 84.0895) requires the Minnesota Department of Natural Resources (DNR) to adopt rules designating species meeting the statutory definitions of endangered, threatened, or species of special concern. The resulting List of Endangered, Threatened, and Special Concern Species is codified as Minnesota Rules, Chapter 6134. The Endangered Species Statute also authorizes the DNR to adopt rules that regulate treatment of species designated as endangered and threatened. These regulations are codified as Minnesota Rules, Parts 6212.1800 to 6212.2300.

Minnesota's Endangered Species Statute and the associated Rules impose a variety of restrictions, a permit program, and several exemptions pertaining to species designated as endangered or threatened. A person may not take, import, transport, or sell any portion of an endangered or threatened species. However, these acts may be allowed by permit issued by the DNR; plants on certain agricultural lands and plants destroyed in consequence of certain agricultural practices are exempt; and the accidental, unknowing destruction of designated plants is exempt. Species of special concern are not protected by Minnesota's Endangered Species Statute or the associated Rules. Persons are advised to read the full text of the Statute and Rules in order to understand all regulations pertaining to species that are designated as endangered, threatened, or species of special concern.

Note that the federal Endangered Species Act of 1973, as amended (16 USC 1531 - 1544) requires the U.S. Department of the Interior to identify species as endangered or threatened according to a separate set of definitions, and imposes a separate set of restrictions pertaining to those species. In the following list, the federal status of seventeen federally-listed species that occur in Minnesota is noted to the right of those species' common names (E = endangered; T = threatened; P=proposed; C = candidate).

DEFINITIONS

A species is considered **endangered** if the species is threatened with extinction throughout all or a significant portion of its range within Minnesota.

A species is considered **threatened** if the species is likely to become endangered within the foreseeable future throughout all or a significant portion of its range within Minnesota.

A species is considered a **species of special concern** if, although the species is not endangered or threatened, it is extremely uncommon in Minnesota, or has unique or highly specific habitat requirements and deserves careful monitoring of its status. Species on the periphery of their range that are not listed as threatened may be included in this category along with those species that were once threatened or endangered but now have increasing or protected, stable populations.

CONTENTS

FOR MORE INFORMATION, CONTACT:

Minnesota Endangered Species Coordinator
Division of Ecological and Water Resources
Minnesota Department of Natural Resources
500 Lafayette Rd., Box 25
St. Paul, MN 55155
1-888-646-6367 (or 612-296-6157 in the metro area)
http://www.dnr.state.mn.us/ets/index.html

Effective August 19, 2013

MAMMALS

Ref 7 - 491-

Threatened

Spilogale putorius .... eastern spotted skunk
Thomomys talpoides .... northern pocket gopher

Special Concern

Alces americanus .... moose
Cervus canadensis .... elk
Cryptotis parva .... North American least shrew
Eptesicus fuscus .... big brown bat
Lynx canadensis .... Canada lynx (Fed. Status: T)
Microtus ochrogaster .... prairie vole
Microtus pinetorum .... woodland vole
Mustela nivalis .... least weasel
Myotis lucifugus .... little brown myotis
Myotis septentrionalis .... northern myotis (Fed. Status: P)
Onychomys leucogaster .... northern grasshopper mouse
Perimyotis subflavus .... tri-colored bat
Perognathus flavescens .... plains pocket mouse
Phenacomys ungava .... eastern heather vole
Puma concolor .... mountain lion
Reithrodontomys megalotis .... western harvest mouse
Sorex fumeus .... smoky shrew
Synaptomys borealis .... northern bog lemming
Urocitellus richardsonii .... Richardson's ground squirrel

BIRDS

Endangered

Ammodramus bairdii .... Baird's sparrow
Ammodramus henslowii .... Henslow's sparrow
Anthus spragueii .... Sprague's pipit (Fed. Status: C)
Athene cunicularia .... burrowing owl
Calcarius ornatus .... chestnut-collared longspur
Charadrius melodus .... piping plover (Fed. Status: E/T)
Lanius ludovicianus .... loggerhead shrike
Podiceps auritus .... horned grebe
Rallus elegans .... king rail

Threatened

Phalaropus tricolor .... Wilson's phalarope
Sterna hirundo .... common tern

Special Concern

Accipiter gentilis .... northern goshawk
Aegolius funereus .... boreal owl
Ammodramus nelsoni .... Nelson's sparrow
Asio flammeus .... short-eared owl
Buteo lineatus .... red-shouldered hawk
Chondestes grammacus .... lark sparrow
Coturnicops noveboracensis .... yellow rail
Cygnus buccinator .... trumpeter swan
Empidonax virescens .... acadian flycatcher
Falco peregrinus .... peregrine falcon
Gallinula galeata .... common gallinule
Leucophaeus pipixcan .... Franklin's gull
Limosa fedoa .... marbled godwit
Parkesia motacilla .... Louisiana waterthrush
Pelecanus erythrorhynchos .... American white pelican
Progne subis .... purple martin
Setophaga cerulea .... cerulean warbler
Setophaga citrina .... hooded warbler
Sterna forsteri .... Forster's tern
Tympanuchus cupido .... greater prairie-chicken
Vireo bellii .... Bell's vireo

AMPHIBIANS AND REPTILES

Ref 7 - 492 -

Endangered

Acris blanchardi .... northern cricket frog
Sistrurus catenatus .... massasauga (Fed. Status: C)

Threatened

Crotalus horridus .... timber rattlesnake
Emydoidea blandingii .... Blanding's turtle
Glyptemys insculpta .... wood turtle
Pantherophis obsoletus .... western ratsnake

Special Concern

Ambystoma maculatum .... spotted salamander
Anaxyrus cognatus .... Great Plains toad
Apalone mutica .... smooth softshell
Coluber constrictor .... North American racer
Hemidactylium scutatum .... four-toed salamander
Heterodon nasicus .... plains hog-nosed snake
Necturus maculosus .... mudpuppy
Pituophis catenifer .... gopher snake
Plestiodon fasciatus .... common five-lined skink
Tropidoclonion lineatum .... lined snake

FISH

Endangered

Alosa chrysochloris .... skipjack herring
Crystallaria asprella .... crystal darter
Hybopsis amnis .... pallid shiner
Noturus exilis .... slender madtom

Threatened

Erimystax x-punctatus .... gravel chub
Fundulus sciadicus .... plains topminnow
Ictiobus niger .... black buffalo
Notropis anogenus .... pugnose shiner
Polyodon spathula .... paddlefish

Special Concern

Acipenser fulvescens .... lake sturgeon
Anguilla rostrata .... American eel
Aphredoderus sayanus .... pirate perch
Clinostomus elongates .... redside dace
Coregonus kiyi .... kiyi
Coregonus nipigon .... Nipigon cisco
Coregonus zenithicus .... shortjaw cisco
Couesius plumbeus .... lake chub
Cycleptus elongatus .... blue sucker
Etheostoma chlorosoma .... bluntnose darter
Etheostoma microperca .... least darter
Hybognathus nuchalis .... Mississippi silvery minnow
Ichthyomyzon fossor .... northern brook lamprey
Ichthyomyzon gagei .... southern brook lamprey
Lepomis gulosus .... warmouth
Lepomis peltastes .... northern longear sunfish
Lythrurus umbratilis .... redfin shiner
Morone mississippiensis .... yellow bass
Moxostoma duquesnei .... black redhorse
Notropis nubilus .... Ozark minnow
Notropis topeka .... Topeka shiner (Fed. Status: E)
Percina evides .... gilt darter
Phenacobius mirabilis .... suckermouth minnow
Platygobio gracilis .... flathead chub
Prosopium coulterii .... pygmy whitefish

Ref 7-493-

MOLLUSKS

Endangered

Arcidens confragosus .... rock pocketbook
Cumberlandia monodonta .... spectaclecase (Fed. Status: E)
Cyclonaias tuberculata .... purple wartyback
Elliptio crassidens .... elephant-ear
Epioblasma triquetra .... snuffbox (Fed. Status: E)
Fusconaia ebena .... ebonyshell
Lampsilis higginsii .... Higgins eye (Fed. Status: E)
Lampsilis teres .... yellow sandshell
Megalonaias nervosa .... washboard
Plethobasus cyphyus .... sheepnose (Fed. Status: E)
Quadrula fragosa .... winged mapleleaf (Fed. Status: E)
Simpsonaias ambigua .... salamander mussel
Tritogonia verrucosa .... pistolgrip

Threatened

Actinonaias ligamentina .... mucket
Alasmidonta marginata .... elktoe
Ellipsaria lineolata .... butterfly
Elliptio dilatata .... spike
Lasmigona costata .... fluted-shell
Ligumia subrostrata .... pondmussel
Quadrula metanevra .... monkeyface
Quadrula nodulata .... wartyback
Truncilla donaciformis .... fawnsfoot
Venustaconcha ellipsiformis .... ellipse
Vertigo meramecensis .... bluff vertigo

Special Concern

Anodonta suborbiculata .... flat floater
Elliptio complanata .... eastern elliptio
Gastrocopta rogersensis .... Rogers' snaggletooth snail
Lasmigona compressa .... creek heelsplitter
Ligumia recta .... black sandshell
Planogyra asteriscus .... eastern flat-whorl snail
Pleurobema sintoxia .... round pigtoe
Striatura ferrea .... black striate snail
Zonitoides limatulus .... dull gloss

JUMPING SPIDERS

Threatened

Tutelina formicaria .... a species of jumping spider

Special Concern

Habronattus calcaratus maddisoni .... a species of jumping spider
Habronattus texanus .... a species of jumping spider
Habronattus viridipes .... a species of jumping spider
Marpissa formosa .... a species of jumping spider
Paradamoetas fontana .... a species of jumping spider
Pelegrina arizonensis .... a species of jumping spider
Phidippus apacheanus .... a species of jumping spider
Phidippus pius .... a species of jumping spider
Sassacus papenhoei .... a species of jumping spider

LEAFHOPPERS

Special Concern

Aflexia rubranura .... red-tailed leafhopper
Attenuipyga vanduzeei .... hill prairie shovelhead leafhopper
Macrosteles clavatus .... caped leafhopper

DRAGONFLIES

Threatened

Ophiogomphus susbehcha .... St. Croix snaketail

Special Concern

Aeschna sitchensis .... zigzag darner
Aeschna subarctica .... subarctic darner
Boyeria grafiana .... ocellated darner
Ophiogomphus anomalus .... extra-striped snaketail
Ophiogomphus howei .... pygmy snaketail
Somatochlora brevicincta .... Quebec emerald
Somatochlora forcipata .... forcipate emerald

BUTTERFLIES AND MOTHS

Ref 7-494-

Endangered

Erynnis persius persius .... persius dusky wing
Hesperia assiniboia .... assiniboia skipper
Hesperia dacotae .... Dakota skipper (Fed. Status: P)
Hesperia ottoe .... ottoe skipper
Hesperia uncas .... uncas skipper
Lycaeides melissa samuelis .... Karner blue (Fed. Status: E)
Oarisma poweshiek .... poweshiek skipper (Fed. Status: P)
Oeneis uhleri varuna .... Uhler's arctic

Threatened

Oarisma garita .... garita skipper

Special Concern

Atrytone arogos iowa .... arogos skipper
Catocala abbreviatella .... abbreviated underwing
Catocala whitneyi .... Whitney's underwing
Erebia mancinus .... disa alpine
Hesperia leonardus .... leonardus skipper
Lycaeides idas nabokovi .... Nabokov's blue
Pyrgus centaureae freija .... grizzled skipper
Schinia indiana .... phlox moth
Schinia lucens .... leadplant flower moth
Speyeria idalia .... regal fritillary

CADDISFLIES

Endangered

Hydroptila waskesia .... a species of purse casemaker caddisfly
Limnephilus janus .... a species of northern caddisfly
Limnephilus secludens .... a species of northern caddisfly
Ochrotrichia spinosa .... a species of purse casemaker caddisfly
Polycentropus milaca .... a species of tube casemaker caddisfly

Threatened

Chilostigma itascae .... headwaters chilostigman caddisfly
Goera stylata .... a species of caddisfly
Hydroptila rono .... a species of purse casemaker caddisfly
Ironoquia punctatissima .... a species of northern caddisfly
Lepidostoma libum .... a species of caddisfly
Limnephilus rossi .... a species of northern caddisfly
Oecetis ditissa .... a species of long-horned caddisfly
Oxyethira ecornuta .... a species of purse casemaker caddisfly
Parapsyche apicalis .... a species of netspinning caddisfly
Polycentropus glacialis .... a species of tube casemaker caddisfly
Ylodes frontalis .... a species of long-horned caddisfly

Special Concern

Agapetus tomus .... a species of caddisfly
Anabolia ozburni .... a species of northern caddisfly
Hydroptila metoeca .... a species of purse casemaker caddisfly
Hydroptila quinola .... a species of purse casemaker caddisfly
Hydroptila tortosa .... a species of purse casemaker caddisfly
Oxyethira itascae .... a species of purse casemaker caddisfly
Protoptila erotica .... a species of saddle casemaker caddisfly
Triaenodes flavescens .... a species of long-horned caddisfly

TIGER BEETLES

Endangered

Cicindela fulgida fulgida .... crimson salflat tiger beetle, fulgida ssp.
Cicindela hirticollis rhodensis .... hairy-necked tiger beetle
Cicindela limbata nympha .... sandy tiger beetle

Threatened

Cicindela fulgida westbournei .... crimson salflat tiger beetle, westb. ssp.
Cicindela lepida .... ghost tiger beetle

Special concern

Cicindela denikei .... Laurentian tiger beetle
Cicindela macra macra .... sandy stream tiger beetle
Cicindela patruela patruela .... northern barrens tiger beetle
Cicindela splendida cyanocephalata .... splendid tiger beetle

VASCULAR PLANTS

Ref 7 - 495 -

Endangered

Achnatherum hymenoides .... Indian rice grass
Agalinis auriculata .... eared false foxglove
Agalinis gattingeri .... round-stemmed false foxglove
Agrostis hyemalis .... winter bentgrass
Allium schoenoprasum .... wild chives
Aristida longespica var. *geniculata* .... slimspike three-awn
Asclepias stenophylla .... narrow-leaved milkweed
Astragalus alpinus var. *alpinus* .... alpine milk-vetch
Bartonia virginica .... yellow bartonia
Botrychium ascendens .... upswept moonwort
Botrychium gallicomontanum .... Frenchman's Bluff moonwort
Botrychium lineare .... slender moonwort
Botrychium spathulatum .... spathulate moonwort
Calamagrostis purpurascens .... purple reedgrass
Caltha natans .... floating marsh marigold
Carex careyana .... Carey's sedge
Carex formosa .... handsome sedge
Carex pallescens .... pale sedge
Carex plantaginea .... plantain-leaved sedge
Carex supina ssp. *spaniocarpa* .... weak arctic sedge
Castilleja septentrionalis .... northern paintbrush
Chrysosplenium iowense .... Iowa golden saxifrage
Commelina erecta .... slender dayflower
Diarrhena obovata .... obovate beakgrain
Dodecatheon meadia var. *meadia* .... prairie shooting star
Draba cana .... hoary whitlow grass
Draba norvegica .... Norwegian whitlow grass
Dryopteris marginalis .... marginal shield fern
Eleocharis wolfii .... Wolf's spikerush
Elodea bifoliata .... two leaf waterweed
Empetrum atropurpureum .... purple crowberry
Empetrum nigrum .... black crowberry
Erigeron acris var. *kamtschaticus* .... bitter fleabane
Erythronium propullans .... dwarf trout lily (Fed. Status: E)
Escobaria vivipara .... ball cactus
Fimbristylis puberula var. *interior* .... hairy fimbry
Hasteola suaveolens .... sweet-smelling Indian-plantain
Hybanthus concolor .... eastern green-violet
Hydrastis canadensis .... goldenseal
Iodanthus pinnatifidus .... purple rocket
Isoetes melanopoda .... prairie quillwort
Juglans cinerea .... butternut
Juncus articulatus .... jointed rush
Juncus marginatus .... marginated rush
Juncus subtilis .... slender rush
Lechea tenuifolia var. *tenuifolia* .... narrow-leaved pinweed
Listera auriculata .... auricled twayblade
Lysimachia maritima .... sea milkwort
Malaxis paludosa .... bog adder's mouth
Marsilea vestita .... hairy waterclover
Montia chamissoi .... montia
Osmorhiza berteroi .... Chilean sweet cicely
Oxytropis viscida .... sticky locoweed
Packera cana .... gray ragwort
Packera indecora .... elegant grounsel
Paronychia canadensis .... Canada forked chickweed
Paronychia fastigiata var. *fastigiata* .... forked chickweed
Parthenium integrifolium .... wild quinine
Phegopteris hexagonoptera .... broad beech fern
Physaria ludoviciana .... bladderpod
Platanthera praeclara .... western prairie fringed orchid (Fed. Status: T)
Polanisia jamesii .... James' polanisia
Polemonium occidentale ssp. *lacustre* .... western Jacob's ladder
Polygala cruciata .... cross-leaved milkwort
Polystichum acrostichoides .... Christmas fern
Potamogeton bicupulatus .... snailseed pondweed
Potamogeton confervoides .... algae-like pondweed
Potamogeton diversifolius .... diverse-leaved pondweed
Potamogeton oakesianus .... Oake's pondweed
Potamogeton pulcher .... spotted pondweed
Prosartes trachycarpa .... rough-fruited fairybells
Psoralidium tenuiflorum .... slender-leaved scurf pea
Rhodiola integrifolia ssp. *leedyi* .... Leedy's roseroot (Fed. Status: T)
Rubus missouricus .... Missouri dewberry
Rubus stipulatus .... bristle-berry
Sagina nodosa ssp. *borealis* .... knotty pearlwort
Sagittaria brevirostra .... short-beaked arrowhead
Saxifraga cernua .... nodding saxifrage
Scleria triglomerata .... tall nutrush
Selaginella selaginoides .... northern spikemoss
Stuckenia vaginata .... sheathed pondweed
Tofieldia pusilla .... small false asphodel
Tsuga canadensis var. *canadensis* .... eastern hemlock
Utricularia purpurea .... purple-flowered bladderwort
Vaccinium uliginosum .... alpine bilberry
Xyris torta .... twisted yellow-eyed grass

Ref 7A -495A-

noted above, a specimen from Linesville, Crawford County, Pennsylvania, provides limited evidence of a historic population in the Linesville Creek–Shenango River Watershed (since 1934, flooded by the Pymatuning Dam), which straddles the Pennsylvania–Ohio border. Conant's (1951, p. 13) repeated searches in the northeasternmost counties, and Thompson's (1953) report of two Wood Turtles in Rocky River, Cuyahoga County, may indicate the recent persistence of an isolated relict population not contiguous with populations in Pennsylvania. Recent sightings in Beaver County, Pennsylvania (PA NHP 2013) bear relevance to determining the native status of Wood Turtles in Ohio.

Illinois.—There are at least two enigmatic records of Wood Turtle from Illinois. One series of two specimens were from Evanston, Cook County, where shipped to the MCZ between 1864 and 1872 (MCZ 4056). As Evanston is the location of Northwestern University, it seems possible that these records were either released captives or mislabeled with the University of origin rather than the capture site. Another specimen was observed in the Des Plaines River Ship Canal, Cook County (Miller 1993, pers. comm. to Iverson 1992), which is clearly atypical habitat in addition to being widely disjunct, and must represent an anomalous occurrence.

Iowa.—The Wood Turtle is narrowly restricted to the Cedar River drainage of northeastern Iowa. In 1924, E.L. Palmer of Cornell University reported a juvenile Wood Turtle from Ames, Story County, Iowa, extending the range south and west from recently discovered sites on the Wisconsin-Minnesota border (Wagner 1922; Palmer 1924). This unusual occurrence—not only a new state record, but near the geographic center of the state, and squarely within the Temperate Prairies ecoregion—was subsequently repeated in large-scale compendia, such as Clifford Pope's Turtles of the United States and Canada (Pope 1939). The observation was discredited (Bailey 1941) as a misidentified juvenile Blanding's turtle (*Emydoidea blandingii*). Nonetheless, by the mid-1940s, Wood Turtles were well-known to occur in the Cedar watershed of northeastern Iowa, and the populations in Black Hawk and Butler counties are the subject of long-term research by biologists the University of Northern Iowa (Tamplin et al. 2006; Tamplin et al. 2009; Spradling et al. 2010; Tamplin, pers. comm.). These populations, and those in extreme southeastern Minnesota and southwestern Wisconsin, represent the only occurrence of Wood Turtles within the prairie ecoregions of the middle United States—noteworthy for what is otherwise a creature of cool, northern forests. In these peripheral prairie regions it is common for the floodplains of larger rivers to support heavily forested floodplains.

Minnesota.—Wood Turtles reach their westernmost extent of occurrence in the Mississippi drainage of south-central Minnesota (Breckenridge 1958; Ernst 1973; Iverson 1992; Ernst and Lovich 2009). In this state, Wood Turtles are known primarily from three distinct regions: (1) watersheds draining into Lake Superior in St. Louis and Lake counties; (2) those from Pine and Chisago counties in the St. Croix watershed; and (3) those along the Cannon and Mississippi Rivers in Rice, Goodhue, Steele, Dodge, Olmsted and Mower counties in the southern part of the state, reaching almost to the Iowa border in Mower County (Ernst 1973).

Wisconsin.—Wood Turtles occur widely throughout the forested regions of northern and western Wisconin (Vogt 1981). Though known from the state for less than a century—first confirmed near St. Croix Falls in Polk County by George Wagner (1922) and subsequently reported by Edgren (1944) from Bayfield County. Wood Turtles are now known to occur throughout the northern two-thirds of Wisconsin, including Douglas and Bayfield counties on the shores of Lake Superior, and known from at least seven major drainages within the Chequamegon National Forest (St. Pierre (2008). Wood Turtles occur in southwestern Wisconsin in portions of the Wisconsin River watershed, but they are absent entirely from

Endangered Species in Minnesota

Ref 8 -496-

County Distribution of Federally-Listed Threatened and Endangered Species

Revised Jan. 10, 2018

County	Species	Status	Habitat
Aitkin	Canada lynx *(Lynx canadensis)*	Threatened	Northern forest
	Gray wolf *Canis lupus*	Threatened	Northern forest
	Northern long-eared bat *Myotis septentrionalis*	Threatened Townships containing northern long-eared bat roost trees and hibernacula - links to Minnesota DNR PDF	Hibernates in caves and mines - swarming in surrounding wooded areas in autumn. Roosts and forages in upland forests during spring and summer.
Anoka	Northern long-eared bat *Myotis septentrionalis*	Threatened	Hibernates in caves and mines - swarming in surrounding wooded areas in autumn. Roosts and forages in upland forests during spring and summer.
Becker	Gray wolf *Canis lupus*	Threatened	Northern forest
	Northern long-eared bat *Myotis septentrionalis*	Threatened	Hibernates in caves and mines - swarming in surrounding wooded areas in autumn. Roosts and forages in upland forests during spring and summer.
Beltrami	Canada lynx *(Lynx canadensis)*	Threatened	Northern forest
	Gray wolf *Canis lupus*	Threatened and Critical Habitat	Northern forest
	Northern long-eared bat *Myotis septentrionalis*	Threatened	Hibernates in caves and mines - swarming in surrounding wooded areas in autumn. Roosts and forages in upland forests during spring and summer.
	Rusty patched bumble bee *Bombus affinis* **Note for project proponents:** this bee is not known to occur throughout the entire county. To determine if your project or ongoing action is within an area that is likely to have the rusty patched bumble bee, use our online tool at https://ecos.fws.gov/ipac/	Endangered	Grasslands with flowering plants from April through October, underground and abandoned rodent cavities or clumps of grasses above ground as nesting sites, and undisturbed soil for hibernating queens to overwinter.

County	Species	Status	Habitat
	Rusty patched bumble bee *Bombus affinis* **Note for project proponents:** this bee is not known to occur throughout the entire county. To determine if your project or ongoing action is within an area that is likely to have the rusty patched bumble bee, use our online tool at https://ecos.fws.gov/ipac/	Endangered	Grasslands with flowering plants from April through October, underground and abandoned rodent cavities or clumps of grasses above ground as nesting sites, and undisturbed soil for hibernating queens to overwinter.
Houston	Northern long-eared bat *Myotis septentrionalis*	Threatened	Hibernates in caves and mines - swarming in surrounding wooded areas in autumn. Roosts and forages in upland forests during spring and summer.
	Higgins eye pearlymussel *(Lampsilis higginsii)*	Endangered	Mississippi River
	Rusty patched bumble bee *Bombus affinis* **Note for project proponents:** this bee is not known to occur throughout the entire county. To determine if your project or ongoing action is within an area that is likely to have the rusty patched bumble bee, use our online tool at https://ecos.fws.gov/ipac/	Endangered	Grasslands with flowering plants from April through October, underground and abandoned rodent cavities or clumps of grasses above ground as nesting sites, and undisturbed soil for hibernating queens to overwinter.
Hubbard	Gray wolf *Canis lupus*	Threatened	Northern forest
	Northern long-eared bat *Myotis septentrionalis*	Threatened Townships containing northern long-eared bat roost trees and hibernacula - links to Minnesota DNR PDF	Hibernates in caves and mines - swarming in surrounding wooded areas in autumn. Roosts and forages in upland forests during spring and summer.
Isanti	Northern long-eared bat *Myotis septentrionalis*	Threatened	Hibernates in caves and mines - swarming in surrounding wooded areas in autumn. Roosts and forages in upland forests during spring and summer.
Itasca	Canada lynx *(Lynx canadensis)*	Threatened	Northern forest
	Gray wolf *Canis lupus*	Threatened and Critical Habitat	Northern forest
	Northern long-eared bat *Myotis septentrionalis*	Threatened	Hibernates in caves and mines - swarming in surrounding wooded areas in autumn. Roosts and forages in upland forests during spring and summer.

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County	Species	Status	Habitat
	Rusty patched bumble bee *Bombus affinis* **Note for project proponents:** this bee is not known to occur throughout the entire county. To determine if your project or ongoing action is within an area that is likely to have the rusty patched bumble bee, use our online tool at https://ecos.fws.gov/ipac/	Endangered	Grasslands with flowering plants from April through October, underground and abandoned rodent cavities or clumps of grasses above ground as nesting sites, and undisturbed soil for hibernating queens to overwinter.
Jackson	Northern long-eared bat *Myotis septentrionalis*	Threatened	Hibernates in caves and mines - swarming in surrounding wooded areas in autumn. Roosts and forages in upland forests during spring and summer.
	Rusty patched bumble bee *Bombus affinis* **Note for project proponents:** this bee is not known to occur throughout the entire county. To determine if your project or ongoing action is within an area that is likely to have the rusty patched bumble bee, use our online tool at https://ecos.fws.gov/ipac	Endangered	Grasslands with flowering plants from April through October, underground and abandoned rodent cavities or clumps of grasses above ground as nesting sites, and undisturbed soil for hibernating queens to overwinter.
	Prairie bush clover *(Lespedeza leptostachya)*	Threatened	Native prairie on well-drained soils
Kanabec	Gray wolf *Canis lupus*	Threatened	Northern forest
	Northern long-eared bat *Myotis septentrionalis*	Threatened	Hibernates in caves and mines - swarming in surrounding wooded areas in autumn. Roosts and forages in upland forests during spring and summer.
Kandiyohi	Northern long-eared bat *Myotis septentrionalis*	Threatened	Hibernates in caves and mines - swarming in surrounding wooded areas in autumn. Roosts and forages in upland forests during spring and summer.
Kittson	Gray wolf *Canis lupus*	Threatened	Northern forest
	Northern long-eared bat *Myotis septentrionalis*	Threatened	Hibernates in caves and mines - swarming in surrounding wooded areas in autumn. Roosts and forages in upland forests during spring and summer.
	Dakota skipper *(Hesperia dacotae)*	Threatened Critical Habitat Maps of Critical Habitat	Native prairie habitat

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County	Species	Status	Habitat
	Poweshiek skipperling *(Oarisma poweshiek)*	Endangered Critical Habitat Maps of Critical Habitat	Native Prairie
	Western prairie fringed orchid *(Platanthera praeclara)*	Threatened	Wet prairies and sedge meadows
Koochiching	Canada lynx *(Lynx canadensis)*	Threatened	Northern forest
	Canada lynx *(Lynx canadensis)*	Critical Habitat	Map of lynx critical habitat in Minnesota
	Gray wolf *Canis lupus*	Threatened and Critical Habitat	Northern forest
	Northern long-eared bat *Myotis septentrionalis*	Threatened	Hibernates in caves and mines - swarming in surrounding wooded areas in autumn. Roosts and forages in upland forests during spring and summer.
Lac Qui Parle	Northern long-eared bat *Myotis septentrionalis*	Threatened	Hibernates in caves and mines - swarming in surrounding wooded areas in autumn. Roosts and forages in upland forests during spring and summer.
	Poweshiek skipperling *(Oarisma poweshiek)*	Endangered Critical Habitat Maps of Critical Habitat	Native Prairie
Lake	Canada lynx *(Lynx canadensis)*	Threatened	Northern forest
	Canada lynx *(Lynx canadensis)*	Critical Habitat	Map of lynx critical habitat in Minnesota
	Gray wolf *Canis lupus*	Threatened and Critical Habitat	Northern forest
	Northern long-eared bat *Myotis septentrionalis*	Threatened	Hibernates in caves and mines - swarming in surrounding wooded areas in autumn. Roosts and forages in upland forests during spring and summer.
Lake of the Woods	Canada lynx *(Lynx canadensis)*	Threatened	Northern forest
	Gray wolf *Canis lupus*	Threatened and Critical Habitat	Northern forest

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County	Species	Status	Habitat
	Poweshiek skipperling *(Oarisma poweshiek)*	Endangered Critical Habitat Maps of Critical Habitat	Native Prairie
Mahnomen	Gray wolf *Canis lupus*	Threatened	Northern forest
	Northern long-eared bat *Myotis septentrionalis*	Threatened	Hibernates in caves and mines - swarming in surrounding wooded areas in autumn. Roosts and forages in upland forests during spring and summer.
	Poweshiek skipperling *(Oarisma poweshiek)*	Endangered Critical Habitat Maps of Critical Habitat	Native Prairie
Marshall	Canada lynx *(Lynx canadensis)*	Threatened	Northern forest
	Gray wolf *Canis lupus*	Threatened	Northern forest
	Northern long-eared bat *Myotis septentrionalis*	Threatened	Hibernates in caves and mines - swarming in surrounding wooded areas in autumn. Roosts and forages in upland forests during spring and summer.
Martin	Northern long-eared bat *Myotis septentrionalis*	Threatened	Hibernates in caves and mines - swarming in surrounding wooded areas in autumn. Roosts and forages in upland forests during spring and summer.
	Prairie bush clover *(Lespedeza leptostachya)*	Threatened	Native prairie on well-drained soils
McLeod	Northern long-eared bat *Myotis septentrionalis*	Threatened	Hibernates in caves and mines - swarming in surrounding wooded areas in autumn. Roosts and forages in upland forests during spring and summer.
Meeker	Northern long-eared bat *Myotis septentrionalis*	Threatened	Hibernates in caves and mines - swarming in surrounding wooded areas in autumn. Roosts and forages in upland forests during spring and summer.
Mille Lacs	Gray wolf *Canis lupus*	Threatened	Northern forest

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County	Species	Status	Habitat
Otter Tail	Gray wolf *Canis lupus*	Threatened	Northern forest
	Northern long-eared bat *Myotis septentrionalis*	Threatened	Hibernates in caves and mines - swarming in surrounding wooded areas in autumn. Roosts and forages in upland forests during spring and summer.
Pennington	Gray wolf *Canis lupus*	Threatened	Northern forest
	Northern long-eared bat *Myotis septentrionalis*	Threatened	Hibernates in caves and mines - swarming in surrounding wooded areas in autumn. Roosts and forages in upland forests during spring and summer.
	Western prairie fringed orchid (*Platanthera praeclara*)	Threatened	Wet prairies and sedge meadows
Pine	Gray wolf *Canis lupus*	Threatened	Northern forest
	Northern long-eared bat *Myotis septentrionalis*	Threatened Townships containing northern long-eared bat roost trees and hibernacula - links to Minnesota DNR PDF	Hibernates in caves and mines - swarming in surrounding wooded areas in autumn. Roosts and forages in upland forests during spring and summer.
	Canada lynx (*Lynx canadensis*)	Threatened	Northern forest
	Spectaclecase (*Cumberlandia monodonta*)	Endangered	St. Croix River
Pipestone	Northern long-eared bat *Myotis septentrionalis*	Threatened	Hibernates in caves and mines - swarming in surrounding wooded areas in autumn. Roosts and forages in upland forests during spring and summer.
	Topeka shiner (*Notropis topeka*)	Endangered	Prairie rivers and streams
	Topeka shiner (*Notropis topeka*)	Critical Habitat	
	Dakota skipper (*Hesperia dacotae)*	Threatened Critical Habitat Maps of Critical Habitat	Native prairie habitat
	Poweshiek skipperling (*Oarisma poweshiek*) - 501- Ref 8	Endangered Critical Habitat Maps of Critical Habitat	Native Prairie

501 Ref 8

County	Species	Status	Habitat
	Rusty patched bumble bee *Bombus affinis* **Note for project proponents:** this bee is not known to occur throughout the entire county. To determine if your project or ongoing action is within an area that is likely to have the rusty patched bumble bee, use our online tool at https://ecos.fws.gov/ipac	Endangered	Grasslands with flowering plants from April through October, underground and abandoned rodent cavities or clumps of grasses above ground as nesting sites, and undisturbed soil for hibernating queens to overwinter.
Rock	Northern long-eared bat *Myotis septentrionalis*	Threatened	Hibernates in caves and mines - swarming in surrounding wooded areas in autumn. Roosts and forages in upland forests during spring and summer.
	Topeka shiner *(Notropis topeka)*	Endangered	Prairie rivers and streams
	Topeka shiner *(Notropis topeka)*	Critical Habitat	
	Prairie bush clover *(Lespedeza leptostachya)*	Threatened	Native prairie on well-drained soils
	Western prairie fringed orchid *(Platanthera praeclara)*	Threatened	Wet prairies and sedge meadows
Roseau	Gray wolf *Canis lupus*	Threatened and Critical Habitat	Northern forest
	Northern long-eared bat *Myotis septentrionalis*	Threatened	Hibernates in caves and mines - swarming in surrounding wooded areas in autumn. Roosts and forages in upland forests during spring and summer.
	Canada lynx *(Lynx canadensis)*	Threatened	Northern forest
	Poweshiek skipperling *(Oarisma poweshiek)*	Endangered Critical Habitat Maps of Critical Habitat	Native Prairie
St. Louis	Canada lynx *(Lynx canadensis)*	Threatened	Northern forest
	Canada lynx *(Lynx canadensis)*	Critical Habitat	Map of lynx critical habitat in Minnesota
	Gray wolf *Canis lupus*	Threatened and Critical Habitat	Northern forest

502 Ref 8

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https://minnesotago.org/trends/biodiversity

Biodiversity

Minnesotaâ€™s transportation system directly impacts the stateâ€™s wildlife and habitat resources. As the state experiences global trends like pollinator and species decline, it is important that transportation decision-makers consider ecosystem health. Understanding the challenges and opportunities associated with biodiversity could help protect native plants and animals â€“ and the habitat that supports them. Minnesotaâ€™s 141,000 total road miles offer an opportunity to provide safety for people, as well as habitat for pollinators, nesting birds and other small wildlife.

Figure 1: Native Plants on a Roadside in Minnesota

Minnesota Wildlife

Minnesota is home to several endangered or threatened species, including the rusty-patched bumble bee, Topeka shiner, and northern long-eared bat. Of over 2,000 known native wildlife species, approximately 16 percent (346) are considered â€œSpecies in Greatest Conservation Needâ€ because they are rare, declining, or face serious threats that may cause them to decline. This is up from 292 species in 2005. Habitat degradation is one of the leading stressors of â€œSpecies in Greatest Conservation Needâ€.[1] Pollinators play a unique, key role in food and flower production. Bumble bees and monarch butterflies are two types of pollinators that are essential to Minnesotaâ€™s environmental health. However, habitat loss and herbicide use have caused both bee and monarch populations to decline. Monarch populations, for example, have decreased 80 percent since the mid-1990s and that trend is expected to continue.[2] Changing practices and policy can help support pollinator populations.

Native Plantings Along Roadsides Provide Habitat

Native prairie land provides important habitat for pollinators and other species. Less than 2 percent of the original native prairie land in Minnesota still exists today. Roadsides provide a vast amount of land that can be used to reverse the loss of native prairie plants and pollinators. In addition to helping pollinators, native plantings help upland birds, songbirds, and provide places to filter water and reduce run-off. Native planting habitat varies in quality. High quality habitat has a high diversity and abundance of native plants that bloom continuously throughout the growing season, adequate food and nesting resources, and minimal pesticide use, among other characteristics. MnDOT works to plant native seeds on constructions projects â€“ between 2010 and 2015, native seed mixes were used in 36 percent of MnDOT project areas, resulting in 2,709 acres of pollinator-friendly habitat.

Ref 8A -502B-

Other Animals at Risk

Minnesota is home to eight bat species. While bats are not pollinators, they do provide ecological benefits â€" like pest control for farmers. The populations of many bat species are declining due to habitat destruction, direct killing, colony disturbance, cave vandalism, use of pesticides, and most recently, white-nose syndrome. Transportation-related construction projects can impact bat populations, so it is important to develop strategies that limit disruption to bat communities. Transportation can also impact wildlife crossings â€" many different species of wildlife have trouble crossing over roads built through their native habitat. The Minnesota Department of Natural Resources provides solutions specifically for turtles and fish. Transportation professionals can help minimize the impact on turtles and fish by building bridges and selecting appropriate culvert designs.[3]

Aquatic Invasive Species

Like roadsides, Minnesotaâ€™s waterways are both affected by and can contribute to environmental health. Opening the Great Lakes Seaway to modern shipping in the mid-20th century increased the risk of aquatic invasive species spreading on ships and through ballast water. Despite recent efforts to prevent the introduction of aquatic invasive species, aquaculture, intentional or unintentional releases, shipping, recreational boating and water gardening have all spread invasive species like the zebra mussel, sea lamprey, spiny and fishhook waterfleas, Eurasian milfoil and purple loosestrife. Aquatic invasive species impacts range from nuisance to devastation, including some forced extinctions of native plants and animals.

The Minnesota DNR tracks water bodies infested with aquatic invasive species that could spread to other waters. About 5 percent of the lakes in Minnesota are on the infested waters list. As of August 2016, zebra mussels were confirmed in 121 lakes, rivers and wetlands. Figure 4 shows the number of water bodies that were added to the infested waters list by year. As of October 2015, there are a total of 820 water bodies listed on the infested waters list.

Figure 2: Number of Water Bodies Added to Infested Waters List by Year[4]

CITATIONS

1. 1 Minnesota DNR MN State Wildlife Action Plan
2. 2017 Minnesota State Agency Pollinator Report
3. Minnesota DNR Roadways and Turtles: Solutions for Safety
4. Minnesota DNR Infested Waters List

Ref 8B-502C-

For Immediate Release

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Lawsuit Launched to Protect Habitat for Critically Endangered Rusty Patched Bumble Bee

MINNEAPOLIS, MN (December 22, 2020) — NRDC (Natural Resources Defense Council), the Center for Biological Diversity and Friends of Minnesota Scientific and Natural Areas recently issued a formal notice of intent to sue the U.S. Fish and Wildlife Service for refusing to designate critical habitat for the highly endangered rusty patched bumble bee.

Despite the bee's disappearance from 87% of its native range, the Service announced in September that designating critical habitat for the species was "not prudent," claiming that availability of habitat does not limit the bee's conservation. The decision contradicted the agency's own findings that habitat loss and degradation have contributed to the bee's decline, worsened by the widespread use of insecticides and herbicides that directly kill the bee and the wildflowers it needs to survive.

"We have no other option but to take action against this administration for its failure to designate habitat for the rusty patched bumble bee," **said Lucas Rhoads, staff attorney for the Pollinator Initiative at NRDC.** "The Service's excuses for failing to protect the bee's home have no basis in either the agency's own science or the law. This species can recover from its devastating decline only if we use every tool at our disposal to protect the bee and its habitat."

The rusty patched bumble bee was once common in the Midwest and the Northeast but was protected as endangered in 2017. In addition to habitat loss and degradation, climate change and disease have also contributed to its decline.

"The Service's refusal to provide the habitat protections this gravely imperiled bee so desperately needs is a betrayal of its mission to protect endangered species," **said Lori Ann Burd, environmental health director at the Center.** "This beautiful bumble bee was once common across much of the country. But if we don't protect the places where it breeds and feeds it will continue on its path toward extinction."

"In 2019, the rusty patched bumble bee was declared by the legislature as Minnesota's 'official bee,'" said **Thomas E. Casey, board chair of Friends of Minnesota Scientific**

Ref 8B -502D-

and Natural Areas. "We need to do everything we can to preserve and enhance habitat for this endangered pollinator."

Background

The rusty patched bumble bee was protected under the Endangered Species Act in January 2017 after a petition from the Xerces Society followed by a lawsuit by NRDC. The Service then failed to designate critical habitat by the statutory deadline, prompting another lawsuit by NRDC in 2019. A legal settlement with NRDC required the agency to move forward with a critical habitat determination in summer of 2020.

The decline of the rusty patched bumble bee is part of a troubling trend of declines in many of the 4,000-plus species of native bees in the United States.

Native bees often provide more effective pollination of native plants than honeybees, which are not native to the United States. Wild pollinator declines across North America are caused by habitat loss, agricultural intensification, pesticide use, invasive non-native species, climate change and pathogens.

About 90% of wild plants and 75% of leading global food crops — including 35% of the global food supply — depend on animal pollinators for reproduction, and the great majority of that work is done by bees.

Despite the growing evidence of declining bee populations, the rusty patched bumblebee is the only bee in the continental United States currently protected under the Endangered Species Act.

The Center for Biological Diversity *is a national, nonprofit conservation organization with more than 1.7 million members and online activists dedicated to the protection of endangered species and wild places.*

The Natural Resources Defense Council (NRDC) *is an international nonprofit environmental organization with more than 3 million members and online activists. Since 1970, our lawyers, scientists, and other environmental specialists have worked to protect the world's natural resources, public health, and the environment. NRDC has offices in New York City; Washington, D.C.; Los Angeles; San Francisco; Chicago; Bozeman, Montana; and Beijing. Visit us at www.nrdc.org and follow us on Twitter @NRDC*

Friends of Minnesota Scientific and Natural Areas *(FMSNA) is a Minnesota non-profit, tax-exempt corporation whose mission is to advocate for the protection, management, and perpetuation of Minnesota's 168+ Scientific and Natural Areas (SNAs), the "crown jewels" of Minnesota's state land base. Please visit us at www.snafriends.org*

Mail body: REF 9. Lynx- wildlife

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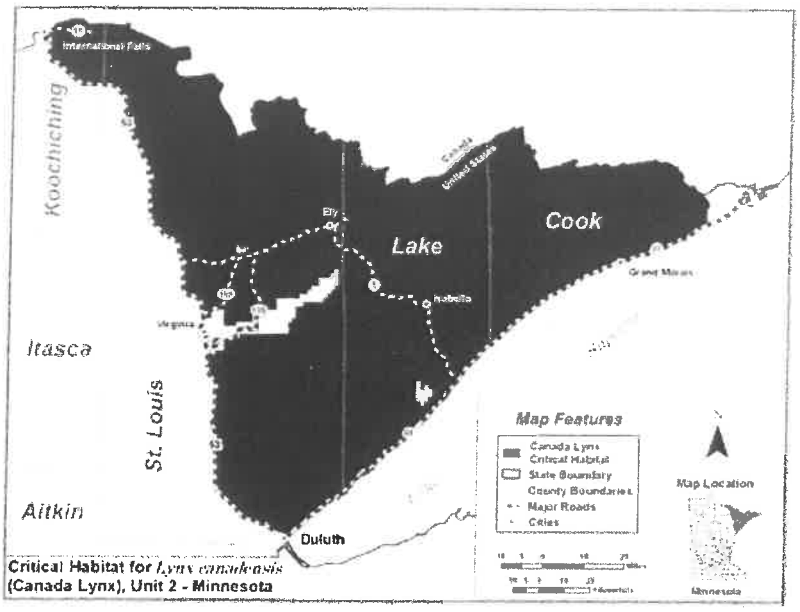
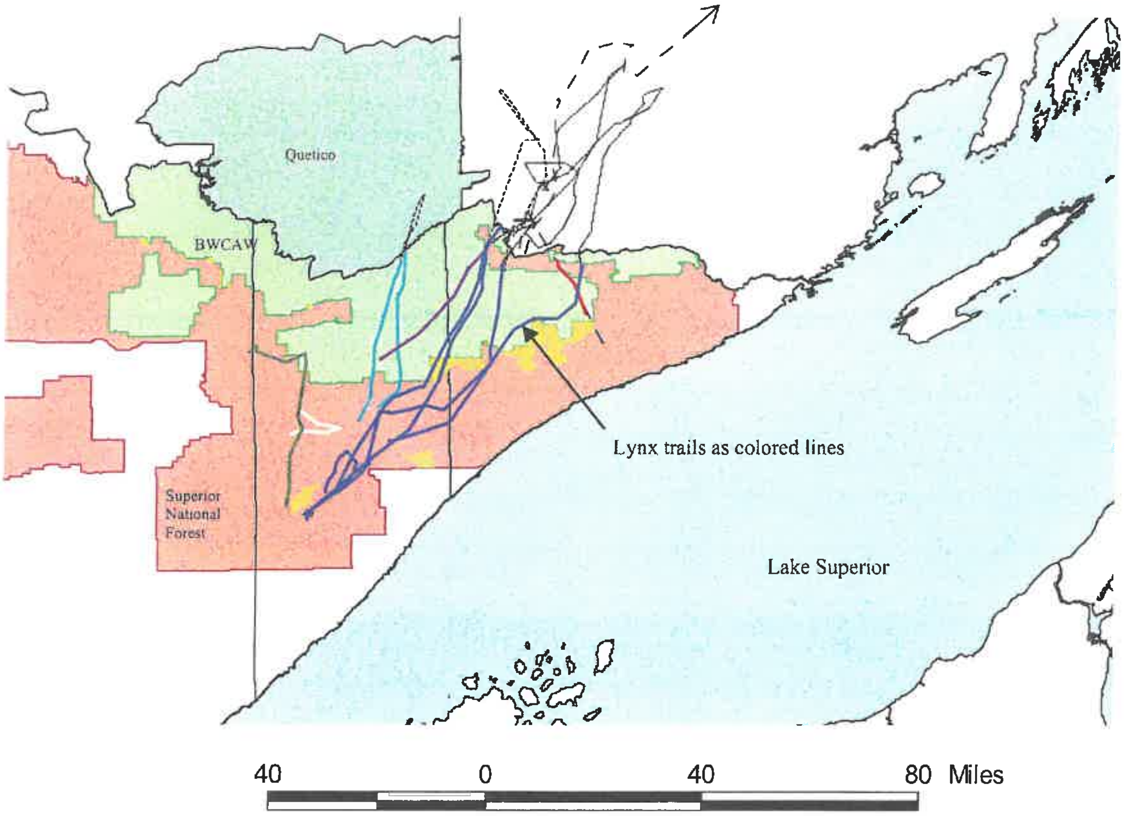


Critical Habitat for *Lynx canadensis* (Canada Lynx), Unit 2 - Minnesota

Ref 10-504-

Habitat and road use by Canada lynx making long-distance movements



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NRRI Technical Report No. NRRI/TR-2010-02 Release 1.0

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If corrections are made to this Technical Report they will be posted at www.nrri.umn.edu\lynx

Ref 10-505-

Sensivity Analysis on Position Accuracy

In any radiotelemetry project, accuracy of spatial location is important. GPS is far more accurate than VHF radiotelemetry, on the order of 5-10 m (Moen *et al.*, 1997). GPS locations are also more accurate than cover type interpretation for satellite imagery. Mixed forest tended to be most common on a long-distance movement, as point location, and also at smaller buffer radii (10 m) when a point might be within same satellite pixel. As buffer radius increased to 50 or 100 m, the background level of cover type composition was reached because more satellite pixels were included. Comparisons of actual and simulated locations with position errors of up to 500 m did not result in a difference in cover type composition, distance to roads, or distance to water as described in each of the above sections. This indicates that the increased position error of 2-dimensional GPS locations relative to 3-dimensional GPS locations would not affect results, and that 2-dimensional GPS locations on a long-distance movement path should be included in the analysis.

Discussion

About 40% of radiocollared male and female lynx made long-distance movements outside of their home range in Minnesota (Moen et al. in review). Not all radiocollared lynx made long-distance movements, but of those that did females tended to move 100-200 km and not return to their original home range, while males moved 50 – 80 km and went back and forth between Ontario and Minnesota (Moen, 2009). Movements were made across roaded areas, and also across the BWCAW which has few linear features such as roads, trails, and logging roads that could guide movement by lynx.

The average distance to a road was < 200 m for lynx on long-distance movements when in a roaded area, and also < 200 m for random locations within home ranges. Lynx use of roads and other linear features is probably based on the energetic efficiency of moving along a road compared to moving through a forest. It is more energetically efficient to walk on or alongside of a road, whether within the home range or while on a long-distance movement.

Movement rate on roads was not faster than movement rates in the BWCAW. Although not significantly different, mean movement rates within the BWCAW (0.7 km/hr) were faster than movement rates in the roaded area (0.4 km/hr). Higher prey densities on the edges of roads could lead to more interruptions, alternatively there could be more interruptions on roads because of vehicles, humans or other animals. It is impossible to determine which of these explanations are the cause of the difference, and it is likely that both operate under some circumstances.

Lynx GPS locations within the home range were about as close to roads or other linear features as GPS locations during long-distance movements. This is consistent with road-density estimates, because throughout the LAUs on the Superior National Forest, and within specific LAUs in lynx home ranges, there was no difference in road density (Table 2). While not significantly different, the density of linear features within the 50% kernel home range was highest at 1.47 km per km^2. This estimate does not include some linear features that are present but not included in the SNF Roads layer. Road density in LAUs overall was about 1.2 km per km^2. Road density of lynx locations while on a trip was similar to the road density in the LAU that lynx were moving through on the trip, and not different from road density within the home range. This implies that although lynx are outside of their home range on a trip, the road density they experience is similar to what is within their home range until they reach the BWCAW.

The distance to water ranged from 100 to 900 m and may reflect the relative abundance of water. GPS collar locations don't show that lynx walk around lakes while on long-distance movements, but the nearly straight-line paths suggest that water is not avoided. Topographic features may influence lynx movements in

Ref 11 - 506 -

Summary of the Superior National Forest's 2018 Canada lynx (*Lynx canadensis*) DNA database and monitoring November 26, 2018 FINAL

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Introduction

Snow tracking and other methods used to obtain genetic samples have confirmed presence of Canada lynx (*Lynx canadensis*) across northeastern Minnesota since December 2000. In 2008, the Superior National Forest (Superior NF) created, and continues to maintain, a database of genetically confirmed Canada lynx (hereafter lynx) to document their occurrence, persistence and reproduction in Minnesota. Genetic samples (typically scat but also hair and tissue) have been collected primarily as part of the Superior NF's survey and monitoring program. Also included in this database are samples collected during an independent genetic research project, a radio telemetry project, mining project surveys, and from specimens that were surrendered to resource agencies, e.g., from animals that had been trapped, shot or killed in vehicle collisions. These samples were submitted to the USDA Forest Service Rocky Mountain Research Station's National Genomics Laboratory for Wildlife and Fish Conservation for testing. Samples that were identified as lynx using mitochondrial DNA analysis were further evaluated using nuclear DNA analysis methods to determine sex (Pilgrim et al. 2005) and individual identification. Further testing was used to determine Canada lynx-bobcat (*Lynx rufus*) hybridization (Schwartz et al. 2004). Field observations combined with DNA analysis have been used to document lynx reproduction every year within the State since 2002.

Summary

The current database contains 1,834 samples that have been submitted for DNA testing. Mitochondrial DNA analysis has identified 1,512 of them (82.4%) as lynx. Nuclear DNA analysis has determined 379 unique lynx genotypes, 178 female (47.0%), 199 male (52.5%) and 2 of indeterminable sex. Since 2010, 37 family groups have been identified producing 81 kittens that survived to the winter following their birth, 43 female (53.1%) and 38 male (46.9%). Of the 355 individuals that were not originally detected as a result of a mortality, 75 (21.1%) are known to have persisted into a second year. Six individuals (1.7%: 3 female and 3 male), have persisted for over 6 years.

During the 2017-2018 survey season 210 samples were collected and submitted for testing. One-hundred eighty-seven (89.0%) were identified as lynx and 68 unique genotypes were determined, 28 female (41.2%) and 40 male (58.8%). Twenty-two individuals (32.4%: 12 female and 10 male) were previously recorded in this database (recaptures), and 46 individuals (67.6%: 16 female, 30 male) are new to the database this year. Field observations suggest that there were at least 11 family groups with as many as 25 kittens found in the survey area. DNA analysis confirm 7 family groups with 16 individuals (7 female, 9 male) genetically consistent with being offspring. There were 23 individuals

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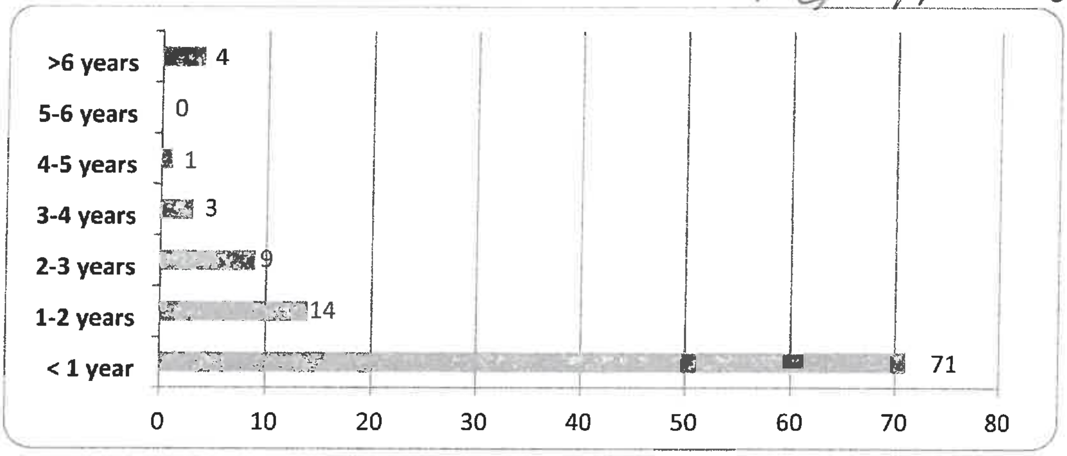

Figure 5. Persistence/recruitment of kittens 2001-2017 (n=102)

Distribution and Dispersal

Lynx detections are distributed over 12 counties in Minnesota. The majority occur in St. Louis, Lake and Cook counties in northeastern Minnesota where essentially all field data collection efforts have been focused (Table 2). There are 19 lynx samples in the database that do not have an accurate enough confirmed location to be represented in this table. The attached map represents locations of samples genetically confirmed as lynx within the State of Minnesota since they were listed as a threatened species under the Endangered Species Act (March 24, 2000).

County	No. of lynx samples	% of lynx samples
Cook	228	15.3%
Lake	1,033	69.2%
St. Louis	213	14.3%
All other	19	1.3%

Table 2. Distribution of lynx samples in Minnesota by county

Dispersal and movement of individuals both within and out of the core survey and monitoring area has been documented. Maximum movement distance is 196 miles for males and 46 miles for females.

2017-2018 Monitoring Results

Species Identification

Two-hundred and ten samples were collected and submitted for analysis during the period of July 2017 through April 2018. One-hundred eighty-seven samples (89.0%) were identified as lynx, and genotypes were obtained from 171 of these identifying 68 unique individuals, 28 female (41.2%) 40 male (58.8%) (Figure 6). Twenty-two individuals (32.4%: 12 female and 10 male) were previously recorded in this database (recaptures), and 46 individuals (67.6%: 16 female and 30 male) were new to the database this year including 16 kittens.

Take

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Section 9 of the Endangered Species Act (ESA) prohibits the take of endangered and threatened species without special exemption. Take is defined in Section 3 (19) of the Endangered Species Act as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct" of a federally listed species (16 U.S.C. Chapter 35 Section 1532). The USDI Fish and Wildlife Service (USFWS) maintains a database of reported incidents of "take" of Canada lynx that have occurred in Minnesota since the year 2001. There have been 73 incidents of reported take of Canada lynx since 2001 (USFWS 2018) (Figure 10). Fifty-three of these incidents have resulted in mortalities to the animal. There have been 7 incidents of shooting (all mortalities), 35 trapped (18 mortalities and 17 released alive), and 15 that have been hit by a vehicle, snowmobile or a train (12 mortalities, 3 unknown outcome (carcass not recovered)). There were also 16 incidents of take that resulted in the mortality of an animal but the cause is unknown. These include cases of likely predation, recovery of decomposed animals or remains, or the recovery of a radio collar that was no longer attached to a study animal.

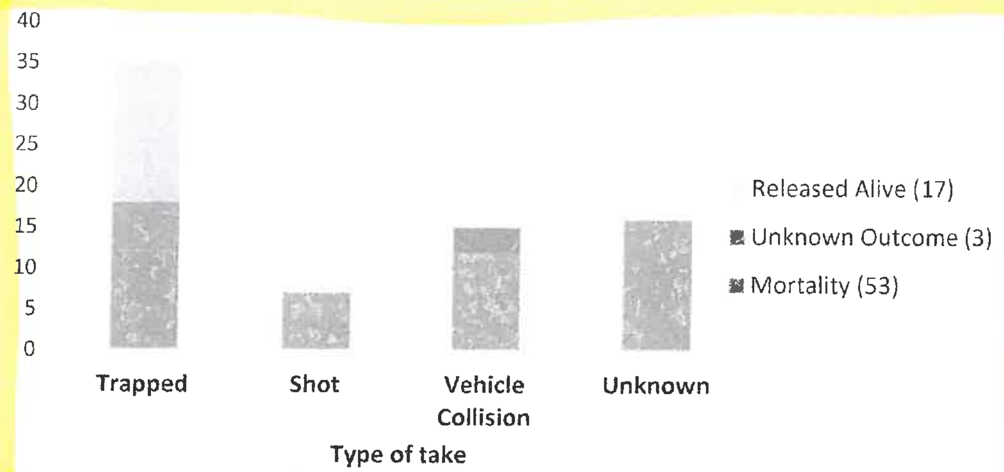

Figure 10. Reported Canada lynx take in Minnesota 2001-2018 by type and outcomes (n = 73)

In calendar year 2017 there were 2 incidents of take reported to USFWS (USDI F&WS 2018). One a vehicle collision along a County Road in Cook County. There was photographic evidence of it being a lynx, but a carcass was never recovered and no DNA sample was obtained. The second was a lynx incidentally trapped in a bobcat set in Lake County that resulted in a mortality. A DNA sample was obtained and it was identified as a 7 year old adult male that was first detected as a kitten in February 2011. DNA analysis has shown that he had sired at least 2 litters with 3 known kittens. So far in calendar year 2018 (as of October 1) there has been 1 incident of take reported to USFWS. Reportedly a lynx had been hit along a snowmobile trail in Cook County. There was photographic evidence of a lynx, but a carcass was never recovered and no DNA sample was obtained.

Incidental Take - Superior National Forest Plan Implementation

Under the terms of ESA, taking that is incidental to and not intended as part of an agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of an Incidental Take Statement issued by USFWS. The risk of incidental take of Canada lynx is not completely eliminated by provisions in the Superior National Forest Land and

Ref 12 -509-

Canada lynx (*Lynx canadensis*) in Minnesota: Road Use and Movements within the Home Range

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Ref 12-510-

Introduction

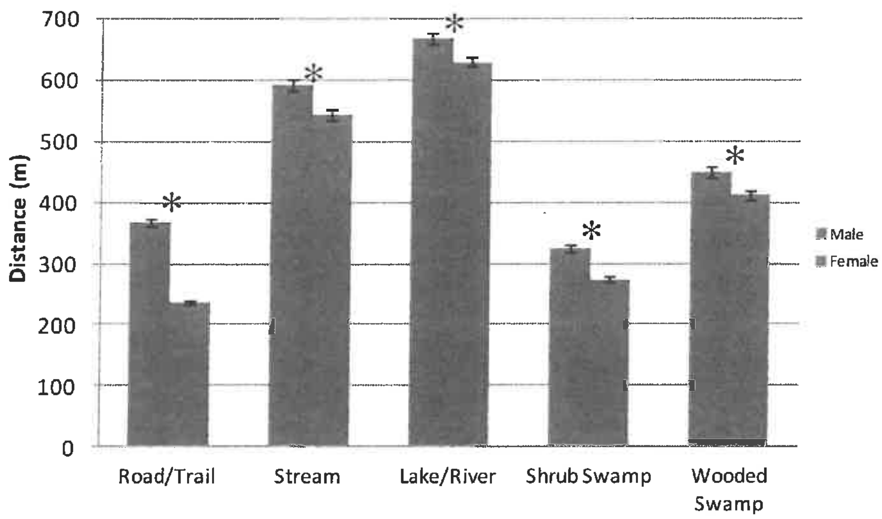
Canada lynx (*Lynx canadensis*) in southern boreal forests maintain larger home ranges than their northern counterparts. This is due to a lack of habitat homogeneity and the need to incorporate a greater diversity of habitat types with sufficient snowshoe hare (*Lepus americanus*) densities in the southern lynx range (Aubry et al. 2000; Murray et al. 2008). Increased habitat diversity, increased fragmentation, and higher human population densities expose southern lynx populations to more human disturbances, including roads and development, than northern lynx populations (Murray et al. 2008).

Based on results of radiotelemetry and snowtracking research, the effects of roads and other human features on behavior of Canada lynx can be positive or negative. Individual characteristics, local habitat conditions, road widths, traffic volume, and other factors affect measured responses to these features (Aubry et al. 2000; Murray et al. 2008). Lynx selected against roads and road edges and crossed highways less than expected within home ranges in Maine and British Columbia (Apps 2000; Fuller et al. 2007). Lynx may also avoid roads by selecting home ranges that have lower road densities than other adjacent areas (Vashon et al. 2008). If true, road presence could limit availability of habitat for lynx. However, lynx neither preferred nor avoided roads when selecting habitat within home ranges and within home range core areas in Maine (Vashon et al. 2008). Lynx also crossed and traveled along highways, and tolerated intermediate levels of snowmobile traffic within home ranges in the Yukon Territory (Mowat et al. 2000). In Wyoming, denning sites were further from roads than expected, but this did not appear to relate to human disturbance, as lynx did not avoid roads with vehicle traffic (Squires et al. 2008).

Regardless of geographic location, roads could benefit lynx by increasing efficiency of movement between preferred use areas. However, roads can also be a mortality risk from vehicle collisions or from incidental human-caused mortality. Increased competition with sympatric carnivores, disturbance, snow compaction, habitat fragmentation, habitat modification and habitat loss are other possible negative effects of roads (Aubry et al. 2000; Buskirk et al. 2000). This ambiguity is relevant to Canada lynx in Minnesota. In Minnesota, lynx regularly cross and travel along roads and other linear features (Moen et al. 2008). Occurrence near roads is also common during long-distance movements between the U.S. and Canada (Moen et al. 2010; Moen et al. *In prep b*). Most lynx deaths in Minnesota have been caused by human activities, including vehicle collisions, trapping, and shooting (Moen et al. 2008), and human presence is expected to be higher along a road.

Female lynx were significantly closer to roads/trails within the home range (236 ± 4 m) than male lynx (367 ± 7 m) (Fig. 3; *t*-test, t_{3857}= -16.14, p < 0.001). Females were also significantly closer to water features and wetlands than males (Fig. 3). This included streams (Female: 543 ± 8 m; Male: 593 ± 10 m; *t*-test, t_{4440}= -3.90, p < 0.001), lakes/rivers (Female: 629 ± 7 m; Male: 668 ± 9 m; *t*-test, t_{4412}= -3.44, p < 0.001), shrub swamps (Female: 274 ± 5 m; Male: 324 ± 5 m; *t*-test, t_{4504}= -7.41, p < 0.001), and wooded swamps (Female: 411 ± 7 m; Male: 449 ± 10 m; *t*-test, t_{4023}= -3.18, p < 0.005). However, the difference in distance to water and wetland features between male and female animals was only about 50 m. Though the 50 m differences are statistically significant, they may not be biologically significant.

Figure 3. Distance (± SEM) to the nearest road/trail, stream, lake/river, shrub swamp and wooded swamp for 4 male (blue) and 3 female (red) lynx. Asterisks indicate significant differences in mean distance.



Among male lynx there were seasonal differences in distance to roads/trails and water features (Table 1). Male lynx were marginally closer to roads/trails during the winter than the denning season (*t*-test, t_{410} = 2.05, p = 0.041). However, male lynx were closer to all other linear features in the denning season than in winter. This included streams (t_{483} = -3.65, p < 0.001), lakes/rivers (t_{500} = 6.56, p < 0.001), shrub swamps (t_{476} = 2.69, p < 0.01) and wooded swamps (t_{533} = 2.93, p < 0.005). One explanation for this could be that males were moving using linear features more during the denning season than during winter. However, a difference of 40 to 100 m between seasons may not be large enough to consider different from a management perspective. There were no summer-fall locations separated by a 6 hour time interval for male lynx.

Ref 12-512-

Linear regression showed a significant negative relationship between distance to nearest road/trail and road/trail density. Distance to roads/trails decreased with increasing road/trail density within a seasonal home range (Fig. 7; $p < 0.005$). This significant relationship between road/trail density and distance to roads/trails was nearly identical for random locations within the seasonal home range (Fig. 7; $p < 0.001$). However, road/trail density does not appear to affect movement rate within a seasonal home range (Fig. 8; $p = 0.16$).

Figure 7. Linear regression of road/trail density and mean distance to nearest road/trail for actual locations (♦, black solid line) and random locations (x, blue dashed line). Each record represents one of 17 seasonal home ranges. For random locations, each record represents the mean of 10 replicates.

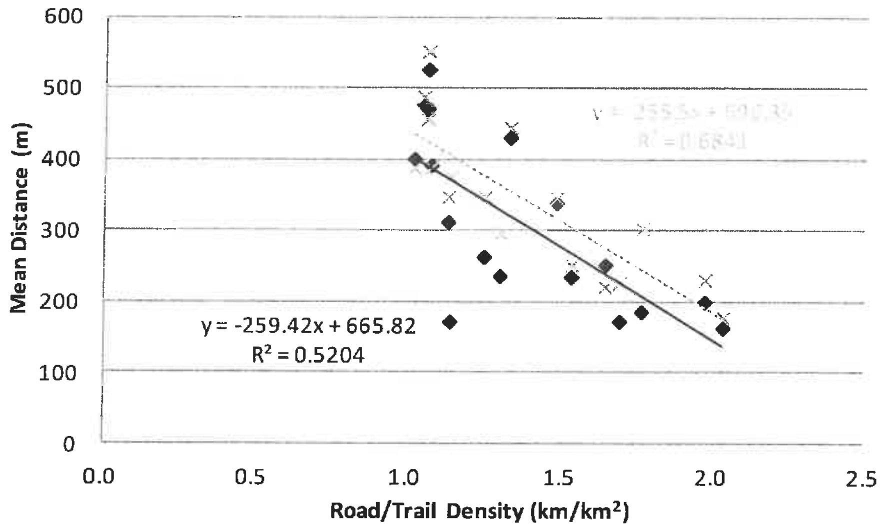
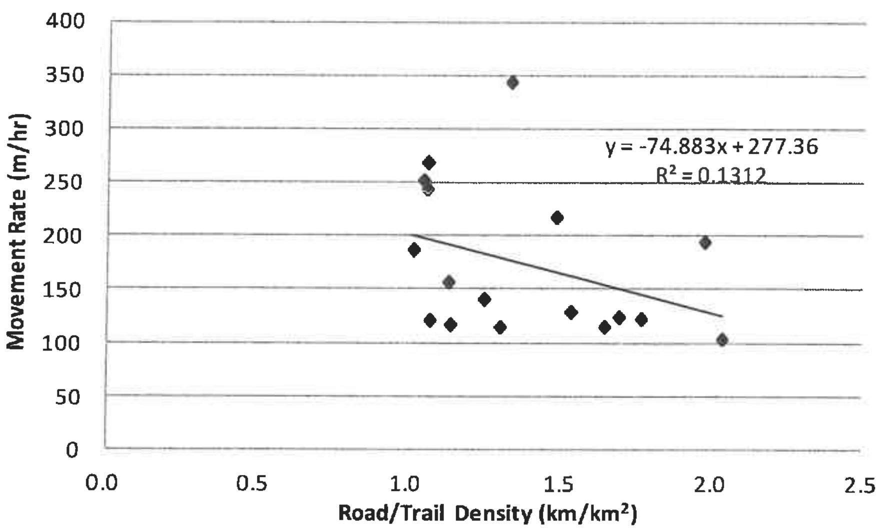


Figure 8. Linear regression of road/trail density and mean movement rate for 17 seasonal home ranges.



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Discussion

Human-lynx interaction is more likely near roads and trails because most human activity occurs near roads. However, the effect of roads and trails on lynx changes with the scale of observation and by geographic location. Lynx presence was lower as road density increased at the southern edge of lynx range in Alberta (Bayne et al. 2008). In Maine and British Columbia, lynx selected against roads and road edges within home ranges (Apps 2000; Fuller et al. 2007). At the home range scale in Minnesota the distance to roads/trails for random locations within a lynx home range was very similar to the distance to roads/trails for actual lynx locations, which implies that there is not selection for or against roads/trails. However, lynx tended to be closer to roads/trails than random expectation when considering only the subset of lynx locations that were < 25 m from a road/trail. This suggests that if lynx are near a road/trail, they will be closer than expected at random.

The relatively uniform road density across Lynx Analysis Units (LAUs) (Moen et al. 2010) could at least partially explain the lack of a relationship between road density and lynx use at larger scales. The ubiquity of roads in each LAU in the Superior National Forest outside of the BWCAW caused lynx to occur an average of 300 m from roads/trails within their home range, with about 60% of home range locations occurring within 300 m of a road/trail. Lynx were even closer to roads/trails during long-distance movements outside of their home range. Lynx preferentially used roads or road corridors on long-distance movements, occurring an average of 177 m from a road/trail (Moen et al. 2010; Moen et al. *In prep b*).

Use of roads/trails would benefit lynx by reducing energetic expenditure during travel and increasing opportunities for foraging. Movement rate decreased with increasing road/trail density. Movement rates on long-distance movements were also faster in the roadless BWCAW than the roaded portions of the Superior National Forest (Moen et al. 2010). This suggests that lynx were not using roads solely for increasing the speed of travel. Prey abundance, vehicle traffic, human activities and encounters with competitors may contribute to slower movement rates on roads, but we cannot determine which factor is responsible for observed differences in movement rates with existing data.

Based on past research on snowshoe hare, there is some support for prey abundance reducing lynx movement rates on roads. Snowshoe hare occur along roads/trails where browse and understory cover are abundant, and are also subject to high rates of predator kills along roads (Pietz and Tester 1983; Sievert and Keith 1985). In Ontario, snowshoe hare track distributions were dependent on distance from anthropogenic corridors, including roads and ditches, with hares appearing more

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BIOLOGICAL OPINION

Effects to
Canada Lynx, Gray Wolf, and Northern Long-eared Bat From the Proposed NorthMet Project and Land Exchange

FWS No. 03E19000-2016-B-0001

Prepared by:
U.S. Fish and Wildlife Service
Twin Cities Field Office

February 2016

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invasive plant species, climate change, or changes in land ownership.

Several of these potential risk factors affecting lynx are proposed in the action area post-land exchange, including mining activities and associated vegetation removal, infrastructure development such as roads, railroads, utility corridors, buildings, and water treatment ponds; associated fragmentation and degradation of habitat; and timber management. Other activities, such as increased recreational use from changes to land use patterns, also may occur. Wildland or prescribed fires are less likely due to full suppression actions in and surrounding the Project area, although they may occur on the other non-federal land exchange parcels. While vegetation will be removed from the Mine and Plant Sites and connecting corridors, timber management may occur on surrounding areas and on non-federal exchange parcels.

Vegetation and Timber

Vegetation management occurs across the range of lynx and can directly affect important habitats and prey. Stand structure, composition, and arrangement are important elements of habitat for snowshoe hares and lynx and as such, alterations to these elements will have varying effects depending on changes (e.g., clearcut versus uneven-aged harvests). The 2013 LCAS (p. 72) indicates that vegetation management promoting high stem density and dense horizontal cover can increase snowshoe hare densities, whereas reducing the density of, for example, sapling-sized conifers in young regenerating forests, reduces the amount and density of horizontal cover, which is needed to sustain snowshoe hares.

Mining

Removal of habitat for the mining operation will result in long-term, and in some areas – permanent, loss of suitable habitat and in turn contribute to habitat fragmentation. In larger mining operations, land exchanges may occur to consolidate private ownership of the surface above a deposit prior to mine development. Depending on lands exchanged, this could retain lynx habitat in public ownership, but could still result in a net loss of habitat. Development of road and railroad access to facilitate development can also directly impact lynx habitat, contribute to fragmentation, facilitate increased competition as a result of snow-compacted routes, and result in direct mortality (LCAS 2013, p. 83).

Roads

Road access to Canada lynx habitat increases the likelihood of human-related adverse effects, simply by increasing the number of humans present in the area. Human-related causes were confirmed for 5 of 11 lynx deaths in Minnesota among radio- and GPS-collared lynx in a recent study (trapping (2), automobile (1), shooting (1) and train (1) (Moen et al. 2008a). Of the remaining six, four died of unknown causes with suspected human involvement (Moen et al. 2008). Six additional lynx deaths have been confirmed in Minnesota due to collisions with vehicles on roads since the species was listed as threatened in 2000 (USFWS, Twin Cities Field Office, Bloomington, MN, unpubl. data).

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These deaths have occurred on a wide variety of roads with average daily traffic volume ranging from 19 to 19,400 vehicles per day (USFWS, Twin Cities Field Office, Bloomington, MN, unpubl. data). There have been four documented lynx road mortalities on the Superior National Forest between 2001 and 2015. These mortalities took place on Cook County Highway 12 (Gunflint Trail), Forest Road 172, Lake County Hwy. 2, and MN Trunk Highway 61 (USFWS, Twin Cities Field Office, Bloomington, MN, unpubl. data). No lynx-vehicle collisions have been reported on roads associated with mining projects, even though lynx have been observed using mine roads at the Northshore Mine and former Cliffs Erie mine site near the Project area (ENSR 2006). Twenty-two lynx were struck and killed by vehicles in Maine between 2000 and 2009; 16 of these deaths occurred on logging roads and 6 occurred on state paved highways. Most mortality on logging roads were on 2-lane dirt haul roads that are open to and used frequently by the public (M.McCollough 2009, pers. comm.). In Colorado, nine lynx deaths due to vehicle collisions have been recorded since 1999 and five other lynx from Colorado were killed in adjacent states (K. Broderdorp et al. 2006, Shenk 2008). As in Minnesota, estimated traffic volumes vary widely among roadkill locations, from 480 to 27,600 vehicles per day.

Roads are a factor in human-caused lynx mortality where they provide access to areas where lynx occur, increasing the risk of negative interactions between people and lynx. Throughout the Forest (outside the Boundary Waters Canoe Area Wilderness, or BWCAW), high and low standard roads bisect many areas that provide potential or suitable lynx habitat. Some temporary roads, such as those used in mineral exploration or mining projects may stay open for more years (greater than 20 years) than those used for resource management (less than 10 years). If these roads remain accessible to the public, then human-lynx conflicts may increase. Further, these corridors may increase potential competition with other predators through increased snow compaction. Effective road closures in appropriate circumstances can reduce the potential effects to lynx and lynx critical habitat.

Lynx populations characteristically fluctuate during approximately 10-year cycles in response to changes in numbers of their primary prey, snowshoe hare. As previously mentioned, on-going northern Minnesota surveys indicated snowshoe hare numbers were high through the late 2000s, with some slight 10-year ups and downs (Erb 2009). Spring 2015 survey results suggested the current hare population may have declined, which would be expected with a fluctuating 10-year cycle, but the upcoming 2015-2016 winter survey will likely provide more conclusive information (Erb 2015, pers. comm.). Reduced prey densities and reduced movement of lynx from Canada may reduce their density in the action area but this would likely be followed by a cyclic increase.

The Superior National Forest is currently implementing the 2004 Forest Plan, which contains direction based on the LCAS and Canada Lynx Conservation Agreement between the USFS and the Service (2000). These apply to all activities implemented by the USFS that occur within LAUs. Thus, the aforementioned risk factors are being minimized and managed to promote the conservation of lynx within the Superior National Forest.

Human Presence and Associated Recreational Activities

The 2013 LCAS (p. 80) indicated that our understanding of the effects of outdoor recreation on

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In the effects analysis, we reach the following conclusions and explain the rationale behind these conclusions. We conclude that the land exchange, in and of itself, will not result in negative effects to lynx, wolf, and NLEB. However, the land exchange will lead to the subsequent development of the newly private lands, which will be an indirect effect of and caused by the proposed land exchange, thereby resulting in significant adverse effects and potential take of lynx, wolf, and NLEB.

Species habitat effectiveness (including quality and quantity) and use of the Mine and Plant Sites and surrounding area within the exchange parcel will be reduced due to vegetation removal and subsequent habitat fragmentation, increasing human presence, noise, increasing traffic, and other factors as mining activities progress. Permeability within the landscape, including the wildlife travel corridors identified in the BA, also may be reduced due to activities at the Mine and Plant Sites and associated transportation infrastructure and traffic. These activities may create an additional impediment to lynx, wolf, and prey movements. The proposed mine could result in an increase in recreational activities due to the increase in human activity in the area. These effects cannot be described precisely, but may increase the incidence of human-wildlife encounters and could contribute towards the general reduction in the value of the mining area to wildlife, including lynx and wolves. Considering the environmental baseline and the additional effects that may be caused by the PolyMet mine, we believe that loss of habitat, reduced habitat effectiveness and fragmentation, including various types of noise, and transportation impacts within and around the Project area represent an adverse effect to lynx, wolf, and NLEB.

Habitat

The BA (pp. 4-1 to 4-15) provided a description of existing vegetation conditions within the Project-area. We briefly summarize the associated acres below (Table 2) and provide additional contextual information.

Table 2. Summary of acres affected by PolyMet Project.

POLYMET PROJECT	Total Acres	Acres Disturbed by Project	Acres Federal
Total project area	7,650	3,918	6,495
Mine Site	3,015	1,719	2,719
Plant site	4,515	2,189	0
Road/utility & RR corridors	120*	<10	0
Lands adjacent to Mine Site	3,776	0	3,776
Non-federal exchange parcels	7,075	n/a	n/a
Wetland Mitigation Sites	2,169**	n/a	n/a

* Most all acres currently disturbed
** 197 acres are upland

The Mine and Plant Sites provide habitat suitable for all species, although most of it occurs on the 3,015-acre Mine Site and on lands surrounding it. Most of the mature forest habitat is in the central and western portions of the Mine Site, with the largest trees reaching approximately 16

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Transportation/Utility Corridor clearing will be minimal because most of the 120-ac corridor is already developed and disturbed. Heavy equipment will be used to remove all trees, vegetation, soil, and overburden. The clearing at the Mine Site will be incremental, with 550 ac removed during the first 2 years and the remainder removed by year 11; 914 ac of wetlands will also be removed.

Stressor: The change in land ownership will result in subsequent mining development. There will be immediate loss of lynx, wolf, and NLEB habitat and associated prey species that use these same habitats. There will also be noise from heavy equipment involved in vegetation and overburden removal.

Exposure: Lynx, wolves, and NLEB will be exposed to human presence, vegetation removal activities, and associated noise in and around the Mine and Plant Sites and along the connecting Transportation/Utility Corridor through year 11, when this vegetation removal will be completed. The Mine Site and eastern portion of the Transportation and Utility Corridors are within LAU SNF#12 and lynx critical habitat, whereas the western portion of the Corridor and the Plant Site are outside; the entire Project area is outside of wolf critical habitat. The BA identified the Transportation/Utility Corridor as being located adjacent to areas with potential for "moderate and high quality wildlife travel corridors." The immediate loss of habitat will expose lynx and wolves to habitat fragmentation, decreased access to travel corridors, decreased habitat effectiveness, and expose adjacent habitats to increased resource use by lynx, wolves, and prey species. Effects to wildlife travel corridors are addressed under the next mining activity discussion. Individual NLEBs, particularly those associated with maternity roosting areas, also will be exposed to the loss of habitat and fragmentation.

Response - Harm: Adult or young lynx, wolves, their prey, and NLEBs could be injured or killed by tree felling and other vegetation removal activities, including at or near any active den sites or maternity roost sites that may be present. Immediate loss of forested habitat eliminates foraging opportunities and subsequently displaces lynx, wolves, NLEBs, and their prey (snowshoe hare, ungulates, insects, etc.). Habitat loss may result in lynx, wolves, and NLEB having to abandon the area temporarily or permanently, including portions of existing home ranges, territories, or maternity roosting sites, to find suitable habitat with adequate prey or new roost sites. Disturbances forcing NLEBs to flee during daylight hours increase their risk of being preyed upon. Similarly, displaced lynx or wolves may come in contact with other predators, including other wolf packs, resulting in lynx or wolf injury or death. It will further fragment the remaining habitat, particularly on the east side of the action area, and may restrict or prevent access to existing (terrestrial) wildlife travel corridors between habitats to the north and south of the Project area, in turn forcing lynx and wolves to travel farther to find available suitable habitat. All three species also could be forced into areas with less suitable habitat. They may experience decreased fitness from less prey and have to expend energy resources to travel elsewhere in search of resources, potentially decreasing reproductive success.

Response-Harass: Lynx, wolves, and NLEB could be annoyed by the noise of heavy equipment, other motorized vehicles, and human presence during the vegetation removal process to the point that they abandon suitable habitat, portions of home ranges or territories, active den sites, wolf rendezvous sites, or maternity roosting sites, and leave the general area. Because noise and disturbance levels will vary depending on factors such as loudness and duration of noise, habitat

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3. Activity: **Transportation and Utility Corridors including infrastructure construction, reconstruction, and/or expansion, on-going maintenance, use via various types of vehicles, trucks, and train cars, and traffic.** *Note*: some of this will occur during pre-production activities with similar effects.

Subactivity: Some clearing of forested habitat will occur along existing roads, railroad tracks, and the utility ROW, and the Dunka Road will be widened between the Plant and Mine Sites. A new railroad spur line and water pipeline in the corridor will also be constructed, and associated maintenance will be on-going. There will be subsequent mining-related vehicle and train travel on roads and railroad tracks between the Mine and Plant Sites and from the Plant Site to off-site destinations.

Stressor: In addition to the effects from pre-production and mining activities covered above, there will be a considerably higher volume of vehicle and train traffic and associated speeds and noise that will occur within potential lynx and wolf home ranges, territories, and/or foraging areas. The higher traffic volumes, road density, and noise may prevent or restrict lynx and wolves from using or crossing roads to access suitable habitat and travel corridors.

Exposure: This activity may affect NLEB for similar reasons (such as habitat loss, noise) already discussed above relative to habitat; therefore, we focus this activity's effects to lynx and wolf. Transportation infrastructure and associated traffic will further fragment habitat in the action area and may restrict lynx and wolf use of the habitat that provides access through travel corridors #16 and 17, and indirectly affect #15 and 18 through increased use if wildlife shift their use to these corridors (addressed above).

Traffic volume resulting from mining and related activities will increase on access and haul roads and highways, and railroad tracks within the action area, particularly on the west side. Increased traffic volume will increase the probability for lynx and wolf mortality by vehicle and train collisions. In addition, vegetation alongside roads and railroad tracks that already attracts prey, particularly deer, and subsequently wolves and lynx, exposes them to the increased traffic levels and mortality risk.

While existing roads will be used, the new access and haul roads and rail spur will increase road density. Current road density in Township 59 North, which includes the Mine Site and federal lands, is 2.2 mi/mi^2, and at just the Mine Site, is 0.5 mi/mi^2. The existing roads in the action area, including the Dunka Road (between the Mine and Plant Sites), State Hwy. 135, and County Hwy. 666, will experience increased traffic volume from the proposed Project. While the Transportation/Utility Corridor is outside the wildlife travel corridors, it runs parallel and perpendicular to them and increased traffic would potentially affect wildlife use of these passages.

Baseline annual average daily traffic volumes in the action area range from approximately 1,850 vehicles on Hwy. 135 to anywhere from 140 to 810 on Hwy. 666 (increases closer to the town of Hoyt Lakes) (Saran 2016, pers. comm.). There will be an increase of approximately 346 vehicle trips per day and 45 train trips per day, totaling 391 per day in the action area above existing traffic levels. The total miles of vehicle and train travel per day in the action area is estimated to be 3,608 mi and 423 mi, respectively, totaling 4,031 mi per day. Vehicle speeds (mostly from

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light trucks and maintenance vehicles) will range from 30 to 40 mph and trains will travel at speeds ranging from 15 to 25 mph.

Snow compaction of existing and new roads used for mining-related activities could provide access into lynx and wolf habitats not previously used by competing carnivores, such as coyotes. However, lynx research related to snow compaction and competitive interactions is limited and has resulted in somewhat different conclusions based on spatial and temporal factors (see Interagency Lynx Biology Team 2013 p. 82). If such competition were to occur, then both lynx and wolves would be exposed to other predators and associated interactions or conflicts, and increased numbers of competing predators seeking similar prey species – which could result in decreased fitness, which was discussed above.

Response - Harm: The risk of death or injury by vehicle or train collision will increase due to estimated traffic volume and associated speeds for the duration of mine construction and operation.

Response-Harass: The traffic volume and associated noise could also annoy lynx and wolves such that they develop an avoidance or reluctance to cross roads and railroad tracks.

Consequences/Intensity: Current road density at the Mine Site will increase during mining activities, mostly at the Mine Site which, when combined with other on-going activities on roads, could displace lynx and wolves. As mentioned, road density was the best predictor of suitable habitat for breeding packs (Mech et al. 1988a; Mladenoff et al. 1995; Thiel 1985). While wolves will use roads and readily cross them, generally, areas with road densities of less than 1 mile/mi^2 are best for wolf survival (Wydeven et al. 2001; Wydeven and Wiedenhoeft 2001), although wolves may tolerate road densities up to 1.2 mi/mi^2 provided large roadless areas are nearby (such as that provided by the BWCAW). However, because most of the new roads will be within the Mine Site and surrounded by other mining activities, effects from an increase in road density essentially will be overshadowed by other disturbances.

Lynx are known to travel on and readily cross most roads and their use of roads and other linear features is probably based on the energetic efficiency of moving along a road compared to moving through a forest. It is more energetically efficient to walk on or alongside of a road, whether within a home range or while on a long-distance movement (Moen et al 2010). Lynx and wolf use of roads may allow them access to and save energetic costs in finding prey, but may also increase the risk of mortality due to vehicle strikes. In addition, attractive roadside vegetation may be conducive to higher prey densities which, in addition to increased probability for mortality, could disturb lynx and wolf prey foraging because of disruptions from traffic, or presence of humans or other animals.

While PolyMet will reduce the vehicle speed limit from 45 to 40 mph in the portion of the Project area under their ownership, vehicles traveling at or below 40 mph still present a risk for collision, given the mortalities that have occurred on other low-volume, low-speed Forest roads in Minnesota and elsewhere. There could be a reduction in the mortality rate in the future as traffic volumes continue but lynx and wolves increase their avoidance of the Project area and adjacent habitats; however, we have no baseline information from which to assess this. Yet given the amount of future land disturbance and associated mining activities, noise, human presence,

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Conservation Measures: PolyMet addressed some of these effects in CMs #3, 4, and 5. Because most project-related roads and railroad tracks will be on private property, access will be limited to employees only. They intend to minimize road construction and reclaim unused roads. Some roads will be reclaimed upon completion of mining activities in approximately 20 years, thereby reducing the transportation corridor use and decreasing road density; the roads on the private lands will also remain closed to the public. Finally, adherence to posted speed limits will be part of employee safety training, but depending on whether or not employees adhere to the required safety conservation measures will affect the probability of lynx and wolf mortality. Employee education will also include lynx identification and reporting. All animal carcasses will be moved out of sight along the transportation corridor between the Mine and Plant Sites to prevent attracting predators to roadsides and railroad tracks and associated vehicle- and train-strikes.

Cumulative Effects

Cumulative effects include the effects of future State, tribal, local or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

There are numerous mining projects already occurring in or adjacent to the action area and at least one being considered in the Mesabi Iron Range; the latter will require separate consultation, as appropriate, pursuant to section 7 of the ESA. Within the action area, there are four on-going operations (FEIS p. 6-72): Cliffs Erie Pellet Yard, Mesabi Mining, Mesabi Nugget, and Northshore Mine - Northshore Ultimate Pit Progression Project. Only the Northshore project has a proposed expansion that is in its initial stages.

In addition to on-going and future mining activities, other future activities on non-federal lands that are reasonably certain to occur and could affect lynx, wolves, and NLEB and their habitats include timber harvest, prescribed burning, road construction and maintenance, recreation, minerals exploration, and fragmentation through human developments. Large-scale mining operations on non-Forest land could result in irreversible or irretrievable loss of lynx and wolf prey habitat, as well as foraging and roosting habitat for NLEB in an area that already has highly fragmented habitat. State, county, and private land timber harvest, related road construction activities, and fire management are not subject to federal management and would not necessarily provide the same level of protection and conservation for threatened and endangered species and their habitats as occurs on the Forest's administered lands. However, timber harvest that regenerates suitable forest habitat and increases numbers and distribution of snowshoe hare, ungulate prey, and foraging areas for NLEB, could also have beneficial effects on these species.

In addition to loss of suitable habitat for these species, including lynx critical habitat, potential increased pressure on adjacent lynx and wolf habitat from disturbed or displaced individuals, impacts to wildlife movement corridors, and human disturbances could result from these various types of activities. These include additional traffic and an increased potential for collisions with lynx and wolves. Lynx and wolves in this part of their range may also be limited by non-habitat factors such as illegal take by hunters and trappers, and collision with vehicles. Lynx may be

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further constrained by a low population size, hybridization with bobcats, and competition with other predators. Recreational activities associated with non-federal lands are expected to continue in the action area and are reasonably certain to remain stable or increase in conjunction with human population increases in northern Minnesota.

Conclusion

We have concluded that the proposed land exchange between the Superior National Forest and the Applicant (PolyMet) will result in development of the private lands. The land exchange, in and of itself, will not result in negative effects to lynx, wolf, lynx and wolf critical habitats, and northern long-eared bat, but the exchange will lead to the subsequent development of the private lands, which will result in significant adverse effects to these three species in the action area. The Forest indicated that future development of the subsequent private land is outside of their jurisdiction. We conclude that the mining development is an indirect effect of, and caused by, the proposed land exchange, allowing for the exemption of incidental take to extend to the USFS and the Applicant; this exemption is effective only if the Reasonable and Prudent Measures (RPM, see Incidental Take Statement, below) are implemented.

The USFS's proposed action (land exchange) will ultimately lead to development of the federal exchange parcel and the remaining private land, which will lead to the subsequent adverse effects to these three species and lynx and wolf critical habitats, including take. Therefore, the USFS would be exempt from any take resulting from the subsequent development of PolyMet's NorthMet mine if the RPMs are implemented. Since development of the subsequent private parcel is beyond the authority of the USFS, their exemption to the take prohibition would not lapse regardless of future activity, or lack thereof, by the Applicant. The Applicant's exemption of incidental take depends upon implementation of the agreed upon Conservation Measures described above and implementation of the RPMs.

After reviewing the current status of Canada lynx, gray wolf, and northern long-eared bat, the environmental baseline for the action area, the effects of the proposed PolyMet mine and land exchange parcels in St. Louis, Lake, and Cook counties, Wetland Mitigation Sites, and the cumulative effects, it is the Service's opinion that the action, as proposed, is not likely to jeopardize the continued existence of Canada lynx, gray wolf, or northern long-eared bat. It is also not likely to adversely modify critical habitat for lynx or wolf.

Based on the assumptions regarding traffic volume, susceptibility to vehicle collisions, traffic speeds, lynx and wolf densities, and current likelihood of vehicle collisions, we estimate that the proposed action will result in approximately one lynx and one wolf taken; take that is likely to occur due to other effects of the project is not likely to be directly detectable and will be expressed in terms of the 3,918 acres of lynx, wolf, and NLEB habitat (less than 0.1 percent in Minnesota) that will be destroyed over the 20-year life of the project. Although destructive locally to the species and their habitats, rangewide effects on numbers, reproduction, and distribution will be minimal for each species. Populations of these three species continue to be wide-ranging across portions of the contiguous United States. Therefore, the estimated proportional impacts to Canada lynx, gray wolves, and northern long-eared bats in the contiguous U.S. would be less than that anticipated for the species in Minnesota alone. This level

Ref 14-523 -

Programmatic Biological Assessment For Federally-Listed species: Gray wolf, Canada Lynx, and their Critical Habitats. for the Superior National Forest

May 17, 2011

USDA Forest Service – Region 9
Superior National Forest
8901 Grand Avenue Place
Duluth, Minnesota 55808

The 2004 Forest Plan is considered "programmatic" in that the Forest Plan allows, but generally does not require specific actions on the ground. The Forest Plan is permissive and generally does not mandate projects in specific locations at specific times. Therefore, the scope of analysis for this BA is not a substitute for project-level programs, activities and practices where more information is available for site-specific analyses and determinations of effects. The evaluations and determinations of effects in this BA are based on known and expected impacts of actions that have been approved for implementation in compliance with management direction, and are not specifically proposed, but are very probable.

The assessment of past, present and reasonably foreseeable probable impacts is evaluated by the review of Monitoring and Evaluation Reports since 2004, the model parameters used for Lynx indicators (Appendix D) (2004 Forest Plan BA) at the Lynx Analysis Unit (LAU) and designated lynx critical habitat scales, best available information describing reasonably foreseeable projects that have not been completed, and the findings of new research since 2004 for both lynx and grey wolf. For analysis purposes, Decade 1 begins January 1, 2005 with Decade 2 beginning on January 1, 2015. For analysis purposes Decade 1 begins January 1, 2005, with Decade 2 beginning January 1, 2015.

1.5 - Determination of Effect

To make a determination of whether the 2004 Forest Plan is likely to affect listed species or designated critical habitat the definitions for determinations of effect, given in the Section 7 consultations from the Endangered Species Consultation Handbook (USDI FWS and NMFS 1998), are used. In making the determinations in this BA the following conclusions were considered.

- **No Effect** – the appropriate conclusion when the action agency determines its proposed action will not affect a listed species or its designated critical habitat.
- **May Effect** - the appropriate conclusion when a proposed action may pose any effects on listed species or designated critical habitat. When the Federal agency proposing the action determines that a "may affect" situation exists, then they must either initiate formal consultation or seek written concurrence from the Fish and Wildlife Service that the action "is not likely to adversely affect" (see definition below) listed species.
- **Is likely to adversely affect** – the appropriate finding in a biological assessment (or conclusion during informal consultation) if any adverse effect to listed species may occur as a direct or indirect result of the proposed action or its interrelated or independent actions, and the effect is not: discountable, insignificant, or interdependent actions, or beneficial. In the event the overall effect of the proposed action is beneficial to the listed species, but is also likely to cause some adverse effects, then the proposed action "is likely to adversely affect" the listed species. If incidental take is anticipated to occur as a result of the proposed action, then an "is likely to adversely affect" determination should be made. An "is likely to adversely affect" determination requires the initiation of formal section 7 consultation.

Ref 14-524-

Excluded areas include a mining district in northeastern Minnesota known as the Iron Range because this area does not contain the biological and physical features essential to the conservation of lynx. The USFWS has stated that in much of the Iron Range mining has removed all vegetation and much of the affected area is flooded. Remaining areas that are that are still vegetated and not flooded are extensively fragmented by the mined areas and by haul roads. Additional areas disturbed by mining were identified and are not included in the final designated habitat (USDI 2009).

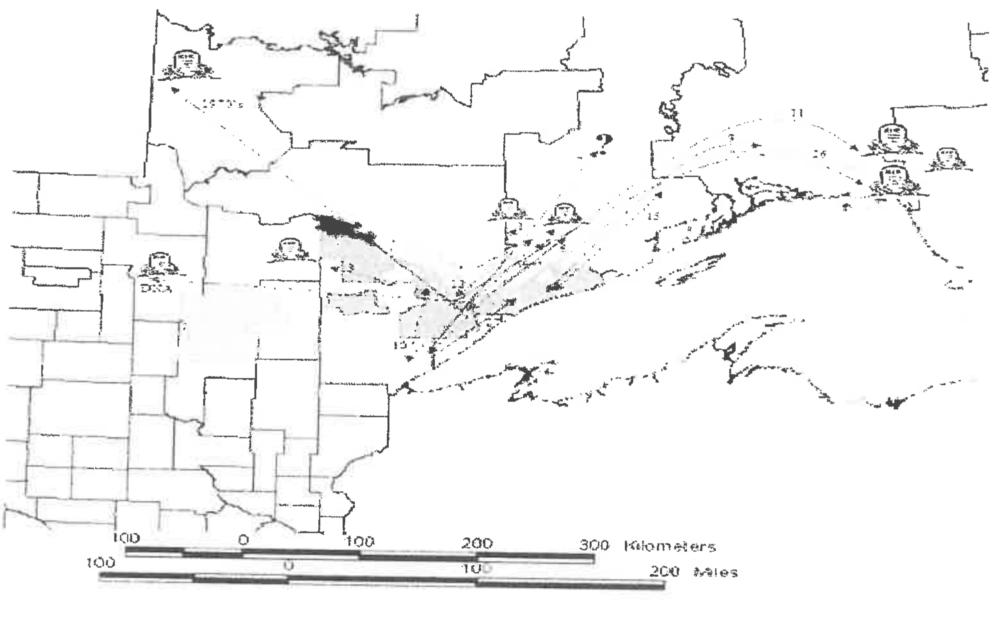
3.3 - Lynx Ecology

This section (**2004 BA - Section 4.3**) discusses information on lynx ecology that is relevant to the discussion of risk factors and management concerns described in Section 3.5 (2004 BA - Section 4.5). New information on the species ecology is available from that discussed in the 2004 BA. Since 2003 the Natural Resources Research Institute (NRRI) in Duluth, MN has been studying the distribution, abundance, persistence, and habitat use of Canada lynx in northeastern Minnesota. NRRI researchers have placed radio collars on 33 lynx, obtained over 15,000 lynx locations, located dens, and documented movements and habitat use. Annual reports, publications, and theses have been produced on lynx ecology in northeastern Minnesota (NRRI 2010).

3.3.1 - Home Range and Dispersal

The information in the 2004 BA (**Section 4.3.1**) on lynx home range and dispersal remains valid, however new information for northeastern Minnesota is available based on research since 2004. Research conducted by the Natural Resources Research Institute (NRRI) in (Burdett 2007 and Moen et al. 2010) indicate that lynx have varied home ranges, and disperse from them within the Superior National Forest, and to and from Canada (see Figure 2).

Figure 2 – Lynx Movement Patterns



Ref 14-525-

land management project on the Forest since 2004. There have been no substantive amendments to the 2004 Forest Plan.

Threatened and Endangered Species and Canada Lynx

There have been no changes in the following SNF management direction. The 2004 BA describes them in detail on pages 113 to 115 (Sections 4.5.5.1 through 4.5.5.4), and in **Section 3.6.2.1** of this BA.

O-WL-7: Minimize the building or upgrading of roads in areas that are important for threatened and endangered species habitat and for habitat connectivity.

O-WL-11: Maintain and, where necessary and feasible, restore sufficient habitat connectivity to reduce mortality related to roads and to allow lynx to disperse within and between LAUs on NFS land.

O-WL-13: Maintain or improve the natural competitive advantage of Canada lynx in deep snow conditions. Snow compacting activities (such as snowmobiling, snowshoeing, skiing, dog sledding) are planned and accommodated in areas best suited to the activity while maintaining large, interconnected areas of habitat with little or no snow-compacting, recreational activities.

O-WL-14: Through coordination with other agencies, participate in cooperative efforts to reduce, to the extent possible, the potential for lynx mortality related to highways and other roads within the proclamation boundary of the National Forest.

S-WL-2: In LAUs on NFS land allow no net increase in groomed or designated over-the-snow trail routes unless the designation effectively consolidates use and improves lynx habitat through a net reduction of compacted snow areas.

G-WL-6: Where a designated trail for snow-compacting activities is desired within LAUs, the proposed route should be planned to protect or improve the integrity of lynx habitat and minimize snow compaction in lynx habitat. The trail should be designed to:

- Move recreational use away from more sensitive or better quality lynx habitat,
- Concentrate use within existing developed areas rather than developing new recreational areas in lynx habitat, and or
- Be located within the outer boundaries of a currently used road and trail system.

G-WL-7: For newly constructed snow-compacting trails, effectively close or restrict to public access those trails, OML 1, OML 2, temporary, and unclassified roads that intersect the new trails unless these trails or roads are being used for other management purposes.

G-WL-8: Within LAUs generally maintain road and snow-compacting trail densities below 2 miles per square mile to maintain the natural competitive advantage of Canada lynx in deep snow. Where the total road and regularly-used snow-compacting trail densities are greater than 2 miles per square mile and coincide with lynx habitat, prioritize roads for seasonal restrictions or reclamation in those areas, where practical or feasible. In this guideline "roads" include all ownerships of classified and unclassified roads and "regularly-used trails" are those that are used most years for most of the snow-season.

G-WL-9: Dirt and gravel roads that are under the jurisdiction of the National Forest and that traverse lynx habitat on NFS land (particularly those roads that could become highways) should generally not be paved or otherwise upgraded in a manner that is likely to lead to significant increases to lynx mortality or substantially impedes movement and dispersal.

If the dirt and gravel roads described above are upgraded or paved in order to meet human health and safety or other environmental concerns and essential management needs, conduct a thorough analysis on effects to lynx and its habitat to determine minimum road design standards practical (including measures to minimize traffic speeds), to minimize or avoid foreseeably contributing to increases in human activity or adverse impacts to lynx and its habitat.

How this lynx-specific management direction addresses the relevant Primary Constituent Elements (PCEs) of lynx critical habitat is discussed in **Section 3.5.7**.

Recreation

There has been no need for change for the following SNF management direction. The 2004 BA describes them in Sections 4.5.5.1 through 4.5.5.4 on pages 115 and 116, and in **Section 3.6.2.1** of this BA.

O-RMV-1: A maximum of 90 additional ATV trail miles and 130 snowmobile trail miles with associated trail facilities (trailhead parking, signs, toilets, etc.) may be added to the designated National Forest Trail system.

S-RMV-1: Motorized recreation use of designated trails is prohibited unless the trail is designated open for specific motorized uses such as for ATVs, OHMs, and snowmobiles.

S-RMV-3: Cross-country OHV travel is prohibited. Standards and guidelines for cross-country snowmobile use are described in Chapter 3 because direction for that use varies by Management Areas. *Summary from Chapter 3*: For most Management Areas: Cross-country snowmobile use is generally allowed unless prohibitions or restrictions are needed for resource protection to meet management objectives. *For Unique Biological, Research Natural, and Wilderness*: Cross-country snowmobile travel is prohibited.

G-RMV-4: RMV use will generally be allowed on existing unclassified, OML1 and OML 2 roads (Except ORVs will generally be prohibited on OML 1 roads). Roads that are determined through site-specific analysis to have immitigable resource and social concerns and/or do not meet management objectives would be effectively closed. (See exceptions for Management Areas: wild segments of eligible Wild, Scenic, and Recreational Rivers, semi-primitive non-

However, some indirect effects can also have short-term effects that are managed through mitigation measures such as seasonal road closures or use restrictions were human access is increased. The Forest Plan and 2004 BA assessed whether sufficient amounts of habitat would be provided over time. Both documents compared coarse-filter vegetative conditions (primarily vegetative type and age) to both management direction (where specifically provided) and the Range of Natural Variability (RNV) (where not specifically provided for).

There is no indication that after five years of Forest Plan implementation that the projected coarse-filter vegetative conditions are in need of change. Forest Plan Monitoring and Evaluation Reports (USDA 2009a) indicate that management direction continues to provide sufficient amounts of lynx habitat (critical habitat) above, consistent with, or below the habitat conditions in RNV projections (USDA 2004).

The Forest Plan direction has and all indications will continue to maintain conditions suitable to support lynx and critical habitat during the planning cycle as indicated in the LCAS (LCAS 2000). Indirect effects from roads and access developed for vegetation management activities are described in the next section: **Human Disturbance.**

Human Disturbance: Winter and non-winter dispersed recreation management and low standard or temporary road construction

Forest-wide Effects

The LCAS (2000) describes that increasing human use of National Forests and human developments in lynx habitat both adjacent to and in mixed-ownership areas increase the potential for impacts to lynx and the species recovery. The LCAS indicated that indirect effects were a potential higher risk than direct impacts. One key indirect effect is that increased snow compaction from winter routes used for human access would allow competing carnivores such as bobcat and/or coyote access into previously inaccessible lynx habitat.

Direct Effects:

1. Local travel, resting, and foraging use patterns could be disrupted or a lynx may be temporarily displaced.
2. Vegetation management activities may disturb a denning female, and if she has kittens she may be forced to move them to another den. It is also possible that management activity may accidentally kill or harm a lynx.

Discussion: As with the previous Vegetation Management section the risk of direct effects to lynx denning is expected to be low. With the majority of the Superior National Forest (2,125,931 acres) within the designated lynx critical habitat area, the relatively low population of resident lynx based on research and survey results, and varied landscape conditions the potential, and number of lynx expected to directly impacted by vegetation management practices is expected to be low. In the event a lynx may be displaced from an area that it uses any stress from the displacement or disruption of use patterns is expected to be low.

Ref 140 -525 D-

Management direction (**G-WL-2**) remains in place to protect known lynx dens, and denning habitat modeling (see **Section 3.5.4.3** - Moen et al 2008) allows project areas to be evaluated for denning habitat. This management direction, analysis tool, and the scattered nature of timber harvest, prescribed fire and other vegetation management projects across the breadth of the Forest reduces the risk to lynx denning and/or denning habitat.

Indirect Effects:

1. Construction of new designated winter recreational trails, new designated trails, and policies that allow recreational vehicle uses on low standard roads or cross-country all facilitate access to historical lynx habitat by competitors (or predators).
2. Increased human access from new trails or road-riding opportunities increases potential for incidental trapping or shooting.
3. Increased planned access can facilitate increased access (generally on old closed or unclassified roads or cross-country) to areas previously would have been as accessible. This would compound impacts of competitors or opportunities for incidental trapping or shooting.

Discussion: The LCAS and National BA did not consider direct effects from road and trail construction as a risk factor to lynx in the Great Lakes geographic area. At a National Forest-scale, road and trail construction would remain a very low risk due to the random nature of the effect. However, through the first decade of Forest Plan implementation and over a longer term, road and trail construction may cumulatively become a measureable risk. The effects are expected to be long-term because once on the landscape, recreational trails and low standard open roads are generally not removed and access is generally not prohibited. The Forest Plan directs the planning for and implementation of consolidated motorized use. In addition, the Forest Plan continues to direct that no net increase in designated snow-compacting trails shall occur. Therefore, there should not be an increase in other-predator access into lynx habitat and subsequent competition with lynx from proposed and approved winter recreation routes. Summer ATV trails will continue to be counted in trail densities since there is no management provision in the LCAS or Forest Plan for a "no net increase" for these types of trails.

Low-standard closed or temporary roads have short-term impacts because these roads are generally closed immediately after their intended use ends. Some low-standard roads are always open depending on the management activity that they support (e.g. temporary roads into timber sales). The number of low-standard roads and their overall mileage will vary annually because of the number of operational management activities across the Forest. The Forest Plan requires the effective closure of these roads, especially where they intersect newly-constructed trails so that motorized recreational use is limited to designated routes.

The Forest Plan provides specific objectives (Chapter 4) for monitoring and evaluating the results of implementing the Forest Plan management direction of roads and trails for either vegetation management or human recreational use. The goal or purpose of decommissioning roads is to make the road "disappear" and render it not accessible to motorized vehicles from the beginning of the road to the point where the main Forest System road is not visible (USDA 2010g). These

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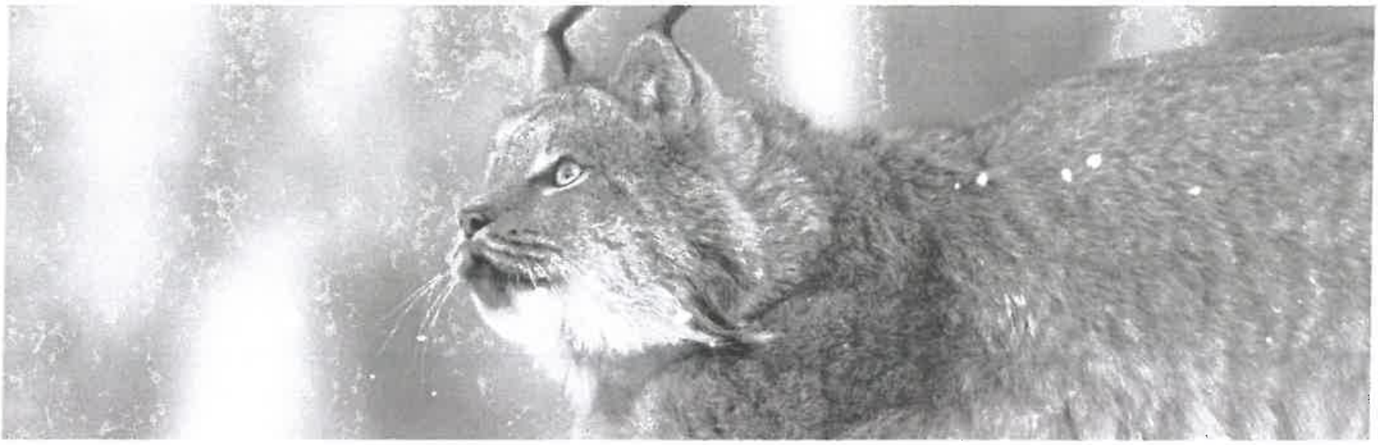

Canada Lynx

WELC is committed to helping this majestic cat thrive in the wild throughout the southern and northern Rocky Mountains.

Canada lynx once ranged from Alaska to New Mexico, but due to a declining population were listed as threatened under the Endangered Species Act in 2000. In order to survive and recover in the wild, lynx need room to roam. The biggest threat to lynx is habitat loss and fragmentation.

Lynx also depend on a stable climate to sustain their primary food source: snowshoe hare. Lynx are seldom seen, but they can live close to people, and suffer from hunting, trapping, and the dangers of roadways.

We are protecting occupied lynx habitat and travel corridors, pushing the U.S. Fish & Wildlife Service to adopt and implement an adequate recovery plan, and ensuring that the U.S. Forest Service complies with the important forest protection designed to conserve lynx in the northern Rockies.

Canada Lynx Projects

https://www.nwf.org/Educational-Resources/Wildlife-Guide/Mammals/Canada-Lynx

Canada Lynx

Lynx canadensis

Status: Threatened

Classification: Mammal

Description

The Canada lynx is like a gray ghost of the Northâ€"elusive, evading human contact. It stands about 20 inches (51 centimeters) tall at the shoulder but weighs about 20 pounds (nine kilograms)â€"scarcely more than a large house cat. It is readily recognized by its long, black ear tufts; short, black-tipped tail; and large, rounded feet with furry pads, which allow it to walk on the snowâ€™s surface.

Range

Historically the Canada lynx ranged from Alaska across Canada and into many of the northern U.S. states. In eastern states, it lived in a transition zone in which boreal coniferous forests yielded to deciduous forests. In the West, it preferred subalpine coniferous forests of mixed age. It would den and seek protection from severe weather in mature forests with downed logs, but hunt for its primary preyâ€"the snowshoe hareâ€"in young forests with more open space.

Although lynx were never abundant in the United States, they probably did occur in most northern states and western mountainous areas as far south as Colorado. Today, while tens of thousands of lynx remain in Canada and Alaska, the U.S. Fish & Wildlife Service can confirm the presence of stable lynx populations below the border only in Maine, Montana, Washington, and Colorado.

Diet

In the northern part of its range, the lynx serves as one half of a classic predator-prey relationship, feeding almost exclusively on the snowshoe hare, a large northern rabbit that wears a brown coat in summer and a white one in winter. The two species evolved together, the cat becoming a specialist in killing the hare, and the hare becoming adept at

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eluding the lynx. The lynx kills an average of one hare every two or three days. It will turn to killing grouse, rodents, and other animals if hares become scarce. The link between lynx and hare is so tight in the North that the two speciesâ€™ populations fluctuate in almost perfect synchrony.

Hare populations follow a natural cyclical pattern, changing approximately every 10 years from abundance to scarcity and back to abundance. Adult lynx usually survive periods of hare scarcity, but their kittens often do not. As a result, the lynx population follows a similar pattern, with its peaks and valleys lagging one to two years behind those of the hare. Lynx populations south of the Canadian border were probably never as abundant or dense as the more northern populations.

The diet of lynx in these southern areas is more variedâ€"including squirrels, small rodents, grouse, and haresâ€"and the populations are less dense and less productive than their northern counterparts. This low density and productivity makes southern lynx populations especially vulnerable to the ever-increasing human activities that affect the abundance of the lynxâ€™s prey base in these regions, or that may cause lynx to avoid areas of otherwise acceptable habitat.

Behavior

These felines are solitary hunters that are more active at night than in the day. They are such well adapted nocturnal hunters that they can spot prey in the darkness from 250 feet away.

Life History

Female lynx enter estrusâ€"the state of being receptive to matingâ€"once a year and raise one litter each year. Mating occurs from February to April and is followed by a gestation period of 8 to 10 weeks. Females give birth to young in logs, stumps, clumps of timber, or similar tangles of roots and branches. Litters usually have two or three kittens, though there may be as few as one or as many as eight. Lynx weigh about seven ounces (200 grams) at birth. Kittens will consume milk from their mother for about five months, although kittens eat some meat as early as one month after birth.

Females provide all of the parental care and help to educate their young in hunting techniques. The young remain with their mother until the following winter's mating season, and siblings may stay together longer. Females reach sexual maturity at 21 months and males at 33 months. In the wild, lynx can live up to 14 years. In captivity, lifespans of 26 years have been recorded.

Conservation

In March 2000, the U.S. Fish & Wildlife Service listed the lynx as threatened in the lower 48 under the Endangered Species Act. The lynxâ€™s gradual disappearance from the contiguous United States resulted from human activities that have compromised both the lynx and its habitat. In the 19th century, trapping put heavy pressure on the species. Now the catâ€™s survival in the U.S. is primarily jeopardized by habitat destruction and fragmentation. Today most suitable lynx habitat in the West is on public land. This includes national and state forests, where logging and recreational development often occur. Some timber practices can remove the mature forest that the lynx needs for denning and rearing young. These activities can also disrupt lynx travel patterns, as the cats prefer tree cover. Roads threaten the lynx by fragmenting its habitat, isolating lynx populations, exposing them to predators, and providing competitor species new access to habitat formerly dominated by the lynx. For example, snowmobile traffic creates trails that may allow competitors like coyotes, wolves, and cougars access to lynx winter habitat. Motor vehicles also

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cause lynx mortality: Recent attempts to reintroduce lynx from Canada into New Yorkâ€™s Adirondack Mountains failed, primarily because the cats were hit by cars and trucks.

To combat the impacts of habitat fragmentation and climate change for imperiled species like the lynx, the National Wildlife Federationâ€™s Northeast Regional Center teamed up with two dozen public and private entities to maintain, enhance, and restore landscape connectivity for wildlife across the Northern Appalachian-Acadian region.

Collectively known as the Staying Connected Initiative, the National Wildlife Federation and its partners are working to conserve key linkage areas that are critical for lynx, bobcat, bear, moose, and other far-ranging mammals to migrate as their habitats change in response to climate change. By maintaining existing links in the landscape and preventing further habitat fragmentation within the linkage areas, the National Wildlife Federation is working to ensure that wildlife within our region have the ability to move where, when, and as far as needed.

Sources

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Wildscreen Arkive

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DNR RESPONSE TO COVID-19: For details on adjustments to DNR services, visit this webpage (https://www.dnr.state.mn.us/covid-19.html). For information on the state's response, visit the Department of Health website (https://www.health.state.mn.us/diseases/coronavirus/index.html) .

Page Menu

Wolf management

Minnesota's wolf legacy is unique: its northeastern corner of lakes and sub-boreal forest once sheltered the last remaining wild wolves in the lower 48 states. Wise and careful management under the Endangered Species Act allowed those remaining wolves to flourish and repopulate northern Wisconsin and Michigan's upper peninsula.

Minnesotans clearly value wolves. Public opinion surveys and attitudes demonstrated during development of the state's wolf management plan show people view the animal as ecologically important, scientifically fascinating, aesthetically attractive, recreationally appealing and significant for future generations. Only a small minority fear and dislike wolves or believe Minnesota would be a more desirable place without this apex predator.

DNR is committed to a responsible, conservative and science-based management strategy that ensures the long-term survival of wolves in Minnesota recognizes the animal's legacy and Minnesotans' collective interest in and concern for this northwoods icon.

Sign up for wolf updates

Enter email address

Submit

— What's new

Ref 17-528-

A. Threatened and Endangered Species

Canis lupis - Gray Wolf - USF&W Threatened

Wolves may occur in any terrestrial habitat. In Minnesota and Wisconsin, they usually occur in areas with few roads, less than 1 mile per square mile, (which increase human access and incompatible land uses) but they apparently can occupy semi-wild lands if they are adjacent to large roadless regions, ungulate prey is abundant and if not killed by humans (Nature Conservancy Species Status Sheet). Wolves are known to occur throughout the Chippewa National Forest. Risk factors for the survival of the gray wolf include illegal and/or accidental human kill of wolves, availability of adequate wild prey, availability of large tracts of land where human presence is relatively low, parasites, and disease.

Two wolf packs are believed to use portions of the project area. The Laura Lake pack uses areas west of MN 6, south of MN 200 to near the Forest boundary. The Willow River pack uses areas east of Big Rice Lake and south of MN 200, the eastern side of the project area.

Determination of Effects

This section evaluates the effects and risks associated with the project alternatives for each species evaluated in detail. Each evaluation concludes with a "determination of effect" using standardized language in accordance with legal requirements of the Endangered Species Act and the National Forest Management Act. The effects from this project are also evaluated cumulatively with other existing and foreseeable effects from other activities and conditions.

A. Threatened and Endangered Species

Canis lupis – Gray Wolf

The Eastern Timber Wolf Recovery Plan (USFWS, 1992) identified five critical factors for long-term survival of the species; (1) large tracts of wild land with low human densities and minimal accessibility by humans, (2) ecologically sound management, (3) availability of adequate prey, (4) adequate understanding of wolf ecology and management, and (5) maintenance of populations that are either free of, or resistant to new parasites and diseases. Factors that are relevant to evaluation of effects of this project include (1), (3) and indirectly (5). In addition, type of human use and activity in the area is a relevant factor for evaluation, as it influences the other factors.

There are three basic effects of increased human accessibility on wolf populations (USFWS, 1992). First, increased human presence increases the chances of deliberate and accidental killing of wolves. The types of human activity in an

Howling For Wolves, Hopkins, MN.

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area, significantly influences this factor. In the Rice Lake Project Area, the majority of human use is related to hunting and other resource gathering, and recreational motor vehicle (RMV) and snowmobile operation. These activity types tend to be the most detrimental to wolves because the activities tend to cover large acreages per hour of activity, and they may involve the pursuit and exploitation of wildlife. Wolves can be killed by hunters either deliberately or accidentally. Hunting can also suppress prey populations.

Secondly, increased human presence can deter wolves from inhabiting an area. Human presence is magnified if it involves motorized vehicles because the amount of area covered in an hour of activity with a motorized vehicle is exponentially greater than that of an hour without a motorized vehicle. In addition, noise and smell created by motorized vehicles tends to increase the zone of influence significantly at any one time. Human activity tends to create an avoidance response. This interferes with necessary life support activities such as hunting, breeding and parturition and causes wolves to spend energy for avoidance rather than for these living requirements.

Finally, increased human presence also increases the chances of introducing new diseases and parasites to wolves via pets; diseases such as heartworm, CPV (Parvo) and Lyme disease.

Studies in Wisconsin, Michigan, Ontario and Minnesota indicate that wolf populations usually fail to sustain themselves in areas where rural roads open to public use have densities exceeding 0.93 miles per square mile of area (USFWS, 1992). However, higher road densities can support wolves if adjacent to large roadless regions inhabited by wolves. The Eastern Timber Wolf Recovery Plan (USFWS, 1992) recommends managing average public road densities so not to exceed 1 mile per square mile, particularly where road densities may be limiting wolf recovery. These low road densities must be maintained over areas large enough to meet the biological needs of wolf packs, free from adverse human disturbance. Average wolf pack territories in Minnesota and Wisconsin are between 20 and 214 square miles (USFWS, 1992). The Rice Lake Project Area, at about 23,500 acres, or over 36 square miles in size, constitutes an area that is large enough where wolf habitat management is a factor. There are no roadless areas in or near the Chippewa National Forest. In actuality, National Forest System Lands provide the most logical resource base in northcentral Minnesota for providing roadless, or near roadless areas for wolf conservation. It is also an obligation for the Forest Service to provide such wolf habitat on National Forest System Lands. The Endangered Species Acts states "All other Federal agencies shall, in consultation with and with the assistance of the Secretary, utilize their authorities in furtherance of the purposes of this Act by carrying out programs for the conservation of endangered species and threatened species listed pursuant to section 4 of this Act" (Section 7(a)(1)). In other words, Federal agencies have more of a responsibility than eliminating or mitigating negative effects to listed species. The Chippewa National Forest Land and Resource Management Plan

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states "The standards and guidelines for the gray wolf are based on the guidelines in the Eastern Timber Wolf Recovery Plan. The Forest Plan will be responsive to any changes in the recovery plan, including changes in the configuration of Wolf Management Zones." The Recovery Plan states that "the more access provided to wolf range, the more detriment there will be to wolves". Also, "the higher grade (standard) the road is, the more access it will provide". However, the Recovery Plan also states that "An open, low standard woods road may have greater potential human impact on wolves than a national forest highway". So, when considering human access and road densities, one should consider all roads and trails, not just higher standard roads.

Human accessibility is best measured by looking at road and trail density. With the exception of water access, nearly 100% of human use is associated with the road and trail system in the Rice Lake Project Area. To conduct a road and trail analysis, the project area was modified to omit the two largest lakes, Big Rice Lake and Laura Lake, and approximately 400 acres encompassing the City of Remer and associated city roads. All land ownerships within the project area were included in the analysis as well as all roads and trails, including State and County roads, Forest Service system roads, designated trails, and user developed and maintained roads and trails that were identified through ground reconnaissance. The road density analysis area totals 19,550 acres, or approximately 30.55 square miles. The analysis was conducted using spatially-reference vector data in the Forest Service Geographic Information System. There was a question whether to include roads that make up the project area boundary, so two analyses were conducted, one including the boundary roads, and one omitting them. These boundary roads include: FR 2103 (west boundary) – 5.8 miles, MN 200 (north boundary) – 6.5 miles, County 133 (east boundary) – 3.4 miles, and County 7 (portion of south boundary) – 1 mile, for a total of 16.7 miles of boundary road. Table 5 shows the resulting road and trail densities for the four alternatives including and excluding the boundary roads. There is no discretion made between road development and maintenance levels, or between roads and trails.

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Table 5. Road and trail densities (miles per square mile) per alternative, Rice Lake Project Area.

		ALT A	ALT B	ALT C	ATL D
Without Boundary Roads	**Total Miles**	51.8	50.7	32.8	49.3
	Density (mi./Sq Mi.)	1.70	1.65	1.04	1.50
With Boundary Roads	**Total Miles**	68.5	67.4	49.5	66.0
	Density (mi./Sq Mi.)	2.24	2.21	1.62	2.16

Depending on whether one considers boundary roads part of the analysis area or not, the existing condition (Alternative A) does not provide for sustainable wolf populations as defined by the Recovery Plan. The other alternatives all reduce road densities in the project area, but none of them meet the Recovery Plan recommendations of less than 1 mile per square mile. If you do not consider the boundary roads, Alternative C comes close to meeting the objectives. To reduce the road and trail densities under Alternative C further, the designated snowmobile trails that traverse the area would have to be eliminated or relocated out of the project area. A likely solution would be to relocate the trails on or along the main road corridors that define the boundary of the project area. These are main transportation corridors that will exist regardless of National Forest management. As the Recovery Plan (USFWS, 1992) states, "the more access provided to wolf range, the more detriment there will be to wolves". Although none of the alternatives could be said to provide a sustainable habitat condition for wolves, Alternative C is clearly better than Alternatives B and D, which provide a slight improvement over the existing condition (Alternative A). Although none of the alternatives propose to worsen habitat conditions for wolves, part of each project proposal on National Forest Lands includes a roads analysis, identifying transportation system conditions needed to meet National Forest goals and objectives. This, in effect, constitutes a decision to either improve conditions for specific resources, or not as they relate to the transportation system and human access. From this perspective, the road density threshold outlined in the Eastern Timber Wolf Recovery Plan is marginally met by Alternative C, and is exceeded by the other alternatives. 7

Cumulative Effects: The wolf population in Minnesota has increased by approximately 50% since 1988 (Table 6). Although one might argue that wolf populations are increasing in Minnesota despite road and trail densities above the threshold identified in the Recovery Plan, wolf populations respond not directly to road and trail densities, but to human activity. Today's wolf population numbers

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reflect the conditions under which the increase occurred, not necessarily the existing condition. To assess cumulative effects, and future wolf habitat security, one must investigate the changing human demographics and how they may influence wolf habitat. Many factors in human demographics are changing at an alarming rate in Northern Minnesota. More people are spending more leisure time in Northern Minnesota than ever before. Cass and Crow Wing Counties are experiencing unprecedented growth, including year-round residents and an expanding tourism industry (Cass and Crow Wing Counties, 2001). The population of Cass County increased by 24.6% between 1990 and 2000, twice the average growth for the State of Minnesota, resulting in a population density of 13.5 persons per square mile (US Census Bureau, 2001). Traffic volumes on regional highways are growing exponentially, resulting in highway upgrades, which with the increased traffic are likely to cause movement barriers and fragmentation of wolf habitat. Pressures on natural resources are increasing, and public forests are receiving increased use from both permanent residents and seasonal recreationists. Table 7 shows the trends in registered all-terrain vehicles (ATVs) and Table 8 shows the same for snowmobiles in the State of Minnesota since records have been kept. ATV numbers have increased by 431% between 1990 and 2000. Snowmobiles show a 46% increase.

Table 6. Results of wolf population and distribution surveys for Minnesota (Minnesota Department of Natural Resources, Section of Wildlife, Grand Rapids, MN).

	1978-79	**1988-89**	**1997-98**
Minimum primary wolf range (sq. miles)	14,038	23,165	33,971
Number of wolf packs	138	233	385
Number of wolves	1,235	1,550-1,750	2,445

Motorized activity in Minnesota's forests has grown significantly, particularly since 1990. In previous decades, logging roads and trails would gradually become inaccessible as they re-vegetated and became obstructed with brush and debris. This resulted in a relatively static road and trail density as new roads and trails were constructed and older ones became impassable. Today, almost all new roads and trails are maintained in a passable condition by four-wheel drive trucks and ATV traffic, creating a condition where newly constructed and reconstructed roads and trails result in a permanent increase in road and trail density. This is a compounding factor with the increasing number of ATVs and snowmobiles, and the increasing hours of use per vehicle. Unless remote wildland areas are managed as habitat for large mammals such as the wolf, Minnesota will likely experience a degradation of habitat capable of providing long-term survival of such species.

Ref 17-533-

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Mail body: Gray Wolf

Ref 18-534-

America's Gray Wolves: A Long Road to Recovery

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AMERICA'S GRAY WOLVES / The Center for Biological Diversity

Few animals evoke the wild like wolves:.Majestic, intelligent and highly social, they're crucial in driving evolution and balancing ecosystems. Wolves once roamed freely throughout North America, in numbers estimated at some 2 million. But federal extermination programs reduced their numbers to the breaking point.

By the 1960s gray wolves were finally protected under what would become the Endangered Species Act. They'd been exterminated from all the contiguous United States except for part of Minnesota and Isle Royale National Park in Michigan.

Gray wolf

Trump is gearing up to strip protection from nearly every wolf in the lower 48.
We're fighting back with Call of the Wild, a national grassroots campaign to save America's wolves.
Please join us.

A COMEBACK ... BUT A LONG ROAD TO RECOVERY

After receiving federal protection, gray wolves saw tremendous recovery in the western Great Lakes region. Their populations grew and expanded through Wisconsin and Michigan. Through natural migration from Canada and reintroduction to Yellowstone National Park and central Idaho, wolves returned to the northern Rockies and are establishing a toehold in the West Coast states. Recovering populations exist in Idaho, Montana, Wyoming, Washington and Oregon, with a few wolves beginning to range into California. In the Southwest Mexican gray wolves have also seen some recovery, but to a lesser degree. Just seven surviving Mexican gray wolves were captured between 1977 and 1980 and bred in captivity. Their progeny were reintroduced into Arizona and New Mexico, but this subspecies of gray wolf continues to struggle in the United States and Mexico.

Despite these substantial gains, the job of wolf recovery is far from over. Wolves need connected populations for genetic sustainability, and natural ecosystems need wolves to maintain a healthy balance of species — yet today wolves occupy less than 10 percent of their historic range and continue to face persecution. The Center has worked to save wolves since our inception, and we continue to defend them through science, the law and with our supporters' help.

OUR WORK TO SAVE WOLVES NATIONWIDE

The Center has always campaigned for wolves since our inception.

Our legal work led to the 1998 reintroduction of Mexican gray wolves into the Apache and Gila national forests. The Center, founded in the Gila in 1989 and maintaining staff in the reintroduction area to the present day, monitors wolf and habitat management. We have vigorously challenged federal shooting and trapping of Mexican wolves and are pushing for the resumption of wolf releases from captivity to the wild. We've petitioned and sued for changes in wolf management, development of a new, science-based Mexican wolf recovery plan, and listing of the Mexican wolf as an endangered subspecies. We help organize public pressure on agencies and elected officials to provide maximum protection for the beleaguered Mexican wolves.

In the northern Rocky Mountains, the Center was part of several successful lawsuits that delayed the removal of federal protections for wolves from April 2003, when first promulgated by the Bush administration, until May 2011, when protections were finally (though still prematurely) removed through an infamous congressional rider. Our legal efforts helped to allow the wolf population to grow by 1,000 animals during those eight years, from 761 to 1,774. Now that management has been turned over to state wildlife managers, we fight to protect wolves from trophy hunting and other exploitation.

We've also stood up for protection of the growing but still vulnerable population of wolves in the West Coast states of Washington, Oregon and California. In Oregon and Washington, we're pushing state wildlife-management agencies to protect the recovering populations and use nonlethal methods to address any conflicts with the agriculture industry. In California our petition led to wolves receiving protection under the state Endangered Species Act. Because of the Center's successful state-listing petition, any wolves that disperse to California are now fully protected under state law, and harming, harassing or killing a wolf in California for any reason other than in defense of human life is illegal.

In the Midwest multiple lawsuits filed by the Center and allies have fought back against the feds' efforts to prematurely remove their protections, allowing continued growth in the wolf population. And we've kept the pressure on state wildlife-management agencies dead set on killing wolves, including a challenge to Minnesota's first-ever regulated wolf-hunting season. Even with our successful lawsuits, wolves remain under attack in Congress, where anti-wolf legislators have continued to try to undo court rulings by attaching delisting riders to major federal budget bills. With the help of Center supporters making calls and sending emails to their members of Congress, we've been able to stop these efforts to permanently end Endangered Species Act protections for gray wolves in Wyoming and the western Great Lakes states.

The year 2019 brought an attack on wolves from the Trump administration, which proposed to remove protections from nearly every gray wolf in the lower 48 states. Our Call of the Wild campaign has held rallies and community hearings across the country and sent more than a million comments opposing the plan to strip wolf protections.

Since the original wolf recovery plans were written in the 1980s, we've learned much more about wolves' behavior, ecology and needs. We know, for example, that returning wolves to ecosystems sets off a chain of events that benefits many species, including songbirds and beavers that gain from a return of streamside vegetation — which thrives in the absence of browsing elk that must move more often to avoid wolves — and pronghorn and foxes that are aided by wolves' control of coyote populations.

A mere 5,000 to 6,000 wolves occupy less than 10 percent of the animals' historic range in the lower 48 states. Establishing wolf populations in remaining suitable habitat in the Northeast, southern Rocky Mountains, Southwest, Pacific Northwest, California and elsewhere would secure a future for wolves and allow them to play their valuable ecological role in more of their former range. The Center seeks an end to wolf persecution and seeks to link isolated wolf populations together to combat inbreeding and allow ecosystem rejuvenation on a broader scale.

Ref 18-535-

Map MAP:
U.S. Gray Wolf Habitat

RELATED CAMPAIGNS

• Wolves on the West Coast
• Mexican gray wolf
• Northern Rocky Mountains gray wolf
• Great Lakes gray wolf
• Alexander Archipelago wolf
• Carnivore Conservation
• The Endangered Species Act

+ KEY DOCUMENTS

+ MEDIA

Contacts: Collette Adkins, Amaroq Weiss and Michael Robinson

Wenaha pack wolf pup photo courtesy ODFW

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DEPARTMENT OF NATURAL RESOURCES

Ref19-536-

Public Comments Processing
Attn. Docket No. FWS-HQ-ES-2018-0097
US Fish & Wildlife Service Headquarters
MS: BPHC
5275 Leesburg Pike
Falls Church, VA 22041-3803

see next page

July 15, 2019

Re: Minnesota Department of Natural Resources Comments on the U.S. Fish and Wildlife Service's Proposed Rule "Removing the Gray Wolf *(Canis lupus)* From the List of Endangered and Threatened Wildlife", 84 Fed. Reg. 9648 ((March 15, 2019) (to be codified at 50 CR 117).

To Whom it May Concern:

The Minnesota Department of Natural Resources (DNR) submits the following comments to the U.S. Fish and Wildlife Service (USFWS) regarding its Proposed Rule "Removing the Gray Wolf *(Canis lupus)* From the List of Endangered and Threatened Wildlife" (Proposed Rule). The primary focus of the Minnesota DNR's comments is on the Minnesota Gray Wolf (wolf or gray wolf) population in relationship to the Proposed Rule. While focusing the bulk of our comments on the recovery of Minnesota's wolf population, the Minnesota DNR recognizes that a blanket delisting across the United States may not be warranted. DNR further recognizes that there are important systemic questions about delisting under the Endangered Species Act (ESA) raised by the USFWS's recent proposal. These broader questions are also discussed below.

At the outset, the Minnesota DNR acknowledges that the recovery of the gray wolf in Minnesota has been a resounding success. In 1978, when the gray wolf was reclassified in Minnesota from endangered to threatened, there were approximately 1,000 gray wolves located in the lower 48 states and these were all located in the tip of the Minnesota Arrowhead Region and on Isle Royale in Lake Superior. 84 Fed. Reg. at 9655. As further outlined below, the Minnesota gray wolf population is currently estimated at 2,655, far in exceedance of its recovery goal of 1,251 -1,400.[1] Furthermore, gray wolves in Minnesota are currently occupying all of their suitable range.[2]

Today, of the estimated 6,000 gray wolves in the lower 48 states, nearly one-half are in Minnesota. As the Proposed Rule sets forth, Minnesota has been the foundation for wolf

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[1] Although the precise number of wolves located in Minnesota pre-settlement is unknown, the wolf population in Minnesota pre-settlement is estimated to have ranged from 4,000 to 8,000. 84 Fed. Reg. at 9655.

[2] For a discussion of what constitutes suitable range for gray wolves in Minnesota *see* Minnesota DNR comments at page 4.

for delisting. Today in Minnesota, gray wolves occupy substantially all of their suitable range; their population are approaching historic numbers; and the state has adopted extensive regulatory mechanisms to preclude the degradation of Minnesota's gray wolf population.

Conclusion

In closing these comments, the Minnesota DNR reaffirms its commitment to gray wolf recovery. Without expressing an opinion on the status of gray wolves outside its borders, the Minnesota DNR recognizes that the recovery of gray wolves in Minnesota has been an over fifty-year process requiring the commitment of extensive federal, state, and tribal resources. Regardless of the outcome of this Proposed Rule, the Minnesota DNR intends to continue to manage Minnesota's wolf population to ensure the sustainability of our gray wolves now and in the future, consistent with our wildlife trust obligations. The Minnesota DNR is further committed to managing its gray wolves to contribute to the success of wolf recovery beyond Minnesota.

Sincerely,

Sarah Strommen
Commissioner
Minnesota Department of Natural Resources

Encl.

Ref 19A -537A-

Federal government removes Endangered Species protection for gray wolves

October 30, 2020 by Greg Seitz

See pgs. 2-4

Gray wolf (Photo by Isster17 via Wikimedia)

In a visit to Minnesota yesterday, Department of the Interior Secretary David Bernhardt announced gray wolves will be removed from the Endangered Species List. The animals have been listed since 1974, except for a short time off the list in 2011 to 2014.

The announcement means wolf management will be conducted by state and tribal governments. That could mean new hunting and trapping seasons, which occurred the last time wolves were taken off the list. The Trump administration heralded the move yesterday as a success story, only possible because of decades of restoration work which have brought wolves back from the brink of extinction.

“President Trump’s Administration has focused on proactive measures, including partnerships with organizations, to ensure listed species flourish to the point of recovery,” said Director of the U.S. Fish and Wildlife Service Aurelia Skipwith. “Today is a win for the gray wolf and the American people. I am grateful for these partnerships with States and Tribes and their commitment to sustainable management of wolves that will ensure the species long-term survival following this delisting."

Ref 19A-537B-

Wildlife advocates say the decision was not justified by science, and pledged to take legal action to keep wolves protected.

"Stripping protections for gray wolves is premature and reckless," said Jamie Rappaport Clark, President and CEO of Defenders of Wildlife. "Gray wolves occupy only a fraction of their former range and need continued federal protection to fully recover. We will be taking the U.S. Fish and Wildlife Service to court to defend this iconic species."

On the road to recovery, or the end of the road?

There was a bounty for wolves in Minnesota from 1849 until 1965. The population hit a low point in the 1960s, with 350-700 wolves still in far northeastern Minnesota, having been eliminated from Wisconsin, Michigan, and other parts of their range.

Today, there are estimated to be about 2,700 gray wolves in Minnesota, and about 6,000 total in the lower 48 states. Prior to European immigration, gray wolves were found throughout what is now the United States.

The Minnesota Department of Natural Resources responded to the delisting announcement by saying the agency believes wolves have indeed recovered in Minnesota, but that a blanket delisting across all states where they are found "may not be warranted."

The DNR is in the middle of receiving public comment on an update to the state's wolf management plan. In response to the delisting, the agency said it would extend the comment period from a planned ending on Nov. 1 until Nov.

20 to give the public a chance to respond in light of the announcement.

Ref 19A -537C-

The DNR has conducted public opinion surveys to help inform its wolf management. The most recent poll found that 87 percent of Minnesota residents believe maintaining a wolf population is important. Two-thirds of the state's hunters feel the same way, despite the competition for their quarry that wolves represent.

One prominent Minnesota deer hunting organization voiced its support for the federal decision.

"[Minnesota Deer Hunters Association] is pleased that the Fish and Wildlife Service has delisted the gray wolf again. The wolf has met all recovery goals in Minnesota for decades and Minnesota DNR has shown that it can responsibly manage a wolf season," stated Minnesota Deer Hunters Association President Denis Quarberg.

Minnesota wolf advocates joined national counterparts in criticizing the decision. They say removing federal protections could lead to inhumane treatment of wolves, disrupt pack dynamics resulting in a far larger impact than just hunting fatalities, and actually worsen human-wolf conflict.

"This political decision to remove federal Endangered Species Act protections for the wolf is against public sentiment, sound science, and will destroy our nation's endangered species," said Maureen Hackett, founder and president of Minnesota-based wolf advocacy group Howling For Wolves. "We need a nonlethal wolf plan and continued funding for prevention methods for farmers and ranchers to ensure an intact and healthy wolf population, because the wolf is vital for our ecology and the legacy of future Minnesotans."

But elected representatives from Minnesota who represent areas with farming and wolves welcomed the decision.

Ref 19A-537 D-

"With Minnesota's whitetail firearm season so close, this announcement could not have come at a better time, as empowering state agencies to responsibly manage the gray wolf will help to conserve our deer herd for generations while putting cattle farmers at ease," said U.S. Representative Pete Stauber (MN-08).

Stauber's district includes northeastern Minnesota, the heart of wolf country. U.S. Representative Collin Peterson (MN-07), a Democrat from western Minnesota, also said he supports the decision.

"For years, I have called for this change on behalf of livestock owners and rural communities in Minnesota," Peterson said. "This final rule allows Minnesota to set rules and protections for gray wolves that are more responsive to the needs of local communities."

A coalition of environmental groups said the decision should meet the same fate as previous attempts to take gray wolves off the Endangered Species List.

"Again and again the courts have rejected premature removal of wolf protections," said Collette Adkins, Minnesota-based carnivore conservation director at the Center for Biological Diversity. "But instead of pursuing further wolf recovery, the Fish and Wildlife Service has just adopted its broadest, most destructive delisting rule yet."

The final rule will be effective 60 days after publication in the Federal Register. The earliest it will take effect is Jan. 1, 2021. The U.S. Fish and Wildlife Service says it will monitor wolf populations for five years to "ensure the continued success of the species."

More information:

- Trump Administration Returns Management and Protection of Gray

Biden must restore wolves' protection

We know what will happen if he doesn't: The wolf population will be depleted.

After decades of bitter legal feuds and culture war skirmishes over the fate of wild wolves in the United States, the Trump administration has tried to put a point at the end of the sentence. In stripping gray wolves of their Endangered Species Act protection across the country, the responsible federal agency went against both science and public opinion, and declared the species "biologically recovered."

This delisting rule won't stand up to scrutiny. More wolves will die as the U.S. Fish and Wildlife Service squares off, once again, in court against conservationists with strong arguments that there's no evidence on which to base the agency's claim that wolves will be just fine.

This issue presents President-elect Joe Biden an opportunity to break from the mold cast by his predecessors. Before this latest effort by the Trump administration, President Barack Obama allowed a previous delisting effort to move forward.

In his first weeks as president, Biden should take decisive action and direct federal wildlife agencies to embrace a science-backed, full recovery of the wolf in the Lower 48 states — which would hinge on restoring federal protections under the Endangered Species Act and keeping them in place.

If Biden chooses instead to allow delisting to stand, well, we've seen that movie before.

In 2012, wolves were removed from the federal endangered species list in Michigan, Wisconsin and Minnesota. A federal judge restored protection in 2014, and an appeals court upheld this ruling in 2017.

In the two-and-a-half years that wolf hunting and trapping were allowed, more than a third of the region's entire wolf population was killed. A repeat of the same fiasco would result in the same leap backward on a nationwide scale.

If allowed to proceed unchecked, federal delisting will trigger a cascade of state management decisions that will bring more state-sanctioned wolf slaughters and doom the species' recovery.

States such as Wisconsin mandate an immediate wolf hunting and trapping season upon federal delisting. Wolves that attempt to disperse from the western Great Lakes states to seek new territory in the Dakotas can be gunned down on sight without penalty.

The fundamental purpose of the Endangered Species Act is to protect and recover imperiled species and the ecosystems upon which they depend. Most of us are now familiar with the many ecological benefits

Ref 19B -537F-

wolves provide, as illustrated by wolf reintroduction to Yellowstone National Park. Yet with delisting, we'll never know how healthy wolf populations might transform their former habitats in the Adirondacks, Sierra Nevada or Black Hills of South Dakota.

Nearly every time the Fish and Wildlife Service has attempted to strip wolves of protection, these efforts have either been overturned in court or withdrawn. Again and again, the courts have told the agency that its attempts to remove protections from wolves were flat-out illegal.

It's time for the Fish and Wildlife Service to unchain this magnificent, ecologically essential species from its absurd legal and political carousel. Delisting was a last-minute "gift" from the Trump administration to conservative voters and the livestock industry right before the November election. If Biden allows it to stand, it would send a signal that he doesn't have the stomach for charting the course needed in the U.S. to undo the incredible damage done to environmental policy over the past four years.

Collette Adkins is a senior attorney and carnivore conservation director for the Center for Biological

Diversity. She wrote this for the Chicago Tribune (TNS).

Ref 20-538-

DNR RESPONSE TO COVID-19: For details on adjustments to DNR services, visit this webpage (https://www.dnr.state.mn.us/covid-19.html). For information on the state's response, visit the Department of Health website (https://www.health.state.mn.us/diseases/coronavirus/index.html) .

Page Menu

Wood turtle surveys

Wood turtles (*Glyptemys insculpta*) (https://www.dnr.state.mn.us/rsg/profile.html?action=elementDetail&selectedElement=ARAAD02020) are the most terrestrial turtle found in Minnesota, placing them at a greater risk than their aquatic counterparts. Predators, habitat loss, road mortality and more have made them a threatened species in Minnesota. That's why we're testing conservation techniques to see how we can help this unique species!

Since 1998, the Nongame Wildlife Program has been monitoring wood turtles along several southeastern Minnesota streams to determine population size and age, range, and habitat use. We've partnered with the Minnesota Biological Survey (https://www.dnr.state.mn.us/eco/mbs/woodturtlexing.html) and the Minnesota Zoo (https://mnzoo.org/conservation/minnesota/freshwater-turtles/) to do extensive telemetry work. We're monitoring adult and juvenile turtles and determine habitat preferences and movements. Our goal is to develop habitat management plans with landowners along these rivers, to help them preserve Minnesota's wood turtles.

The Nongame Wildlife Program and Minnesota Biological Survey have been surveying rivers and streams across eastern Minnesota to better understand where wood turtles are found and how abundant they are. Using this information, we can focus our efforts on the most important or critical locations for wood turtles in Minnesota.

In addition, the Nongame Wildlife Program has been studying ways we can help wood turtles in northeast Minnesota. We received two competitive State Wildlife Grants and are working with Wisconsin, Michigan, and Iowa to identify threats to wood turtles in the Upper Midwest and the effectiveness of different conservation techniques. In partnership with the University of Minnesota, we've created flood-safe nesting habitats,

Ref 20-539-

protected nests from predators, installed road barriers, and enhanced foraging habitat. Field surveys, game cameras, and telemetry were used to assess the effectiveness of these conservation actions. We created a monitoring protocol and collected baseline population data that will let us see the long-term effect of these conservation actions on the population.

A Minnesota Wood Turtle Conservation Plan was developed to identify priorities for wood turtle conservation over the next 10 years. The Plan identifies strategies to maintain and enhance habitat, decrease adult turtle mortality, increase survival of young turtles, fill knowledge gaps, and increase conservation partnerships. The Plan outlines specific actions the DNR and our partners can take to help wood turtles in Minnesota.

(/)

Questions?

Call 651-296-6157 or 888-MINNDNR (646-6367)

Email us: info.dnr@state.mn.us (mailto:info.dnr@state.mn.us)

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DNR RESPONSE TO COVID-19: For details on adjustments to DNR services, visit this webpage (https://www.dnr.state.mn.us/covid-19.html). For information on the state's response, visit the Department of Health website (https://www.health.state.mn.us/diseases/coronavirus/index.html) .

Page Menu

Helping Turtles Across the Road

Troubled Turtle Times

Although pre-dating dinosaurs by several million years, turtles everywhere are fast disappearing today. The "hide in my shell and wait it out" strategy that has enabled turtles to weather the geologic changes leading to the extinction of countless other species, however, has proven of little use in surviving the peril posed by fast moving trucks and cars.

Roadway mortality, in fact, is believed to be a major factor in turtle population declines throughout the United States. Helping these typically inoffensive animals safely across roads is therefore an important and valuable contribution to the preservation of North America's turtles. Turtles injured while trying to cross the road may be taken to your nearest permitted wildlife rehabilitator (/eco/nongame/rehabilitation/index.html).

Why Turtles Cross Roads?

Unlike the infamous chicken of many riddles, turtles cross roads not just to get to the other side but because turtles actually have someplace to go. In Minnesota, where all turtles are mainly aquatic, overland journeys usually occur: (1) in connection with seasonal movements between different wetland habitats, (2) during the annual early summer nesting migration of egg laden females, or (3) when newly hatched youngsters seek out the backwaters and ponds that will serve as their permanent home. Turtles can travel many miles during a single year, and may even be found far from water; this is no need for concern. Turtles crossing roads in late-May and June are often moving to familiar nesting locations.

Giving Turtles A Hand

Ref 22-541-

Projects in Minnesota regions

see page 2

Northeast Projects

Camp Ripley research and survey coordination

Through annual Inter-agency Agreements, a variety of wildlife and plant work is done for the Department of Military Affairs at Camp Ripley by the Department of Natural Resources. This work is coordinated by the Regional Nongame Specialist at Brainerd and includes projects on wolves, songbirds, owls, frogs and toads, jumping spiders, dragonflies, and other endangered animals and plants. For more information on the projects at Camp Ripley, contact Brian Dirks, Animal Survey Coordinator at brian.dirks@state.mn.us or (320) 632-7635.

Landscaping for Wildlife demonstration areas

Three demonstration areas have been developed to show the 16 habitat components of "landscaping for wildlife" methods. At the 110-acre Uppgaard Wildlife Management Area between Crosslake and Pequot Lakes, examples of the different components are marked with signs, and well-maintained trails lead the visitor to wildflower gardens, feeders, wildlife-viewing blinds, and scenic overlooks. At the Northland Arboretum in Brainerd, two backyard areas have been developed to show the visitor the variety of plants that are valuable to wildlife. There are also displays of bird feeders and nesting boxes. At the DNR Regional Headquarters, also in Brainerd, three terraces have been planted with native woodland and prairie plant species. These plants are labeled to assist with identification and an information board inside the main entrance provides additional information on plants that are currently blooming. A bird feeding station is also maintained on the river side of the building which features a squirrel-proof feeder array.

Red-shouldered hawk forest management guidelines

The red-shouldered hawk *(Buteo lineatus)* is a state-listed species of special concern. In 1992, "The Generic Environmental Impact Statement on Timber Harvesting and Forest Management in Minnesota" put special emphasis on the red-shouldered hawk because of projected population declines under all timber harvesting scenarios for the next 50 years. This decline is anticipated due to the loss of large contiguous stands of mature hardwoods throughout the state. Following the completion of surveys to assess distribution, management guidelines are being developed to help guide forest management activities. The goal is to prevent population declines of this species.

Northern goshawk survey

Nest surveys were conducted in northern Minnesota in addition to the use of radio telemetry to track the northern goshawk *(Accipiter gentilis)*. With the aid of aircraft and radio telemetry, it was discovered that the northern goshawks do not leave Minnesota in the winter. Additional flights are planned in hopes of gathering further information regarding these beautiful raptors.

Timber planning

The goal of Nongame staff's participation in this 5-year timber planning process is to ensure the continuation of an ecologically sound and diverse forest. This cooperative plan between the DNR's divisions of Forestry and Wildlife utilizes GIS and the Natural Heritage Data bases to provide necessary information to ensure each area (landscape) is managed and harvested to its potential, while maintaining the natural diversity of the forest landscape. Special provisions are given to managing endangered and threatened species when managing the forest landscape.

Boreal owl population monitoring

This small, flat-headed, earless owl is found only in the extreme northeastern portion of Minnesota and considered at the edge of its range. The boreal owl *(Aegolius funereus)* population is monitored in late winter on predetermined routes during the evening hours. Researchers stop every mile to listen for the owl's unique call, which is similar to the sound of a soft high-pitched bell.

Black-throated blue warbler survey

The black-throated blue warbler *(Dendroica caerulescens)* is only found in northeastern Minnesota and has a very small range. In Tettegouche State Park, 50 singing males were found and documentation of a breeding population was verified. Further study of this unique bird will determine it's specific habitat preferences.

Common loon migration study

In the fall of 1998, researchers counted common loons *(Gavia immer)* weekly on lakes Winnibigoshish and Mille Lacs to determine pre-migratory numbers, flock sizes and locations. Counts were made from shore, boat and plane. On Lake Winnibigoshish, the highest count was recorded on October 21 with 1,599 loons. A final report on this study entitled "Fall Staging of the Common Loon on Lakes Winnibigoshish and Mille Lacs" will soon be published in the Loon, the journal of the Minnesota Ornithologists Union. On Lake Mille Lacs, the highest count total occurred on October 20 with 1,688 loons, a record high count for any lake in Minnesota at any time!

Common tern management

Since 1982, the Department has overseen monitoring of these rare waterbirds. The common tern *(Sterna hirundo)* is classified as threatened. This species nests in Lake of the Woods County, Leech Lake, Mille Lacs Lake, and Lake Superior in the Duluth Harbor. Program emphasis includes monitoring nest productivity, nest protection measures, and habitat improvement. In 1999, there were five nesting colony sites for the common tern, and a statewide population of fewer than 900 nesting pairs.

Northwest Projects

Piping plover & common tern monitoring

Ref22-542

Since 1982, the Department has overseen monitoring of these rare species. The piping plover (*Charadrius melodus*) is endangered, and the common tern (*Sterna hirundo*) is classified as threatened. Both species nest in Lake of the Woods County. Program emphasis includes monitoring nest productivity, nest protection measures, and habitat improvement. In 1999 there were only three pairs of plovers found in the state. Currently there are five nesting colony sites for the common tern, and a statewide population of fewer than 900 nesting pairs. In 2004 piping plovers did not nest anywhere in Minnesota, presumably due to continued erosion and problems at nesting sites. Currently, there are two common tern nesting sites in Lake of the Woods County, one on Pine/Curry Island, and the other on the NW Angle Islands.

Central Projects

DNR Eagle Cam

Lights Out Twin Cities

Save birds and energy by turning off unnecessary lights during spring and fall migration.

Peregrine Falcon Project

Restoring peregrine populations.

Cricket frog survey

Going, going, gone from the states' frog chorus, the cricket frog (*Acris crepitans*) is so rarely heard in Minnesota that biologists were considering declaring it extirpated (gone forever) in Minnesota. Much to everyone's surprise, a chorus of cricket frogs was heard calling in Bloomington in July of 1998. Since then, Nongame Wildlife Program personnel have been out each spring looking and listening for this rare species along the Minnesota river Valley where these frogs have persisted despite river limited habitat and flooding.

This Bloomington population is located far from the species historically known home range in southeast Minnesota. Therefore, DNR biologists had questions about the origin of the cricket frogs at this unexpected location.

In 2003, with funding from the Nongame Wildlife Program, Dr. Andrew Simons in the Dept. of Fisheries, Wildlife and Conservation Biology at the U of MN, took on the challenge of determining the origin of the Bloomington cricket frogs. Five of these tiny and allusive frogs were captured. Without causing any mortality, a toe was clipped from each frog for a tissue sample.

The results from the Minnesota frogs were compared to DNA analysis of 40 other cricket frogs collected from across the nation. The researchers concluded that "That the Bloomington population has DNA sequences that are unique compared to other northern cricket frog populations." They recommended that these frogs be managed as a native endangered species.

In July 2004, a second population was discovered near Winona by a volunteer with the DNR's Frog and Toad Calling Survey project.

Timber rattlesnake survey & habitat improvement

The timber rattlesnake *(Crotalus horridus)* is a state threatened species and is only found in the blufflands of southeastern Minnesota. This docile snake, although venomous, poses little threat to humans, yet many people feel compelled to kill any snake they encounter, including timber rattlesnakes. Minnesota paid a bounty for timber rattlers until 1989. In the 1940's, nearly 6000 rattlesnakes were submitted for bounty in Houston County alone! By 1987, fewer than 200 snakes were turned in for bounty in the same county. Intensive harvest had a tremendous impact on Minnesota's rattlesnake population. So much so that the species was listed as threatened in 1996. Today, we still have rattlesnakes in Minnesota, but their range has reduced, and many once active dens are now gone.

The timber rattlesnake inhabits south and west-facing bluff prairies with associated forest. In May, snakes emerge from their dens and begin sunning on rock ledges and outcroppings. Gravid females remain around the den until they give birth to live young in September. Nongravid females and males disperse around the end of May to mid-June. These snakes search for rodents and small birds in forests and bottomlands within two miles of their dens.

Because rattlesnakes are declining throughout their range, the Nongame Wildlife Program embarked on a survey effort to assess areas where snakes were known to occur historically and where snake-human encounters were increasing. These spring surveys have revealed good and bad news. The bad news is that many once active dens are no longer active. Furthermore, much of the bluff prairie habitat the snakes depend on is getting severely overgrown with eastern red cedar. The good news is that there are still areas where the snake population appears to be stable, with signs of reproduction. In addition to spring surveys, the Nongame Wildlife Program is also conducting bluff prairie restoration to improve habitat for snakes and minimize snake-human encounters. So far, the habitat work has been very productive in restoring bluffs back to their prairie origins.

A Timber Rattlesnake Recovery Plan PDF (1.7 mb) was finalized in April, 2009.

Wood turtle surveys

The wood turtle *(Glyptemys insculpta)* is a threatened species in Minnesota. A turtle once common to Minnesota's medium-sized to small gravel bottomed streams along the eastern half of the state, is now found in only a handful of places in southeastern and northeastern Minnesota. Wood turtles are a river species, spending their lives in and around river systems. They will stage on sand bars and sandy riverbanks in the spring for breeding, and then will disperse to summer foraging grounds. Wood turtles eat a variety of foods including berries, earthworms, snails and insects. While they are a long-lived species, they face significant threats from development pressure, recreation, and degrading water quality in our river systems.

Since 1998, the Nongame Wildlife Program has been monitoring these wood turtles along several southeastern Minnesota streams to determine population size and age, range and habitat use. This monitoring has involved extensive telemetry work to follow adult and juvenile turtles throughout the field season to determine habitat preferences and movements. The goal is to develop habitat management plans with landowners along these rivers, to help them preserve Minnesota's only terrestrial turtle.

Oak savanna restoration for the Karner blue butterfly

Ref 22-543-

The Karner blue butterfly *(Lycaeides melissa samuelis)* is a federally endangered species and is only found in one location in Minnesota. This small, beautiful butterfly inhabits oak savanna and requires lupine plants on which to lay its eggs. Oak savannas are one of the rarest native plant communities in Minnesota. Once covering more than five million acres in Minnesota, less than 4500 acres of savanna remain today. Many of these acres are becoming overgrown or are being invaded by invasive species such as honeysuckle, buckthorn and Japanese barberry. The Nongame Wildlife Program is working in partnership with the Division of Fish and Wildlife to restore oak savannas, particularly in areas where the Karner blue butterfly are known to occur. This work is challenging because oak savannas and lupine need some disturbance such as fire to maintain them. The butterflies are not known to be able to survive fire.

The Nongame Wildlife Program conducts annual monitoring transects to get a population index for Karner blues. While our populations are very low, we are managing to keep hanging on. Current restoration efforts involve removing invasive species and reintroducing fire in three valleys in southeastern Minnesota. There are twelve oak savanna valleys identified for recovery, but currently the work is being done to the three highest priority sites. More than 40 acres of oak savanna is well on its way toward restoration. Hopefully, the Karner blues will follow suit.

South Projects

Blanding's turtle survey and conservation

The Blanding's turtle *(Emydoidea blandingii)* is a state-listed threatened species. It depends upon riparian areas, variety of wetland types, and is frequently associated with sandy upland soils for nesting. However, its specific habitats and conservation needs differ across Minnesota. This ongoing project is conducted to locate areas where this rare species if found and to provide critical protection to the habitat to ensure their presence in Minnesota's landscape. There is an intensive effort in southwestern Minnesota to assess its presence, distribution and estimate the abundance. Describe and summarize study populations and formulate research and conservation recommendations.

This project will contribute towards development of a sound comprehensive conservation plan for Blanding's turtles statewide and provide valuable decision making tools. Habitat conservation efforts for Blanding's turtles dovetail well with other initiatives aimed at conservation and restoration of rivers corridors, wetlands and adjacent grasslands. Active citizen cooperation play a key role in this project by reporting all Blanding's turtle sightings.

Shorebird conservation

Shorebirds are among the most remarkable creatures on earth. Each year, most undertake phenomenal migrations from their wintering grounds as far south as southern South American, en route to their breeding grounds as far north as the Arctic Ocean. On these extraordinary journeys, shorebirds face increasing threats because they depend upon shorelines and wetlands, both coastal and along interior waterways. Lack of habitat is compounded by increased threats from water pollution, high rates of predation, and other factors which make their journey more perilous every year.

There are 74 shorebirds species in the Western Hemisphere. More than a third are in decline. At least five are highly imperiled and 22 are conservation priorities. Closer to home, nesting and migratory shorebirds historically have been important components of Minnesota's landscape despite serious habitat loss and degradation of wetlands and grasslands. Shorebirds are one of the Nongame Wildlife Program's priorities for southwest Minnesota.

Managing for shorebirds in the Prairie Parkland Province is challenging because of the dynamic nature of wetland conditions over time and across the landscape. Conservation of shorebird habitats benefits many other species, including waterfowl, migratory birds, amphibians and reptiles, commercial and recreationaly valuable fish, and endangered and threatened species. Shorebirds can be valuable indicators of environmental health. Shorebird viewing attracts many wildlife watching tourists which are an economic boon for nearby communities. Shorebirds serve as a valuable vehicle for cooperative conservation.

Statewide

Lights Out Twin Cities

Save birds and energy by turning off unnecessary lights during spring and fall migration.

Project WILD

Project WILD is an **interdisciplinary conservation and environmental education program** emphasizing wildlife.

Minnesota Frog & Toad Calling Survey

An ongoing state-wide study of Minnesota's frogs and toads.

Minnesota's Important Bird Areas

Important Bird Areas are **voluntary and non-regulatory**, and part of an **international conservation effort**.

Trumpeter Swan Restoration Project

2004 project results.

Get the Lead Out Project

Lead poisoning prevention

Minnesota Loon Monitoring Program

 Ref 23-544-

1.

Glyptemys insculpta **(Le Conte, 1830)** **Wood Turtle**

MN Status:
threatened
Federal Status:
none
CITES:
yes
USFS:
yes
Group:
reptile
Class:
Chelonia
Order:
Cryptodeira
Family:
Emydidae
Habitats:
Fire Dependent Forest, Mesic Hardwood Forest, Upland Prairie, River Shore, Wet Forest, Small Rivers and Streams, Medium Rivers and Streams, Savanna

(Mouse over a habitat for definition)

Click to enlarge

DNR
Map Interpretation

Map Interpretation

Synonyms

Glyptemys insculpta, Clemmys insculpta

Basis for Listing

The wood turtle is on the western edge of its range in Minnesota. It occurs north into Ontario, east to Nova Scotia, and south from northern Iowa to northern Virginia. Because of its dependence on forested riverine systems and well-drained soils, the wood turtle was probably never uniformly distributed in the Upper Great Lakes Region, but was locally abundant in areas with optimal habitat. Throughout its range, many populations have become impacted or extirpated by human activities. In Minnesota, factors contributing to its decline include the loss or fragmentation of riverine forests related to agriculture, timber harvest, road construction, and development; siltation of streams caused by excessive run-off; and flooding of nesting areas. Prime wood turtle habitat is also attractive to recreationists, leading to increased collection and road kills. In addition, human activity attracts predators into areas because of trash left behind. An increase in predators can in turn impact wood turtle populations, with predators digging up nests or eating young turtles. All of these problems are compounded by the wood turtle's low reproductive potential, resulting in few juveniles recruited into the population. The wood turtle was designated a threatened species in Minnesota in 1984.

Description

The carapace (upper shell) of an adult wood turtle averages 14-20 cm (5.5-8 in.) in length (Oldfield and Moriarty 1994) and is comprised of individual plate-like scales or scutes that have concentric grooves that resemble growth-rings on a tree. Yellowish-colored skin on the limbs and underside of the neck is typical of Minnesota wood turtles, but the color can range from yellowish-orange to red in turtles further east. Adult male wood turtles can be distinguished from females by their larger, wider head; longer, thicker tail; and concave shape of their plastron (lower shell).

Habitat

The wood turtle is largely aquatic, preferring small- to medium-sized, fast-moving rivers and streams with adjacent deciduous and coniferous forests. The substrates of wood turtle streams typically consist of sand or gravel. Wood turtles will occupy adjacent alder thickets, forest, and grassland habitat for basking and foraging, typically staying within 1/4 mile of the river or stream. In southeast Minnesota, wood turtles are often found foraging in agricultural fields along rivers. Sandy, sparsely vegetated areas that are not prone to flooding and have ample exposure to direct sunlight provide important nesting sites.

Biology / Life History

Wood turtles overwinter in rivers or streams where turtles may gather in bank undercuts or near log-jams. They become active by late April, basking on logs or riverbanks on sunny days. Breeding is most frequent in the spring and fall. In late May or June, gravid females dig nests in exposed sandbars, cut-banks, or other open, well-drained areas and lay 4-18 eggs (Ernst et al. 1994). Hatchlings generally emerge in late August or September. Wood turtle nests are destroyed by a variety of predators including raccoons (*Procyon lotor*), skunks, and foxes. Hatchling turtles traveling from their nest to water often fall prey to birds and other predators. Fish and snapping turtles (*Chelydra serpentina*) eat many hatchlings that manage to reach water (Harding and Bloomer 1979). Females lay only 1 clutch of eggs per year, and may not nest every year (Ross et al. 1991). The wood turtle is very long-lived, maturing between the ages of 14 and 18 years (Farrell and Graham 1991; Brooks et al. 1992). During the summer, the wood turtle will forage on land, typically staying within 150 m (492 ft.) of a river and occupying a home range of less than 3 ha (7.4 ac.) (Buech 1994; Ernst et al. 1994). The use of upland habitat varies widely among individual turtles (Ernst et al. 1994). The wooded floodplains and uplands adjacent to wood turtle streams supply a variety of foods, including berries, succulent leaves, mushrooms, insects, and earthworms.

Conservation / Management

Ref 23 - 545-

Habitat degradation and destruction, illegal collecting for the pet trade, and increased mortality from road kills and predation have impacted wood turtle populations throughout their range. This late maturing species has low recruitment potential and is highly vulnerable to the loss of any individuals from the population. Conservation efforts should include identification of viable wood turtle populations and the protection of upland foraging habitat and nesting sites. Activities affecting water quality and water level management must also be addressed.

Preservation of high-quality wood turtle habitat is dependent upon reasonable floodplain conservation techniques and zoning restrictions, including maintaining water quality; controlling sedimentation; restricting pesticide use near waterways; enforcing minimum set-back requirements and stream-side buffer zones; and use of best management practices for timber harvest, livestock grazing, and agriculture. Damming and channelization change the substrate and flow characteristics of streams, making them unsuitable for wood turtles. Certain fisheries management activities, such as streambank stabilization and the digging of sand traps in trout streams, can also negatively alter wood turtle habitat (Harding 1991). Woody debris in rivers provides turtles with cover and basking sites and should be retained, when possible. Recreationists can impact wood turtle populations through increased collecting and by attracting predators to food and trash discarded at picnic areas. Trash left on sandbars and islands where turtles nest can attract skunks and raccoons that may also dig up and destroy turtle nests. Limiting recreational use of streams in prime wood turtle habitat may be necessary. Lastly, wood turtles are susceptible to being killed by farm machinery while foraging in agricultural fields.

Conservation Efforts in Minnesota

Several conservation efforts have been undertaken to determine the distribution and abundance of wood turtles in Minnesota. Surveys have been conducted by the Minnesota Biological Survey and Nongame Wildlife Program, and by the U.S. Forest Service to determine the extent of wood turtle distribution in Minnesota and to locate nesting sites. The U.S. Forest Service has conducted research on movements, habitat use of adult turtles, and nesting success. The Nongame Wildlife Program has conducted research on movements and habitat use of adult and juvenile turtles. Wood turtle management recommendations have been developed by the DNR for natural resource managers working in areas with known wood turtle populations.

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Ref 24-546-

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July–August 2019

Turtles of the Forest

Researchers look for ways to keep wood turtles in Minnesota's landscapes.

by Gaea Crozier

(https://files.dnr.state.mn.us/mcvmagazine/issues/2019/jul-aug/img//woodturtles/woodturtles01.jpg)

This adult wood turtle was captured by researchers surveying in northeastern Minnesota. Photo by Richard Hamilton Smith.

(https://files.dnr.state.mn.us/mcvmagazine/issues/2019/jul-aug/img//woodturtles/woodturtles02.jpg)

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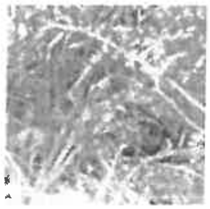
(https://files.dnr.state.mn.us/mcvmagazine/issues/2019/jul-aug/img//woodturtles/woodturtles08.jpg)
The author and Maria record information about three turtles caught on the nesting site surrounded by the electric fence. Photo by Richard Hamilton Smith.


(https://files.dnr.state.mn.us/mcvmagazine/issues/2019/jul-aug/img//woodturtles/woodturtles09.jpg)
After the scientists collected information on a wood turtle, it is released in the same spot where it was found. Photo by Richard Hamilton Smith.

Along a rushing river in Minnesota's north woods, Maria Berkeland and I are slogging through stagnant oxbows, combing the river banks, and fighting our way through thick brush as we search for a rare reptile, the wood turtle. It is a sunny day in early June, and turtles should be out basking in the warm sun. But wood turtles are well camouflaged against the dark, mucky soil, and they like to tuck into thickets of dead grass and under downed trees, so we must walk slowly, constantly scanning the ground.

The wood turtle (*Glyptemys insculpta*) is a medium-sized turtle, likely unfamiliar to most Minnesotans. Its shell is brown with yellow markings and has an intricate pattern of circular grooves that form what look like irregular pyramids. The underside of the shell is a golden yellow with large black blotches. The colors are especially vivid and beautiful when

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the shell is wet. The pattern of underside blotches is unique on each turtle, allowing individual turtles to be identified from just a photograph. Wood turtles look almost as if they are smiling at you.

Wood turtles occupy a range that includes the Upper Midwest, the northeastern United States, and parts of eastern Canada. They are found only in a small number of places in southeastern and northeastern Minnesota. They prefer fast-moving rivers and streams with a sand or gravel bottom and bordered by deciduous and coniferous forests. In spring, wood turtles spend much of their time in or close to the river, nesting in openings such as sand points, sandbars, and cut banks along the river's edge. In the summer and early fall they spend most of their time on land searching for berries, leaves, mushrooms, insects, and earthworms to eat.

On this early summer day we are sticking close to the river, hoping to find wood turtles and learn more about them so we can help their kind.

A Vulnerable Species.

The wood turtle is a threatened species in Minnesota. It is the most terrestrial of the state's riverine turtle species, and it faces hazards in its travels between hibernation sites in the river and nesting and foraging sites on land. Among the many threats facing wood turtles

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are road mortality, nest flooding, predation, habitat fragmentation and destruction, invasive species, and poaching. The cumulative result of these threats is a species that is declining across most of its range and is being considered for protection under the federal Endangered Species Act.

The Minnesota DNR's Nongame Wildlife Program is studying wood turtles to figure out how we can help this vulnerable species. The project is funded by citizen donations to the Nongame Wildlife Program and a grant from the U.S. Fish and Wildlife Service. It is a collaborative effort with the University of Minnesota Duluth's Natural Resources Research Institute, West Virginia University, the U.S. Forest Service, and the Fond du Lac Band of Lake Superior Chippewa. Maya Hamady, now retired from the Nongame Wildlife Program, initiated the project with partners from Wisconsin, Michigan, and Iowa so the four states could combine efforts and collectively identify ways to help wood turtles in the region.

Along the river bank, Maria spies a wood turtle and grabs it before it can slide back into the safety of the river. Maria, a graduate student at the University of Minnesota, is among the

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researchers who have spent the past four years searching for wood turtles along northeastern Minnesota rivers. The turtle flails its chunky legs trying to escape from Maria's grasp. Having no luck, it tucks tightly into its shell.

It turns out the creature has been through this before. Maria counts the notches that researchers previously engraved into the edge of its shell. Turtle number 3318. This turtle was last captured in 2012 along this stretch of river. Maria measures, weighs, and photographs the turtle, then turns it over to determine its age.

The bottom of the shell has growth lines that resemble growth rings on a tree. And indeed, they can be used the same way. Maria counts each growth line to estimate how old the turtle is. When a turtle reaches 20 to 25 years of age, the lines begin growing close together, and they wear away after years of sliding over sand and rocks. The growth lines are becoming too difficult to count on this turtle, but it was 20 when it was last captured in 2012, making it 26 years old now. The oldest wood turtle documented in Minnesota was at least 55 years old when it was captured in 2014.

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Maria releases turtle 3318, and it quickly slips into the river. The University of Minnesota will use the information from this turtle to assess how the population is doing. Ron Moen, head of the Natural Resources Research Institute lab studying wood turtles, says, "With over 1,000 turtles marked since 1990, we can reconstruct the population over the past 30 years. The model shows that adult survival needs to be very high to maintain a stable population."

Few wood turtles make it to adulthood. But those that do typically have long life spans and go on to replenish the population, albeit slowly, for many decades. Even a small increase in adult mortality can cause the population to slowly decline over time. 7

Turtle Survival Techniques.

It can be tough out there for wood turtles. When they cross roads or trails, the slow reptiles are no match for fast-moving vehicles that can kill or injure them. Predators such as raccoons and foxes are an ongoing threat. Flooding can destroy

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their nests and reduce their reproductive success for a season.

Turtle road mortality is related to habitat destruction and loss of habitat connectivity, which alone are major threats to wood turtles. Increasingly, development, agriculture, and roads are fragmenting the areas these turtles call home. This puts turtles at risk. They often cross roads to get to nesting and foraging habitats—a difficult task for slow-moving turtles, especially when your strategy is to tuck into your shell and stay in place when frightened.

Wood turtles nest in sandy or gravelly areas, and they are attracted to sand mines, gravel pits, agricultural fields, and roads when these places are conveniently located near the river or if natural nesting sites are lacking. But this can be a risky gamble, resulting in high nest failure and female turtles killed while crossing roads. Adult females are particularly susceptible to being

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killed by vehicles as they travel to seek out a nesting site, and loss of breeding females can be detrimental to population sustainability.

Accordingly, the Nongame Wildlife Program, with additional funding from the Minnesota Herpetological Society, is experimenting with ways to help wood turtles: putting up fencing to keep them off roads, creating flood-safe nesting habitat, and installing barriers to protect nests from predators. Fencing was installed in locations where turtles were at risk of being killed. Nesting habitat was created nearby as an alternative to the road. At each created nesting site, vegetation was removed and the soil loosened to create open areas for nesting. These created nesting sites are strategically located in areas with good foraging habitat, near the river,

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Bald eagles in summer

Where to see Minnesota's bald eagles in the summer

Minnesota and Wisconsin are fortunate to be home to the largest population of nesting bald eagles in the United States outside of Alaska.

In 1989, there were 390 occupied breeding areas in Minnesota, today there are over 700. Nests are constructed in large white or red pine trees, aspen or cottonwood, near lakes and rivers in remote areas. In recent years however eagles are choosing sites near lakes with moderate recreational use, near dwellings and even in metropolitan areas. There are an estimated 30 active eagle nests in the twin cities metropolitan area

Eagles will often return to the same nest year after year if it is successful. The nest is commonly 6-8 feet across and added onto each year. Eagles lay 1-3 eggs beginning as early as January. Parents take turns incubating the eggs which hatch in about 35 days. The young eagles begin to fly at three months of age (late May through early July). Four weeks or so after they have learned to fly, the young eagles leave the nest for good.

Human disturbance near the nest site may cause eagles to abandon their nests or leave the young vulnerable to severe weather and predators. Therefore, it is necessary to protect nesting areas during the breeding and nesting season. Minnesota Department of Natural Resources' Nongame Wildlife Program personnel and U.S. Forest Service biologists work with other state and private organizations to develop site

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NATIONAL BALD EAGLE MANAGEMENT GUIDELINES

U.S. Fish and Wildlife Service

May 2007

The Service intends to pursue the development of regulations that would authorize, under limited circumstances, the use of permits if "take" of an eagle is anticipated but unavoidable. Additionally, if the bald eagle is delisted, the Service intends to provide a regulatory mechanism to honor existing (take) authorizations under the Endangered Species Act (ESA).

During the interim period until the Service completes a rulemaking for permits under the Eagle Act, the Service does not intend to refer for prosecution the incidental "*take*" of any bald eagle under the MBTA or Eagle Act, if such take is in full compliance with the terms and conditions of an incidental take statement issued to the action agency or applicant under the authority of section 7(b)(4) of the ESA or a permit issued under the authority of section 10(a)(1)(B) of the ESA.

The Guidelines are applicable throughout the United States, including Alaska. The primary purpose of these Guidelines is to provide information that will minimize or prevent violations only of *Federal* laws governing bald eagles. In addition to Federal laws, many states and some smaller jurisdictions and tribes have additional laws and regulations protecting bald eagles. In some cases those laws and regulations may be more protective (restrictive) than these Federal guidelines. If you are planning activities that may affect bald eagles, we therefore recommend that you contact both your nearest U.S. Fish and Wildlife Service Field Office (see the contact information on p.16) and your state wildlife agency for assistance.

LEGAL PROTECTIONS FOR THE BALD EAGLE

The Bald and Golden Eagle Protection Act

The Eagle Act (16 U.S.C. 668-668c), enacted in 1940, and amended several times since then, prohibits anyone, without a permit issued by the Secretary of the Interior, from "taking" bald eagles, including their parts, nests, or eggs. The Act provides criminal and civil penalties for persons who "take, possess, sell, purchase, barter, offer to sell, purchase or barter, transport, export or import, at any time or any manner, any bald eagle ... [or any golden eagle], alive or dead, or any part, nest, or egg thereof." The Act defines "take" as "pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest or disturb." "Disturb" means:

> "Disturb means to agitate or bother a bald or golden eagle to a degree that causes, or is likely to cause, based on the best scientific information available, 1) injury to an eagle, 2) a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior, or 3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior."

In addition to immediate impacts, this definition also covers impacts that result from human-induced alterations initiated around a previously used nest site during a time when eagles are not present, if, upon the eagle=s return, such alterations agitate or bother an eagle to a degree that injures an eagle or substantially interferes with normal breeding, feeding, or sheltering habits and causes, or is likely to cause, a loss of productivity or nest abandonment.

A violation of the Act can result in a criminal fine of $100,000 ($200,000 for organizations), imprisonment for one year, or both, for a first offense. Penalties increase substantially for additional offenses, and a second violation of this Act is a felony.

The Migratory Bird Treaty Act
The MBTA (16 U.S.C. 703-712), prohibits the taking of any migratory bird or any part, nest, or egg, except as permitted by regulation. The MBTA was enacted in 1918; a 1972 agreement supplementing one of the bilateral treaties underlying the MBTA had the effect of expanding the scope of the Act to cover bald eagles and other raptors. Implementing regulations define "take" under the MBTA as "pursue, hunt, shoot, wound, kill, trap, capture, possess, or collect."

Copies of the Eagle Act and the MBTA are available at: http://permits.fws.gov/ltr/ltr.shtml.

State laws and regulations
Most states have their own regulations and/or guidelines for bald eagle management. Some states may continue to list the bald eagle as endangered, threatened, or of special concern. If you plan activities that may affect bald eagles, we urge you to familiarize yourself with the regulations and/or guidelines that apply to bald eagles in your state. Your adherence to the Guidelines herein does not ensure that you are in compliance with state laws and regulations because state regulations can be more specific and/or restrictive than these Guidelines.

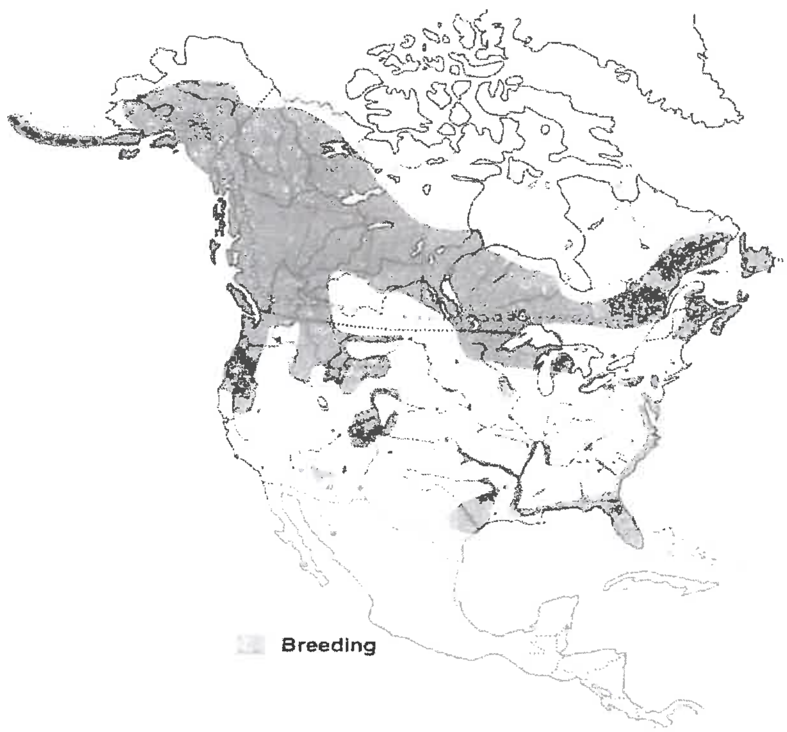
NATURAL HISTORY OF THE BALD EAGLE

Bald eagles are a North American species that historically occurred throughout the contiguous United States and Alaska. After severely declining in the lower 48 States between the 1870s and the 1970s, bald eagles have rebounded and re-established breeding territories in each of the lower 48 states. The largest North American breeding populations are in Alaska and Canada, but there are also significant bald eagle populations in Florida, the Pacific Northwest, the Greater Yellowstone area, the Great Lakes states, and the Chesapeake Bay region. Bald eagle distribution varies seasonally. Bald eagles that nest in southern latitudes frequently move northward in late spring and early summer, often summering as far north as Canada. Most eagles that breed at northern latitudes migrate southward during winter, or to coastal areas where waters remain unfrozen. Migrants frequently concentrate in large numbers at sites where food is abundant and they often roost together communally. In some cases, concentration areas are used year-round: in summer by southern eagles and in winter by northern eagles.

Juvenile bald eagles have mottled brown and white plumage, gradually acquiring their dark brown body and distinctive white head and tail as they mature. Bald eagles generally attain adult plumage by 5 years of age. Most are capable of breeding at 4 or 5 years of age, but in healthy populations they may not start breeding until much older. Bald eagles may live 15 to 25 years in the wild. Adults weigh 8 to 14 pounds (occasionally reaching 16 pounds in Alaska) and have wingspans of 5 to 8 feet. Those in the northern range are larger than those in the south, and females are larger than males.

Where do bald eagles nest?
Breeding bald eagles occupy "territories," areas they will typically defend against intrusion by other eagles. In addition to the active nest, a territory may include one or more alternate nests (nests built or maintained by the eagles but not used for nesting in a given year). The Eagle Act prohibits removal or destruction of both active and alternate bald eagle nests. Bald eagles exhibit high nest site fidelity and nesting territories are often used year after year. Some territories are known to have been used continually for over half a century.

Bald eagles generally nest near coastlines, rivers, large lakes or streams that support an adequate food supply. They often nest in mature or old-growth trees; snags (dead trees); cliffs; rock promontories; rarely on the ground; and with increasing frequency on human-made structures such as power poles and communication towers. In forested areas, bald eagles often select the tallest trees with limbs strong enough to support a nest that can weigh more than 1,000 pounds. Nest sites typically include at least one perch with a clear view of the water where the eagles usually forage. Shoreline trees or snags located in reservoirs provide the visibility and accessibility needed to locate aquatic prey. Eagle nests are constructed with large sticks, and may be lined with moss, grass, plant stalks, lichens, seaweed, or sod. Nests are usually about 4-6 feet in diameter and 3 feet deep, although larger nests exist.



Copyright *Birds of North America*, 2000

The range of breeding bald eagles in 2000 (shaded areas). This map shows only the larger concentrations of nests; eagles have continued to expand into additional nesting territories in many states. The dotted line represents the bald eagle's wintering range.

When do bald eagles nest?

Nesting activity begins several months before egg-laying. Egg-laying dates vary throughout the U.S., ranging from October in Florida, to late April or even early May in the northern United States. Incubation typically lasts 33-35 days, but can be as long as 40 days. Eaglets make their first unsteady flights about 10 to 12 weeks after hatching, and fledge (leave their nests) within a few days after that first flight. However, young birds usually remain in the vicinity of the nest for several weeks after fledging because they are almost completely dependent on their parents for food until they disperse from the nesting territory approximately 6 weeks later.

The bald eagle breeding season tends to be longer in the southern U.S., and re-nesting following an unsuccessful first nesting attempt is more common there as well. The following table shows the timing of bald eagle breeding seasons in different regions of the country. The table represents the range of time within which the majority of nesting activities occur in each region and does not apply to any specific nesting pair. Because the timing of nesting activities may vary within a given region, you should contact the nearest U.S. Fish and Wildlife Service Field Office (see page 16) and/or your state wildlife conservation agency for more specific information on nesting chronology in your area.

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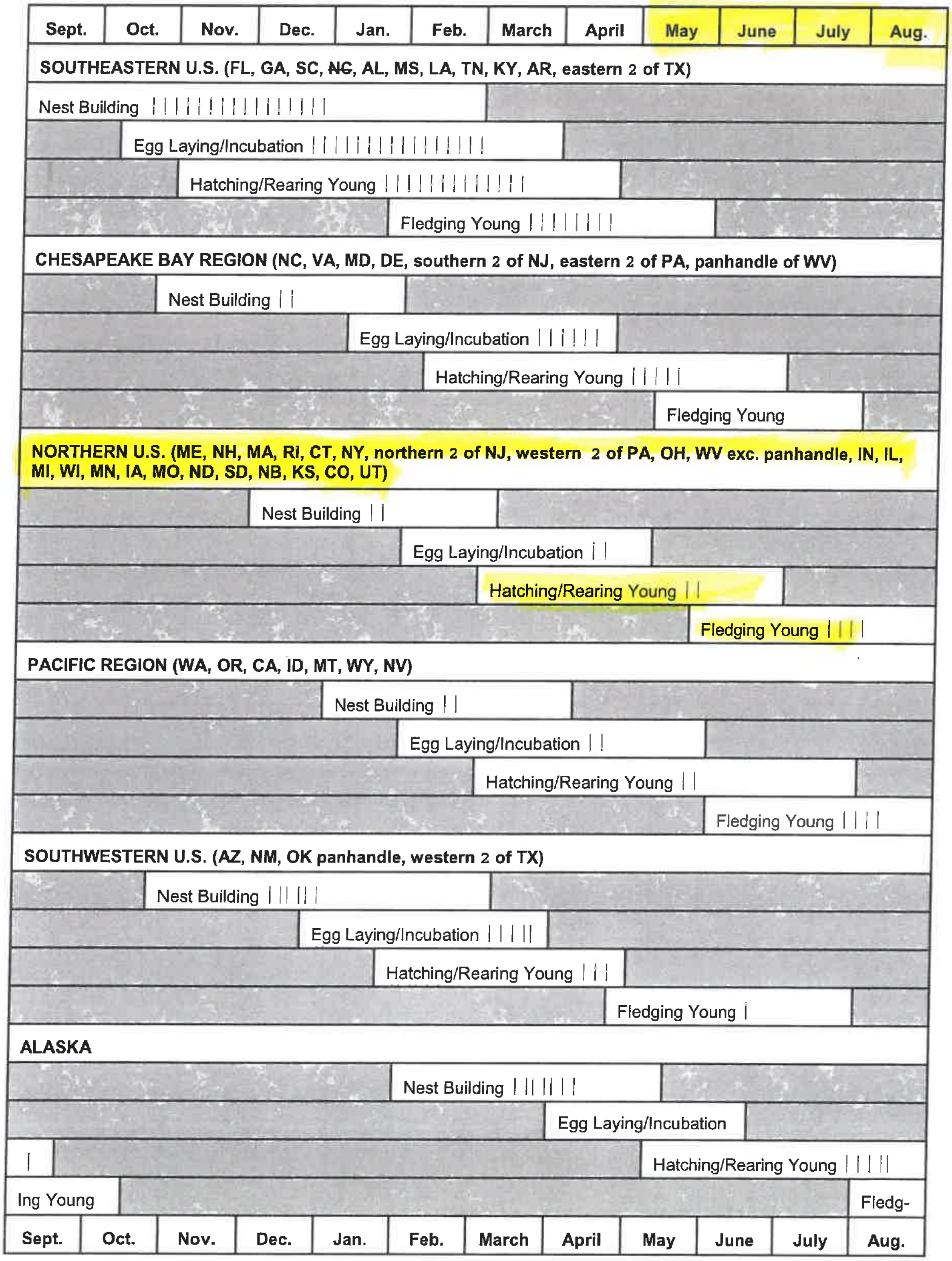
Chronology of typical reproductive activities of bald eagles in the United States.



How many chicks do bald eagles raise?
The number of eagle eggs laid will vary from 1-3, with 1-2 eggs being the most common. Only one eagle egg is laid per day, although not always on successive days. Hatching of young occurs on different days with the result that chicks in the same nest are sometimes of unequal size. The overall national fledging rate is approximately one chick per nest, annually, which results in a healthy expanding population.

What do bald eagles eat?
Bald eagles are opportunistic feeders. Fish comprise much of their diet, but they also eat waterfowl, shorebirds/colonial waterbirds, small mammals, turtles, and carrion. Because they are visual hunters, eagles typically locate their prey from a conspicuous perch, or soaring flight, then swoop down and strike. Wintering bald eagles often congregate in large numbers along streams to feed on spawning salmon or other fish species, and often gather in large numbers in areas below reservoirs, especially hydropower dams, where fish are abundant. Wintering eagles also take birds from rafts of ducks at reservoirs and rivers, and congregate on melting ice shelves to scavenge dead fish from the current or the soft melting ice. Bald eagles will also feed on carcasses along roads, in landfills, and at feedlots.

During the breeding season, adults carry prey to the nest to feed the young. Adults feed their chicks by tearing off pieces of food and holding them to the beaks of the eaglets. After fledging, immature eagles are slow to develop hunting skills, and must learn to locate reliable food sources and master feeding techniques. Young eagles will congregate together, often feeding upon easily acquired food such as carrion and fish found in abundance at the mouths of streams and shallow bays and at landfills.

The impact of human activity on nesting bald eagles
During the breeding season, bald eagles are sensitive to a variety of human activities. However, not all bald eagle pairs react to human activities in the same way. Some pairs nest successfully just dozens of yards from human activity, while others abandon nest sites in response to activities much farther away. This variability may be related to a number of factors, including visibility, duration, noise levels, extent of the area affected by the activity, prior experiences with humans, and tolerance of the individual nesting pair. The relative sensitivity of bald eagles during various stages of the breeding season is outlined in the following table.

Nesting Bald Eagle Sensitivity to Human Activities

Phase	Activity	Sensitivity to Human Activity	Comments
I	Courtship and Nest Building	Most sensitive period; likely to respond negatively	Most critical time period. Disturbance is manifested in nest abandonment. Bald eagles in newly established territories are more prone to abandon nest sites.
II	Egg laying	Very sensitive period	Human activity of even limited duration may cause nest desertion and abandonment of territory for the breeding season.
III	Incubation and early nestling period (up to 4 weeks)	Very sensitive period	Adults are less likely to abandon the nest near and after hatching. However, flushed adults leave eggs and young unattended; eggs are susceptible to cooling, loss of moisture, overheating, and predation; young are vulnerable to elements.
IV	Nestling period, 4 to 8 weeks	Moderately sensitive period	Likelihood of nest abandonment and vulnerability of the nestlings to elements somewhat decreases. However, nestlings may miss feedings, affecting their survival.
V	Nestlings 8 weeks through fledging	Very sensitive period	Gaining flight capability, nestlings 8 weeks and older may flush from the nest prematurely due to disruption and die.

If agitated by human activities, eagles may inadequately construct or repair their nest, may expend energy defending the nest rather than tending to their young, or may abandon the nest altogether. Activities that cause prolonged absences of adults from their nests can jeopardize eggs or young. Depending on weather conditions, eggs may overheat or cool too much and fail to hatch. Unattended eggs and nestlings are subject to predation. Young nestlings are particularly vulnerable because they rely on their parents to provide warmth or shade, without which they may die as a result of hypothermia or heat stress. If food delivery schedules are interrupted, the young may not develop healthy plumage, which can affect their survival. In addition, adults startled while incubating or brooding young may damage eggs or injure their young as they abruptly leave the nest. Older nestlings no longer require constant attention from the adults, but they may be startled by loud or intrusive human activities and prematurely jump from the nest before they are able to fly or care for themselves. Once fledged, juveniles range up to ¼ mile from the nest site, often to a site with minimal human activity. During this period, until about six weeks after departure from the nest, the juveniles still depend on the adults to feed them.

The impact of human activity on foraging and roosting bald eagles

Disruption, destruction, or obstruction of roosting and foraging areas can also negatively affect bald eagles. Disruptive activities in or near eagle foraging areas can interfere with feeding, reducing chances of survival. Interference with feeding can also result in reduced productivity (number of young successfully fledged). Migrating and wintering bald eagles often congregate at specific sites for purposes of feeding and sheltering. Bald eagles rely on established roost sites because of their proximity to sufficient food sources. Roost sites are usually in mature trees where the eagles are somewhat sheltered from the wind and weather. Human activities near or within communal roost sites may prevent eagles from feeding or taking shelter, especially if there are not other undisturbed and productive feeding and roosting sites available. Activities that permanently alter communal roost sites and important foraging areas can altogether eliminate the elements that are essential for feeding and sheltering eagles.

Where a human activity agitates or bothers roosting or foraging bald eagles to the degree that causes injury or substantially interferes with breeding, feeding, or sheltering behavior and causes, or is likely to cause, a loss of productivity or nest abandonment, the conduct of the activity constitutes a violation of the Eagle Act's prohibition against disturbing eagles. The circumstances that might result in such an outcome are difficult to predict without detailed site-specific information. If your activities may disturb roosting or foraging bald eagles, you should contact your local Fish and Wildlife Service Field Office (see page 16) for advice and recommendations for how to avoid such disturbance.

RECOMMENDATIONS FOR AVOIDING DISTURBANCE AT NEST SITES

In developing these Guidelines, we relied on existing state and regional bald eagle guidelines, scientific literature on bald eagle disturbance, and recommendations of state and Federal biologists who monitor the impacts of human activity on eagles. Despite these resources, uncertainties remain regarding the effects of many activities on eagles and how eagles in different situations may or may not respond to certain human activities. The Service recognizes this uncertainty and views the collection of better biological data on the response of eagles to disturbance as a high priority. To the extent that resources allow, the Service will continue to collect data on responses of bald eagles to human activities conducted according to the recommendations within these Guidelines to ensure that adequate protection from disturbance is being afforded, and to identify circumstances where the Guidelines might be modified. These data will be used to make future adjustments to the Guidelines.

To avoid disturbing nesting bald eagles, we recommend (1) keeping a distance between the activity and the nest (distance buffers), (2) maintaining preferably forested (or natural) areas between the activity and around nest trees (landscape buffers), and (3) avoiding certain activities during the breeding season. The buffer areas serve to minimize visual and auditory impacts associated with human activities near nest sites. Ideally, buffers would be large enough to protect existing nest trees and provide for alternative or replacement nest trees.

The size and shape of effective buffers vary depending on the topography and other ecological characteristics surrounding the nest site. In open areas where there are little or no forested or topographical buffers, such as in many western states, distance alone must serve as the buffer. Consequently, in open areas, the distance between the activity and the nest may need to be larger than the distances recommended under Categories A and B of these guidelines (pg. 12) if no landscape buffers are present. The height of the nest above the ground may also ameliorate effects of human activities; eagles at higher nests may be less prone to disturbance.

In addition to the physical features of the landscape and nest site, the appropriate size for the distance buffer may vary according to the historical tolerances of eagles to human activities in particular localities, and may also depend on the location of the nest in relation to feeding and roosting areas used by the eagles. Increased competition for nest sites may lead bald eagles to nest closer to human activity (and other eagles).

Seasonal restrictions can prevent the potential impacts of many shorter-term, obtrusive activities that do not entail landscape alterations (e.g. fireworks, outdoor concerts). In proximity to the nest, these kinds of activities should be conducted only outside the breeding season. For activities that entail both short-term, obtrusive characteristics and more permanent impacts (e.g., building construction), we recommend a combination of both approaches: retaining a landscape buffer *and* observing seasonal restrictions.

For assistance in determining the appropriate size and configuration of buffers or the timing of activities in the vicinity of a bald eagle nest, we encourage you to contact the nearest U.S. Fish and Wildlife Service Field Office (see page 16).

Existing Uses
Eagles are unlikely to be disturbed by routine use of roads, homes, and other facilities where such use pre-dates the eagles' successful nesting activity in a given area. Therefore, in most cases *ongoing* existing uses may proceed with the same intensity with little risk of disturbing bald eagles. However, some *intermittent, occasional, or irregular* uses that pre-date eagle nesting in an area may disturb bald eagles. For example: a pair of eagles may begin nesting in an area and subsequently be disturbed by activities associated with an annual outdoor flea market, even though the flea market has been held annually at the same location. In such situations, human activity should be adjusted or relocated to minimize potential impacts on the nesting pair.

ACTIVITY-SPECIFIC GUIDELINES

The following section provides the Service=s management recommendations for avoiding bald eagle disturbance as a result of new or intermittent activities proposed in the vicinity of bald eagle nests. Activities are separated into 8 categories (A – H) based on the nature and magnitude of impacts to bald eagles that usually result from the type of activity. Activities with similar or comparable impacts are grouped together.

In most cases, impacts will vary based on the visibility of the activity from the eagle nest and the degree to which similar activities are already occurring in proximity to the nest site. Visibility is a factor because, in general, eagles are more prone to disturbance when an activity occurs in full view. For this reason, we recommend that people locate activities farther from the nest structure in areas with open vistas, in contrast to areas where the view is shielded by rolling topography, trees, or other screening factors. The recommendations also take into account the existence of similar activities in the area because the continued presence of nesting bald eagles in the vicinity of the existing activities indicates that the eagles in that area can tolerate a greater degree of human activity than we can generally expect from eagles in areas that experience fewer human impacts. To illustrate how these factors affect the likelihood of disturbing eagles, we have incorporated the recommendations for some activities into a table (categories A and B).

First, determine which category your activity falls into (between categories A – H). If the activity you plan to undertake is not specifically addressed in these guidelines, follow the recommendations for the most similar activity represented.

If your activity is under A or B, our recommendations are in table form. The vertical axis shows the degree of visibility of the activity from the nest. The horizontal axis (header row) represents the degree to which similar activities are ongoing in the vicinity of the nest. Locate the row that best describes how visible your activity will be from the eagle nest. Then, choose the column that best describes the degree to which similar activities are ongoing in the vicinity of the eagle nest. The box where the column and row come together contains our management recommendations for how far you should locate your activity from the nest to avoid disturbing the eagles. The numerical distances shown in the tables are the closest the activity should be conducted relative to the nest. In some cases we have included additional recommendations (other than recommended *distance* from the nest) you should follow to help ensure that your activity will not disturb the eagles.

Alternate nests

For activities that entail permanent landscape alterations that may result in bald eagle disturbance, these recommendations apply to both active and alternate bald eagle nests. Disturbance becomes an issue with regard to alternate nests if eagles return for breeding purposes and react to land use changes that occurred while the nest was inactive. The likelihood that an alternate nest will again become active decreases the longer it goes unused. If you plan activities in the vicinity of an alternate bald eagle nest and have information to show that the nest has not been active during the preceding 5 breeding seasons, the recommendations provided in these guidelines for avoiding disturbance around the nest site may no longer be warranted. The nest itself remains protected by other provisions of the Eagle Act, however, and may not be destroyed.

If special circumstances exist that make it unlikely an inactive nest will be reused before 5 years of disuse have passed, and you believe that the probability of reuse is low enough to warrant disregarding the recommendations for avoiding disturbance, you should be prepared to provide all the reasons for your conclusion, including information regarding past use of the nest site. Without sufficient documentation, you should continue to follow these guidelines when conducting activities around the nest site. If we are able to determine that it is unlikely the nest will be reused, we may advise you that the recommendations provided in these guidelines for avoiding disturbance are no longer necessary around that nest site.

This guidance is intended to minimize disturbance, as defined by Federal regulation. In addition to Federal laws, most states and some tribes and smaller jurisdictions have additional laws and regulations protecting bald eagles. In some cases those laws and regulations may be more protective (restrictive) than these Federal guidelines.

Temporary Impacts

For activities that have temporary impacts, such as the use of loud machinery, fireworks displays, or summer boating activities, we recommend seasonal restrictions. These types of activities can generally be carried out outside of the breeding season without causing disturbance. The recommended restrictions for these types of activities can be lifted for alternate nests within a particular territory, including nests that were attended during the current breeding season but not used to raise young, after eggs laid in another nest within the territory have hatched (depending on the distance between the alternate nest and the active nest).

In general, activities should be kept as far away from nest trees as possible; loud and disruptive activities should be conducted when eagles are not nesting; and activity between the nest and the nearest foraging area should be minimized. If the activity you plan to undertake is not specifically addressed in these guidelines, follow the recommendations for the most similar activity addressed, or contact your local U.S. Fish and Wildlife Service Field Office for additional guidance.

If you believe that special circumstances apply to your situation that increase or diminish the likelihood of bald eagle disturbance, or if it is not possible to adhere to the guidelines, you should contact your local Service Field Office for further guidance.

Category A:
Building construction, 1 or 2 story, with project footprint of ½ acre or less.
Construction of roads, trails, canals, power lines, and other linear utilities.
Agriculture and aquaculture – new or expanded operations.
Alteration of shorelines or wetlands.
Installation of docks or moorings.
Water impoundment.

Category B:
Building construction, 3 or more stories.
Building construction, 1 or 2 story, with project footprint of more than ½ acre.
Installation or expansion of marinas with a capacity of 6 or more boats.
Mining and associated activities.
Oil and natural gas drilling and refining and associated activities.

	If there is no similar activity within 1 mile of the nest	***If there is similar activity closer than 1 mile from the nest***
If the activity will be visible from the nest	660 feet. Landscape buffers are recommended.	660 feet, or as close as existing tolerated activity of similar scope. Landscape buffers are recommended.
If the activity will not be visible from the nest	Category A: 330 feet. Clearing, external construction, and landscaping between 330 feet and 660 feet should be done outside breeding season. Category B: 660 feet.	330 feet, or as close as existing tolerated activity of similar scope. Clearing, external construction and landscaping within 660 feet should be done outside breeding season.

The numerical distances shown in the table are the closest the activity should be conducted relative to the nest.

Category C. Timber Operations and Forestry Practices

- Avoid clear cutting or removal of overstory trees within 330 feet of the nest at any time.

- Avoid timber harvesting operations, including road construction and chain saw and yarding operations, during the breeding season within 660 feet of the nest. The distance may be decreased to 330 feet around alternate nests within a particular territory, including nests that were attended during the current breeding season but not used to raise young, after eggs laid in another nest within the territory have hatched.

- Selective thinning and other silviculture management practices designed to conserve or enhance habitat, including prescribed burning close to the nest tree, should be undertaken outside the breeding season. Precautions such as raking leaves and woody debris from around the nest tree should be taken to prevent crown fire or fire climbing the nest tree. If it is determined that a burn during the breeding season would be beneficial, then, to ensure that no take or disturbance will occur, these activities should be conducted only when neither adult eagles nor young are present at the nest tree (i.e., at the beginning of, or end of, the breeding season, either before the particular nest is active or after the young have fledged from that nest). Appropriate Federal and state biologists should be consulted before any prescribed burning is conducted during the breeding season.

- Avoid construction of log transfer facilities and in-water log storage areas within 330 feet of the nest.

Category D. Off-road vehicle use (including snowmobiles). No buffer is necessary around nest sites outside the breeding season. During the breeding season, do not operate off-road vehicles within 330 feet of the nest. In open areas, where there is increased visibility and exposure to noise, this distance should be extended to 660 feet.

Category E. Motorized Watercraft use (including jet skis/personal watercraft). No buffer is necessary around nest sites outside the breeding season. During the breeding season, within 330 feet of the nest, (1) do not operate jet skis (personal watercraft), and (2) avoid concentrations of noisy vessels (e.g., commercial fishing boats and tour boats), except where eagles have demonstrated tolerance for such activity. Other motorized boat traffic passing within 330 feet of the nest should attempt to minimize trips and avoid stopping in the area where feasible, particularly where eagles are unaccustomed to boat traffic. Buffers for airboats should be larger than 330 feet due to the increased noise they generate, combined with their speed, maneuverability, and visibility.

Category F. Non-motorized recreation and human entry (e.g., hiking, camping, fishing, hunting, birdwatching, kayaking, canoeing). No buffer is necessary around nest sites outside the breeding season. If the activity will be visible or highly audible from the nest, maintain a 330-foot buffer during the breeding season, particularly where eagles are unaccustomed to such activity.

Category G. Helicopters and fixed-wing aircraft.
Except for authorized biologists trained in survey techniques, avoid operating aircraft within 1,000 feet of the nest during the breeding season, except where eagles have demonstrated tolerance for such activity.

Category H. Blasting and other loud, intermittent noises.
Avoid blasting and other activities that produce extremely loud noises within 1/2 mile of active nests, unless greater tolerance to the activity (or similar activity) has been demonstrated by the eagles in the nesting area. This recommendation applies to the use of fireworks classified by the Federal Department of Transportation as Class B explosives, which includes the larger fireworks that are intended for licensed public display.

RECOMMENDATIONS FOR AVOIDING DISTURBANCE AT FORAGING AREAS AND COMMUNAL ROOST SITES

1. Minimize potentially disruptive activities and development in the eagles' direct flight path between their nest and roost sites and important foraging areas.

2. Locate long-term and permanent water-dependent facilities, such as boat ramps and marinas, away from important eagle foraging areas.

3. Avoid recreational and commercial boating and fishing near critical eagle foraging areas during peak feeding times (usually early to mid-morning and late afternoon), except where eagles have demonstrated tolerance to such activity.

4. Do not use explosives within ½ mile (or within 1 mile in open areas) of communal roosts when eagles are congregating, without prior coordination with the U.S. Fish and Wildlife Service and your state wildlife agency.

5. Locate aircraft corridors no closer than 1,000 feet vertical or horizontal distance from communal roost sites.

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NatureServe
EXPLORER

Data Coverage Statuses Sources Use Guidelines and Citations

About the Data > Statuses

Statuses

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NatureServe and its member programs and collaborators use a rigorous, consistent, and transparent methodology to assess the conservation status (extinction or extirpation risk) of species of plants, animals, and fungi, as well as the conservation status (elimination or extirpation risk) of ecosystems (ecological communities and systems). Visit our website to learn more about the methodology.

NatureServe Global Conservation Status Ranks

Listed below are definitions for interpreting NatureServe's global (range-wide) conservation status ranks. Global conservation status ranks are assigned by NatureServe scientists or by a designated lead office in the NatureServe network.

A note about rounded ranks. NatureServe Explorer now allows users the option to view search results as rounded ranks. As the table below shows, one variant in the ranking system is a range rank, which communicates uncertainty associated with conservation status ranks. For example, incomplete survey data may lead to the designation of a species or ecosytem as G1G2. Rounded ranks convert conservation status ranks to a single value that is easier to interpret and summarize. Range ranks that span adjancent ranks (e.g., G1G2 or G4G5) are rounded to the more imperiled rank (e.g., G1G2 is rounded to G1). Range ranks that span three ranks (e.g., G2G4) are rounded to the rank in the middle of the range (e.g., G2G4 is rounded to G3).

Global (G) Conservation Status Ranks

GLOBAL RANK	DEFINITION
GX	**Presumed Extinct** (species) — Not located despite intensive searches and virtually no likelihood of rediscovery **Presumed Collapsed** (ecosystems, i.e., ecological communities and systems) — Collapsed throughout its range, due to loss of key dominant and characteristic taxa and/or elimination of the sites and ecological processes on which the type depends
GH	**Possibly Extinct** (species) or **Possibly Collapsed** (ecosystems) — Known from only historical occurrences but still some hope of rediscovery. Examples of evidence include (1) that a species

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GLOBAL RANK	DEFINITION
	has not been documented in approximately 20-40 years despite some searching and/or some evidence of significant habitat loss or degradation; (2) that a species or ecosystem has been

G1 Northern Long eared BAT	**Critically Imperiled** — At very high risk of extinction or collapse due to very restricted range, very few populations or occurrences, very steep declines, very severe threats, or other factors.
G2 Rusty Patch Bumble Bee	**Imperiled** — At high risk of extinction or collapse due to restricted range, few populations or occurrences, steep declines, severe threats, or other factors.
G3	**Vulnerable** — At moderate risk of extinction or collapse due to a fairly restricted range, relatively few populations or occurrences, recent and widespread declines, threats, or other factors.
G4	**Apparently Secure** — At fairly low risk of extinction or collapse due to an extensive range and/or many populations or occurrences, but with possible cause for some concern as a result of local recent declines, threats, or other factors.
G5	**Secure** — At very low risk or extinction or collapse due to a very extensive range, abundant populations or occurrences, and little to no concern from declines or threats.

Variant Global Conservation Status Ranks

RANK	DEFINITION
G#G#	**Range Rank** — A numeric range rank (e.g., G2G3, G1G3) is used to indicate uncertainty about the exact status of a taxon or ecosystem type. Ranges cannot skip more than two ranks (e.g., GU should be used rather than G1G4).
GU	**Unrankable** — Currently unrankable due to lack of information or due to substantially conflicting information about status or trends. NOTE: Whenever possible (when the range of uncertainty is three consecutive ranks or less), a range rank (e.g., G2G3) should be used to delineate the limits (range) of uncertainty.
GNR	**Unranked** — Global rank not yet assessed.
GNA	**Not Applicable** — A conservation status rank is not applicable because the species or ecosystem is not a suitable target for conservation activities. A global conservation status rank may be not applicable for several reasons, related to its relevance as a conservation target. For species, typically the species is a hybrid without conservation value, or of domestic origin. For ecosystems, the type is typically non-native (e.g, many ruderal vegetation types), agricultural (e.g. pasture, orchard) or developed (e.g. lawn, garden, golf course).

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NatureServe
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Current Search Criteria:

Searching For: , or

Refine Search:

Find records where any name or code is similar to :

...Add additional search terms

Filter

- [ ] Canada
- [ ] United States

For more criteria, refine search to ecosystems only.

1 record found.

Matching Species Records:

- Animals - Insects - Bees - Bumble Bees -	NatureServe Status () ⓘ	Distribution
Bombus affinis **Rusty-patched Bumble Bee**	**G2:** Imperiled	**Canada :** NB , ON , QC **United States:** CT , DC, GA , IA , IL , IN , KY , MA , MD , ME , MI , MN, NC , ND , NH , NJ, NY , OH , PA , RI, SC , SD, TN , VA , VT , WI , WV

Ref 28A-572-

NatureServe
EXPLORER

Current Search Criteria:

Searching For:

Refine Search:

Find records where any name or code is similar to :

...Add additional search terms

Filter

☐ Canada

☐ United States

For more criteria, refine search to ecosystems only

1 record found.

Matching Species Records:

- Animals - Vertebrates - Mammals -	NatureServe Status () ⓘ	Distribution
Myotis septentrionalis **Northern Long-eared Bat**	**G1:** Critically Imperiled	**Canada :** AB , BC , LB , MB , NB , NF , NS , NT , ON , PE , QC , SK , YT **United States :** AL , AR , CT , DC , DE, FL , GA , IA , IL , IN , KS , KY , LA , MA , MD , ME , MI , MN , MO , MS , MT , NC , ND, NE , NH , NJ , NY , OH, OK , PA , RI , SC , SD , TN , VA , VT

Ref 29-573-

Conserving the nature of America

In the Midwest

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Endangered Species Program

The mission of the U.S. Fish and Wildlife Service's Endangered Species program is conserving and restoring threatened and endangered species and their ecosystems.

U.S. Fish and Wildlife Service in the Midwest

Rusty patched bumble bee feeding on wild bergamot (*Monarda fistulosa*)
Photo Kim Mitchell; USFWS

See page 2 →

Fact Sheet
Rusty Patched Bumble Bee (*Bombus affinis*)

PDF Version

The U.S. Fish and Wildlife Service listed the rusty patched bumble bee as endangered under the Endangered Species Act. Endangered species are animals and plants that are in danger of becoming extinct. Identifying, protecting and recovering endangered species is a primary objective of the U.S. Fish and Wildlife Service's endangered species program.

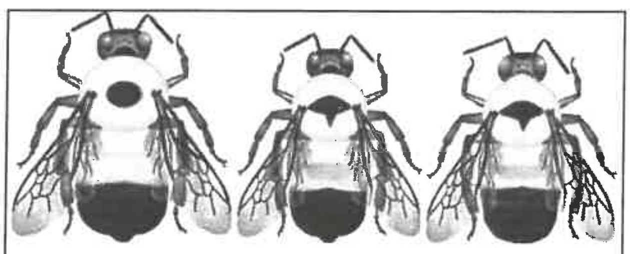
What is a rusty patched bumble bee?

Appearance:

Rusty patched bumble bees live in colonies that include a single queen and female workers. The colony produces males and new queens in late summer. Queens are the largest bees in the colony, and workers are the smallest. All rusty patched bumble bees have entirely black heads, but only workers and males have a rusty reddish patch centrally located on the back.

Habitat:

Rusty patched bumble bees once occupied grasslands and tallgrass prairies of the Upper Midwest and Northeast, but most grasslands and prairies have been lost, degraded, or fragmented by conversion to other uses. Bumble bees need areas that provide nectar and pollen from flowers, nesting sites (underground and abandoned rodent cavities or clumps of grasses), and overwintering sites for hibernating queens (undisturbed soil).



Illustrations of a rusty patched bumble bee queen (left), worker (center), and male (right).
By Elaine Evans, The Xerces Society.

Reproduction:

Rusty patched bumble bee colonies have an annual cycle. In spring, solitary queens emerge and find nest sites, collect nectar and pollen from flowers and begin laying eggs, which are fertilized by sperm stored since mating the previous fall. Workers hatch from these first eggs and colonies grow as workers collect food, defend the colony, and care for young. Queens remain within the nests and continue laying eggs. In late summer, new queens and males also hatch from eggs. Males disperse to mate with new queens from other colonies. In fall, founding queens, workers and males die. Only new queens go into diapause (a form of hibernation) over winter - and the cycle begins again in spring.

Feeding Habits:

Bumble bees gather pollen and nectar from a variety of flowering plants. The rusty patched emerges early in spring and is one of the last species to go into hibernation. It needs a constant supply and

Why conserve rusty patched bumble bees?

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The Midwest Region includes Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio and Wisconsin.
[Find a location near you »]

diversity of flowers blooming throughout the colony's long life, April through September.

Range:

Historically, the rusty patched bumble bee was broadly distributed across the eastern United States and Upper Midwest, from Maine in the U.S. and southern Quebec and Ontario in Canada, south to the northeast corner of Georgia, reaching west to the eastern edges of North and South Dakota. Its range included 28 states, the District of Columbia and 2 provinces in Canada. Since 2000, this bumble bee has been reported from only 13 states and 1 Canadian province: Illinois, Indiana, Iowa, Maine, Maryland, Massachusetts, Minnesota, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, Wisconsin – and Ontario, Canada.

As pollinators, rusty patched bumble bees contribute to our food security and the healthy functioning of our ecosystems. Bumble bees are keystone species in most ecosystems, necessary not only for native wildflower reproduction, but also for creating seeds and fruits that feed wildlife as diverse as songbirds and grizzly bears.

Bumble bees are among the most important pollinators of crops such as blueberries, cranberries, and clover and almost the only insect pollinators of tomatoes. Bumble bees are more effective pollinators than honey bees for some crops because of their ability to "buzz pollinate." The economic value of pollination services provided by native insects (mostly bees) is estimated at $3 billion per year in the United States.

Why is the rusty patched bumble bee declining?

Habitat loss and degradation:

Most of prairies and grasslands of the Upper Midwest and Northeast have been converted to monoculture farms or developed areas, such as cities and roads. Grasslands that remain tend to be small and isolated.

Intensive farming:

Increases in farm size and technology advances improved the operating efficiency of farms but have led to practices that harm bumble bees, including increased use of pesticides, loss of crop diversity which results in flowering crops being available for only a short time, loss of hedgerows and the flowers that grew there, and loss of legume pastures.

Disease:

Pathogens and parasites may pose a threat to rusty patched bumble bees, although their prevalence and effects in North American bumble bees are not well understood.

Pesticides:

The rusty patched bumble bee may be vulnerable to pesticides used across its range. Pesticides are used widely on farms and in cities and have both lethal and sublethal toxic effects. Bumble bees can absorb toxins directly through their exoskeleton and through contaminated nectar and pollen. Rusty patched bumble bees nest in the ground and may be susceptible to pesticides that persist in agricultural soils, lawns and turf.

Global climate change:

Climate changes that may harm bumble bees include increased temperature and precipitation extremes, increased drought, early snow melt and late frost events. These changes may lead to more exposure to or susceptibility to disease, fewer flowering plants, fewer places for queens to hibernate and nest, less time for foraging due to high temperatures, and asynchronous flowering plant and bumble bee spring emergence.

What is being done to conserve rusty patched bumble bees?

U.S. Fish and Wildlife Service:

Several Service programs work to assess, protect, and restore pollinators and their habitats. Also, the Service works with partners to recover endangered and threatened pollinators and pollinator-dependent plants. Concern about pollinator declines prompted formation of the North American Pollinator Protection Campaign, a collaboration of people dedicated to pollinator conservation and education. The Service has a Memorandum of Understanding with the Pollinator Partnership to work together on those goals. The Service is a natural collaborator because our mission is to work with others to conserve, fish, wildlife, and plants and their habitats.

Other Efforts:

Trusts, conservancies, restoration groups and partnerships are supporting pollinator initiatives and incorporating native plants that support bees and other pollinators into their current activities. For example, the USDA Natural Resource Conservation Service is working with landowners in Michigan, Minnesota, Montana, North Dakota, South Dakota, and Wisconsin to make bee-friendly conservation improvements to their land. Improvements include the practices of planting cover crops, wildflowers, or native grasses and improved management on grazing lands.

Research:

Researchers are studying and monitoring the impacts of GMO crops and certain pesticides on pollinators. Efforts by citizen scientists and researchers to determine the status of declining bee species are underway throughout the U.S.

What can I do to help conserve the rusty patched bumble bee?

Garden:

Grow a garden or add a flowering tree or shrub to your yard. Even small areas or containers on patios can provide nectar and pollen for native bees.

Native plants:

Use native plants in your yard such as lupines, asters, bee balm, native prairie plants and spring ephemerals. Don't forget spring blooming shrubs like ninebark and pussy willow! Avoid invasive non-native plants and remove them if they

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Executive Summary

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The Rusty-patched Bumble Bee is a medium to large bumble bee that has a rusty-coloured patch bordered by yellow on the first half of its abdomen. Like most bumble bees, it has an annual life cycle and requires a variety of habitats at different stages in this cycle.

In the 1970s, the Rusty-patched Bumble Bee was relatively common throughout its range which, in Canada, includes southern Ontario and southwestern Quebec. Since the mid-1990s, the species has suffered rapid, severe decline. It was listed as Endangered on Schedule 1 of the *Species at Risk Act* in 2012.

The primary threats to the Rusty-patched Bumble Bee are the use of pesticides, particularly neonicotinoids, pathogen transmission and spillover, climate change and severe weather events as well as intensive agriculture, urban and suburban development, and the road network development.

There are unknowns regarding the feasibility of recovery of the Rusty-patched Bumble Bee. Nevertheless, in keeping with the precautionary principle, this recovery strategy has been prepared as per subsection 41(1) of SARA, as would be done when recovery is determined to be feasible. This recovery strategy addresses unknowns surrounding the feasibility of recovery.

The population and distribution objectives for the Rusty-patched Bumble Bee in Canada are to ensure the viability of the local population in Pinery Provincial Park and of any other local population that might be discovered in the future, and, as needed, increase the number of viable local populations in the species' current and historical range, in order to form, in the long term and to the extent possible, a species' distribution that is not severely fragmented as a result of human activity.

Broad strategies as well as research and management approaches to achieve the objectives are presented in the Strategic Direction for Recovery section.

Critical habitat for the Rusty-patched Bumble Bee is partially identified in this recovery strategy. The critical habitat for the species is identified as any suitable habitat located within a 1,000 m radius of any valid sightings of the species since 2005. A schedule of studies outlines the activities required to complete the identification of critical habitat.

One or more action plans will follow this recovery strategy and will be posted on the Species at Risk Public Registry within five years of the posting of the final recovery strategy.

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Table 6. Activities likely to result in destruction of critical habitat

Description of Activity	Description of Effect (biophysical or other characteristics) in Relation to Function Loss	Details of Effect
Application of insecticides (particularly neonicotinoids) within or near critical habitat, including areas where drift into critical habitat may occur.	Application of systemic insecticides (e.g., neonicotinoids) may result in direct loss or degradation of foraging habitat because they spread throughout the plant, from roots up through the vascular system to the floral parts (e.g., pollen and nectar) that are used by bumble bee workers. The reduced quality of foraging resources could result in a decrease in reproductive success and survival rates. The use of non-systemic (or contact) insecticides may result in the temporary destruction of critical habitat because the chemicals may drift onto the pollen and nectar of surrounding flowers, making them unsuitable as forage for Bumble Bees.	If this activity were to occur within the boundaries of critical habitat at any time of year, it is likely that the effects on critical habitat would be direct and cumulative. If this activity were to occur outside the boundaries of critical habitat, it could destroy critical habitat, as the chemicals could drift or leach into critical habitat. The effects of this activity apply year-round because many pesticides are persistent; however, more serious effects could result when products are applied during the active colony period (March/April to October).
Application of herbicides within or near critical habitat, including areas where drift into critical habitat may occur.	Application of herbicides can directly eliminate suitable flowering plants used as forage or reduce the abundance of such plants. The reduction in foraging resources could lead to a decrease in reproductive success and survival rates. The use of broad-spectrum herbicides (e.g., glysophate) increases the likelihood of destruction of foraging habitat.	If this activity were to occur during the active colony period (March/April to October) within the bounds of critical habitat, it is likely that the effects on critical habitat would be direct and cumulative. If this activity were to occur outside the boundaries of critical habitat, it could destroy critical habitat, as the products used could drift or leach into critical habitat.
Activities that alter soil characteristics (e.g., removal, of woody debris, compaction, modification of drainage).	Activities that alter soil characteristics may cause habitat loss or permanent or temporary degradation of nesting and overwintering habitat, if the extent of alteration exceeds a critical threshold (this threshold remains to be determined). The risk of destruction of critical habitat is increased if the activities are carried out in the critical function zone of a nesting or overwintering site.	If this activity were to occur within the boundaries of critical habitat at any time of year, it is likely that the effects on critical habitat would be direct and cumulative. The effects of this activity are applicable at all times of the year. The effects of this type of alteration of nesting habitat would be more severe during the active colony period (March/April to October). By contrast, in overwintering habitat, the

7.3 Activities Likely to Result in the Destruction of Critical Habitat

Understanding what constitutes destruction of critical habitat is necessary for the protection and management of critical habitat. Destruction is determined on a case-by-case basis. Destruction would result if part of the critical habitat were degraded, either permanently or temporarily, such that it would not serve its function when needed by the species. Destruction may result from a single activity or multiple activities at one point in time or from the cumulative effects of one or more activities over time. It should be noted that not all activities that occur in or near critical habitat are likely to cause its destruction.

Critical habitat for the Rusty-patched Bumble Bee may be destroyed by any alteration that adversely modifies any biological, chemical or physical feature to the extent that individuals can no longer use their environment for one of their life processes, such as overwintering, nesting or foraging. Within the critical habitat boundaries, activities that could ultimately alter the structure and composition of open habitats where suitable flowering plant species are available can destroy Rusty-patched Bumble Bee critical habitat. Overwintering and nesting habitats (see section 7.2 – Habitat suitability) are of prime importance because they restrict important population segments within a microhabitat for a substantial period of time. Little information exists on the biophysical attributes of nesting and overwintering habitat, and all occupied nesting and overwintering sites deserve special attention. Considering the species' ecological traits, the timing of activities has a particularly significant influence in relation to the likelihood of destruction.

Table 6 presents examples of activities that could result in the destruction of critical habitat. This list of activities is based on the threats assessed and described in section 4 (Threats) and should not be considered exhaustive or exclusive. For some activities, the identification of thresholds may lead to a refinement or more precise description of the aspects of a given activity that are likely to destroy critical habitat.

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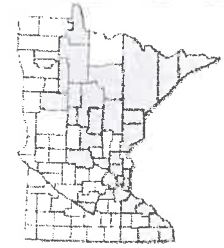
MN Status:
special concern
Federal Status:
threatened
CITES:
none
USFS:
yes

Group:
mammal
Class:
Mammalia
Order:
Chiroptera
Family:
Vespertilionidae
Habitats:
Fire Dependent Forest, Mesic Hardwood Forest, Floodplain Forest, Subterranean

Basis for Listing

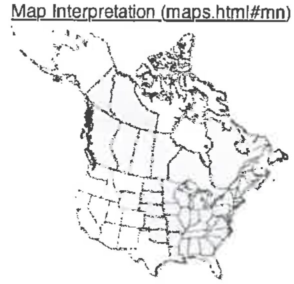
The Northern Long-eared Bat (*Myotis septentrionalis*), also known as the Northern Myotis, is widely distributed in Canada and throughout the eastern half of the United States. It was designated a species of special concern in Minnesota in 1984, at which time it was known from only a few widely distributed localities in the state. Subsequent survey work (https://www.dnr.state.mn.us/eco/mcbs/procedures_mammals.html) has documented additional locations in Minnesota and confirmed that the species can be found in the state in both summer and winter. A large hibernating population was documented in St. Louis County, and Northern Long-eared Bats have been found in many other caves and mines surveyed in Minnesota, though typically in low numbers.

The spread of white-nose syndrome (https://pubs.usgs.gov/fs/2016/3084/fs20163084.pdf) PDF (WNS) across the eastern portion of the United States has become the major threat to the Northern Long-eared Bat. White-nose syndrome is caused by the fungus (*Pseudogymnoascus destructans*), which thrives in cave environments. The fungus is believed to cause cave bats to arouse from hibernation, subsequently depleting stored body fat, often leading to emaciation and death (Frick et al. 2010). The syndrome is associated with high mortality in bat hibernacula, with some sites documenting up to 90 or 100 percent mortality (Lankau and Rogall 2016). The fungus was first documented in Minnesota during winter 2011-2012, and the presence of the disease was confirmed during winter 2015-2016. Declines in the number of hibernating Northern Long-eared Bats as great as 100% were observed in Minnesota's hibernacula in 2017, following the second year of WNS infection.



Map Interpretation (maps.html#mn)

Human disturbance in caves occupied by Northern Long-eared Bats, wind turbine-caused mortalities, and habitat loss are other potential threats. Northern Long-eared Bats were designated as a federally threatened species (https://www.fws.gov/Midwest/endangered/mammals/nleb/index.html) by the U. S. Fish and Wildlife Service in April 2015 and remain listed as a special concern species in Minnesota. A list of all townships (http://files.dnr.state.mn.us/eco/ereview/minnesota_nleb_township_list_and_map.pdf) PDF containing known Northern Long-eared Bat roost trees and/or hibernacula in Minnesota is available.



Map Interpretation (maps.html#na)

Description

The Northern Long-eared Bat is a medium-sized bat, with relatively long ears with a long sharply pointed tragus (fleshy projection in the ear). The pelage is dull brown on the back and pale grayish brown on the underside. The membranes are dark, and the calcar (a bone or cartilage growth from the ankle that helps to support the tail membrane in flight) is slightly keeled. Adults typically measure 7.8-9.5 cm (3.1-3.7 in.) in total body length, with a tail length of 3.2-3.4 cm (1.2-1.3 in.). Weights range from 5.0-6.4 g (0.18-0.23 oz.) (Hazard 1982). The Northern Long-eared Bat can be distinguished from the Little Brown Myotis (https://www.dnr.state.mn.us/rsg/profile.html?action=elementDetail&selectedElement=AMACC01010) (*Myotis lucifugus*) by its long ears and pointed tragi. When folded forward, the Northern Long-eared Bats' ears extend at least 3 mm (0.12 in.) beyond its nose. The ears of the Little Brown Myotis, on the other hand, are even with or only barely extend past the tip of the nose, and the tragi are shorter and blunted.

Habitat

Northern Long-eared Bats have been found in the winter in Minnesota in natural caves, sand mines, and iron mines. Hibernacula are shared between both sexes and often multiple species of bats. Preferred sites typically have high humidity levels, minimal airflow, and a constant temperature (Fitch and Shump 1979). After spring emergence, bats migrate to summer roosting and foraging grounds. In summer, the species is often associated with forested habitats (Fire-Dependent Forests (http://files.dnr.state.mn.us/natural_resources/npc/fire_dependent_forest/lmf_fd_system.pdf) PDF, Mesic Hardwood Forests (http://files.dnr.state.mn.us/natural_resources/npc/mesic_hardwood/lmf_mh_system.pdf) PDF, and Floodplain Forests (http://files.dnr.state.mn.us/natural_resources/npc/floodplain_forest/lmf_ff_system.pdf) PDF) where they make use of tree roosts, especially near water sources. Loose bark, broken tree limbs, cavities, and cracks in a tree can all be utilized by bats as roosting sites. The sexes tend to roost separately, with females forming small (~30 individuals) maternity colonies to bear and rear their offspring. Males often roost alone, as they do not have the same high temperature needs as maternity colonies.

Biology / Life History

Northern Long-eared Bats enter their winter hibernacula from late August through September. They typically roost singly or in small groups (Nordquist and Birney 1985). Emergence from the hibernaculum takes place during May. Bats in the family Vespertilionidae ('vesper bats' or 'evening bats') display delayed fertilization, where mating takes place in fall, ovulation and fertilization do not occur until spring. Females bear a single offspring in June or July. The earliest-born young are usually able to fly by early July, and the nursery colonies disband around this time. Northern Long-eared Bats forage for insects over water, in forest clearings, and under tree canopies, using echolocation to catch prey and to navigate. They may also glean insects off leaves and other surfaces, a behavior that may be aided by their unusually large ears. Foraging takes place throughout the night, peaking before midnight and again just before sunrise (Laubach et al. 1994).

Conservation / Management

The appearance of WNS in 2006 resulted in unprecedented mortality among hibernating bats in the northeastern U.S.. The ability of the disease causing fungus (*Pseudogymnoascus destructans*) to spread rapidly prompted immediate action for research and monitoring. In 2008, a coordinated effort was made by the Department of Interior, Department of Agriculture, Department of Defense, and State wildlife management agencies to develop an effective national response to the disease. Elements of the plan included research on the fungus and monitoring of affected bat populations, education about the fungus and ecological importance of bats, reduction of environmental transmission to and from bats, and evaluation of the ecological and economic consequences of WNS (U.S. Fish and Wildlife Service 2011 (https://www.whitenosesyndrome.org/sites/default/files/white-nose_syndrome_national_plan_may_2011_0.pdf) PDF). Although much

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has been learned about the disease since onset, a cure or method of preventing the fungus from entering other hibernacula is as yet unknown.

Gaps in knowledge about the Northern Long-eared Bat have also inspired state projects focused on the ecology of the species, which can vary by region. Winter hibernacula surveys document trends in hibernating populations and assess the health of these bats. As a species that utilizes trees during summer, retention of roost trees in a variety of decay classes provides critical habitat for recovery from the disease and successful reproduction.

Conservation Efforts in Minnesota

The Minnesota DNR's Minnesota Biological Survey (https://www.dnr.state.mn.us/mbs/index.html) has been monitoring the health of hibernating bats since 2010. Collaborating with national research projects addressing the spread and possible control of WNS, the Minnesota DNR continues to provide information on the status of Northern Long-eared Bats through winter hibernacula surveys, summer acoustic surveys, and targeted population assessments (https://www.dnr.state.mn.us/eco/mcbs/procedures_mammals.html) Education about the importance of bats and effects of WNS is also a component of conservation efforts.

The Minnesota Environmental and Natural Resources Trust Fund (https://www.lccmr.leg.mn/projects/2015/work_plans_may/_2015_03i.pdf) PDF provided support for a cooperative partnership between the Minnesota Department of Natural Resources, the University of Minnesota Natural Resources Research Institute, and the U.S. Forest Service to assess critical summer habitat for Northern Long-eared Bats in the state. Information collected about roosts, colony trees, and stands will inform forest management recommendations to ensure adequate roost and foraging habitat for the Northern Long-eared Bat.

Authors/Revisions

Melissa Boman (MNDNR), 2018

(Note: all content ©MNDNR)

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See pgs 2-3

Does the Long Eared Bat Affect your Schedule?

Construction delays are not uncommon in the A/E/C industry. They can be caused by the climate, change in project scope, design changes, subcontractors, etc. None of these causes are out of the ordinary but one fairly new cause of delays might strike you as odd, which is the northern long-eared bat (NLEB (https://www.fws.gov/Midwest/endangered/mammals/nleb/index.html)). The northern long eared bat is federally listed as a threatened species under the Endangered Species Act. (*according to the U.S. Fish and Wildlife Service (https://www.fws.gov/Midwest/endangered/mammals/nleb/index.html)) (USFWS)* Threatened species are animals and plants that are likely to become endangered in the foreseeable future. Because the northern long-eared bat is listed as a threatened species, it is afforded the protections of the Act and also increases the priority of the species for funds, grants, and recovery opportunities. Since the northern long-eared bat is found in 37 states from the Atlantic Coast westward to eastern Montana and Wyoming *(according to USFWS)*, this species and the protection of it has caused problems when it comes to development of land and construction.

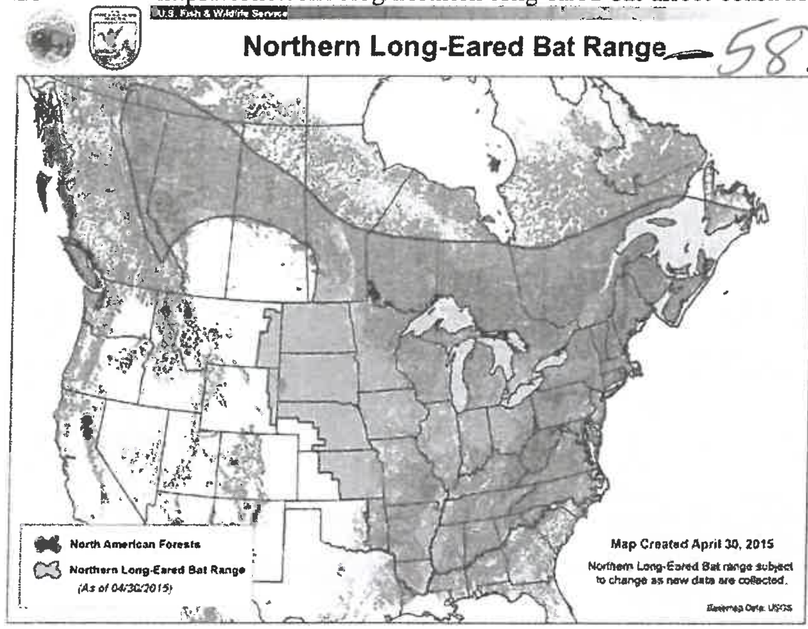
We asked our horticulture consultant, David Flick (http://www.terratechnologies.com/Staff_Qualifications/Flick_resume.htm) with Terra Technologies (http://www.terratechnologies.com) a few questions about the northern long-eared bat and the affects it has on development (https://ibhc.com/services/development/) in the Midwest.

If a developer wants to build within the NLEB mating season, what steps do they need to take to do so?

1

"The USFWS maintains an on-line test on their website to determine if the proposed activity requires a permit. Additionally, you can call the local Ecological (http://www.fws.gov/Midwest/endangered/mammals

/nleb/nlebRangeMap.html) Services office of the USFWS for a site specific consultation. In some states where the NLEB is the only regulated bat, most activities will likely not adversely affect the species, provided no hibernacula or roost trees are present on the parcel. Consult with a qualified biologist if necessary to obtain a best professional judgment memo for the project."



581

Ref 32

If approved, what steps are taken next to ensure the design minimizes the environmental impact for the bats? (thus avoiding the need to revise the project later in development)

"Project specific design attributes will be cited in the permit correspondence if your project requires an authorization. Most commonly, the USFWS will send a clearance letter signifying the project does not require a permit. Such letters include recommendations regarding seasonal limitations for habitat clearing."

What problems have you faced when dealing with the bat's habitats?

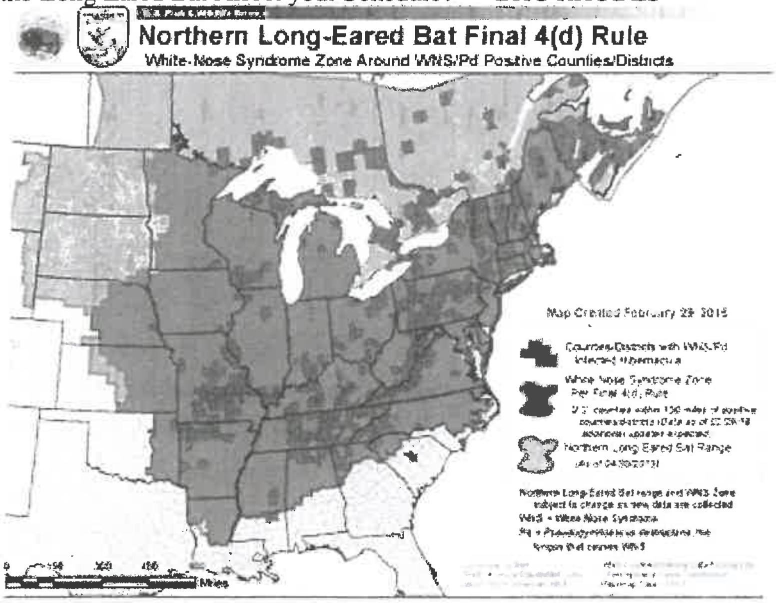
"Regulation of the NLEB began in May 2015. Because the bat is a generalist *(meaning they eat whatever they can catch)*, protected critical habitats include any tree or shrub 3-inches caliper or larger at breast height when the project is located within the regulated buffer zone. Buffer zones are established within 150 miles of any known hibernacula where the NLEB is present with evidence of the White Nose Syndrome (https://www.fws.gov/Midwest/endangered/mammals/nleb/index.html) *(This syndrome is the reason these bats are in trouble. No other threat is as severe and immediate as this disease.)* For most projects (https://ibhc.com/services/development/), the project owner requesting the environmental assessment has completed NLEB assessment studies to quantify the type of habitat present and the proximity to known high quality NLEB habitat."

What are the financial costs of these problems?

"No financial information is available yet, but project activities will be severely hampered if hibernacula is present on or adjacent to the project site."

(https://3wr00m3ki7a73xoty53t2h14-wpengine.netdna-ssl.com/wp-content/uploads/2016/04/Picture1.png) 2

How does the bat habitat effect the construction schedule? Ref 32 - 581 -



"By default, USFWS recommends clearing be limited to the November 1 through March 31 period in most states, provided you receive a clearance letter from their agency. The most crucial months of protection in the Midwest USA is June 1 through July 31, the lactating period for the bat while roosting in trees and shrubs."

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Are there locations where development is protected? (Meaning, no matter the date, you cannot build)

"The USFWS has not published any mandatory exclusion zones in the Midwest USA, but regulations severely limit project disturbance within 1000 feet of roost trees and known hibernacula."

To learn more about the NLEB or how it can affect your construction schedule, visit www.fws.gov (https://www.fws.gov/Midwest/Endangered/mammals/nleb/nlebFactSheet.html) or contact our experts at ibhc.com (https://ibhc.com/services/development/)or 913.663.1900.

Tags: Architecture (https://ibhc.com/tag/architecture/), Civil Engineering (https://ibhc.com/tag/civil-engineering/), Construction (https://ibhc.com/tag/construction/), Construction Delays (https://ibhc.com/tag/construction-delays/), Development (https://ibhc.com/tag/development-2/), Endangered Species (https://ibhc.com/tag/endangered-species/), Northern Long Eared Bat (https://ibhc.com/tag/northern-long-eared-bat/)

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3

Mail body: Decibel levels

Ref 33 -583-

About Decibels (dB)

About Decibels (dB)

Prepared by Gregg Vanderheiden Ph.D.
Trace R&D Center Univ of Maryland.

What is a Decibel (dB)?

A dB or Decibel is a logarithmic unit of measure of the ratio between two numbers.

dB and Power (20dB = 100x)

- When talking about power, a 3dB represents a ratio of two to one or a doubling of power.
  - Thus, a gain of 10dB would represent a ratio of ten to one for power - so **10 dB be 10 times the power**
  - A **40dB power gain would be 10,000 times the power.**

dB and Voltage gain (20dB = 10x)

- When talking about voltage, 6dB represents a ratio of two to one or a doubling of voltage.
  - 20dB would represent a ratio of ten to one for voltage **- so 20 dB would be 10 times the voltage.**
  - A **40dB voltage gain would be 100 times the voltage.**

dB SPL (Sound Pressure Level) (20dB = 10x)

- The term "SPL" stands for sound pressure level. SPL measures are taken with respect to the minimum threshold for human hearing. A 20 dB difference in SPL represents a ratio of ten-to-one in sound pressure.
  - Thus, a **40dB SPL would be a sound pressure level that is 100 times greater** than the sound pressure level of **the quietest sound that normal human hearing can detect.**

Perception of Loudness (20dB = 4x)

- Interestingly, our perception of loudness is not the same as sound pressure level. Although the actual formulae is somewhat complex, as a rough rule of thumb, an increase of 10db SPL is perceived to be approximately twice as loud.
  - Thus a **20 Db gain would seem to be about 4 times as loud.**
  - And a **40 Db gain would seem to be about 16 times as loud.**

Ref 34 -584

Harmful Noise Levels

Topic Overview

The effects of noise on hearing vary among people. Some people's ears are more sensitive to loud sound especially at certain frequencies. (Frequency means how low or high a tone is.) But any sound that is lou enough and lasts long enough can damage hearing and lead to hearing loss (/health-library /ug2252#ug2252-sec).

COVID-19

A sound's loudness is measured in decibels (dB). Normal conversation is about 60 dB, a lawn mower is a dB, and a loud rock concert is about 120 dB. In general, sounds above 85 are harmful, depending on how long and how often you are exposed to them and whether you wear hearing protection, such as earplugs or earmuffs.

Following is a table of the decibel level of a number of sounds.

See pg. 2

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Noise levels

Noise	Average decibels (dB)
Leaves rustling, soft music, whisper	30
Average home noise	40
Normal conversation, background music	60
Office noise, inside car at 60 mph	70
Vacuum cleaner, average radio	75
Heavy traffic, window air conditioner, noisy restaurant, power lawn mower	80–89 **(sounds above 85 dB are harmful)**
Subway, shouted conversation	90–95
Boom box, ATV, motorcycle	96–100
School dance	101–105
Chainsaw, leaf blower, snowmobile	106–115
Sports crowd, rock concert, loud symphony	120–129
Stock car races	130
Gun shot, siren at 100 feet	140

COVID-19

As loudness increases, the amount of time you can hear the sound before damage occurs decreases. Hearing protectors reduce the loudness of sound reaching the ears, making it possible to listen to louder sounds for a longer time.

Preventing damage to your hearing

An easy way to become aware of potentially harmful noise is to pay attention to warning signs that a sound might be damaging to your hearing. A sound may be harmful if:

- You have difficulty talking or hearing others talk over the sound.
- The sound makes your ears hurt.
- Your ears are ringing after hearing the sound.

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Unfortunately, inadequate broad-scale information on many of these attendant effects for the Columbia basin prevents identification of their component contributions. Similarly detailed analyses are needed to address the relations between roads and fish at a landscape scale in other ecoregions.

Conclusions—The range of specific case studies for broad-scale assessment of road relations in the Columbia basin provides a substantial base of information on which to evaluate the direct effects of roads and the cumulative effects of activities associated with roads on aquatic habitats and species in the Northwest.

Terrestrial Vertebrates

Issue—Effects of roads on vertebrate populations act along three lines: direct effects, such as habitat loss and fragmentation; road use effects, such as traffic causing vertebrate avoidance or road kill; and additional facilitation effects, such as overhunting or overtrapping, which can increase with road access.

Findings—In recent research in the interior Columbia River basin, Wisdom and others (2000) identify more than 65 species of terrestrial vertebrates negatively affected by many factors associated with roads. Specific factors include habitat loss and fragmentation, negative edge effects, reduced densities of snags and logs, overhunting, overtrapping, poaching, collection, disturbance, collisions, movement barriers, displacement or avoidance, and chronic, negative interactions with people. These factors and their effects on vertebrates in relation to roads are summarized from Wisdom and others (2000) as follows:

Road construction converts large areas of habitat to nonhabitat (Forman 2000, Hann and others 1997, Reed and others 1996); the resulting motorized traffic facilitates the spread of exotic plants and animals, further reducing quality of habitat for native flora and fauna (Bennett 1991, Hann and others 1997). Roads also create habitat edge (Mader 1984, Reed and others 1996); increased edge changes habitat in favor of species that use edges, and to the detriment of species that avoid edges or experience increased mortality near or along edges (Marcot and others 1994).

Species dependent on large trees, snags, or logs, particularly cavity-using birds and mammals, are vulnerable to increased harvest of these structures along roads (Hann and others 1997). Motorized access facilitates firewood cutting, as well as commercial harvest, of these structures.

Several large mammals are vulnerable to poaching, such as caribou, pronghorn antelope, mountain goat, bighorn sheep, wolf, and grizzly bear (Autenrieth 1978, Bruns, 1977, Chadwick 1973, Dood and others 1986, Greer 1985, Gullison and Hardner 1993, Horejsi 1989, Knight and others 1988, Lloyd and Fleck 1977, Luce and Cundy 1994, Mattson 1990, McLellan 1990, McLellan and Shackleton 1988, Mech 1970, Scott and Servheen 1985, Singer 1978, Thiel 1993, Van Ballenberghe and others 1975, Yoakum 1978). Roads facilitate this poaching (Cole and others 1997).

Gray wolf and grizzly bear experience chronic, negative interactions with humans, and roads are a key facilitator of such interactions (Mace and others 1996, Mattson and others 1992, Thiel 1985). Repeated, negative interactions of these two species with humans increases mortality of both species and often causes high-quality habitats near roads to function as population sinks (Mattson and others 1996a, 1996b; Mech 1973).

Carnivorous mammals such as marten (*Martes americana*), fisher (*M. pennanti*), lynx (*Lynx canadensis*), and wolverine (*Gulo luscus*) are vulnerable to overtrapping (Bailey and others 1986, Banci 1994, Coulter 1966, Fortin and Cantin 1994, Hodgman and others 1994,

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Hornocker and Hash 1981, Jones 1991, Parker and others 1983, Thompson 1994, Witmer and others 1998), and overtrapping can be facilitated by road access (Bailey and others 1986, Hodgman and others 1994, Terra-Berns and others 1997, Witmer and others 1998). Movement and dispersal of some of these species also is believed to be inhibited by high rates of traffic on highways (Ruediger 1996), but this has not been validated. Carnivorous mammals such as lynx also are vulnerable to increased mortality from highway encounters with motorized vehicles (as summarized by Terra-Berns and others 1997).

Reptiles seek roads for thermal cooling and heating, and in doing so, these species experience significant, chronic mortality from motorized vehicles (Vestjens 1973). Highways and other roads with moderate to high rates of motorized traffic may function as population sinks for many species of reptiles, resulting in reduced population size and increased isolation of populations (Bennett 1991). In Australia, for example, 5 million reptiles and frogs are estimated to be killed annually by motorized vehicles on roads (Ehmann and Cogger 1985, as cited by Bennett 1991). Roads also facilitate human access into habitats for collecting and killing reptiles.

Many species are sensitive to harassment or human presence, which often are facilitated by road access; potential reductions in productivity, increases in energy expenditures, or displace-ments in population distribution or habitat use can occur (Bennett 1991, Mader 1984). Exam-ples of such road-associated effects are human disturbance of leks (sage grouse [*Centrocercus urophasianus*] and sharp-tailed grouse [*Tympanuchus phasianellus*]), nests (ferruginous hawk [*Buteo regalis*]), and dens (kit fox [*Vulpes macrotis*]). Another example is elk avoidance of large areas near roads open to traffic (Lyon 1983, Rowland and others 2000), with elk avoidance increasing with increasing rate of traffic (Wisdom and others 2000, Johnson and others 2000).

Bats are vulnerable to disturbance and displacement caused by human activities in caves, mines, and on rock faces (Hill and Smith 1984, Nagorsen and Brigham 1993). Cave or mine exploration and rock climbing are examples of recreation that could reduce population fitness of bats that roost in these sites (Nagorsen and Brigham 1993, Tuttle 1988). Such activities may be facilitated by human developments and road access (Hill and Smith 1984).

Ground squirrels often are targets of recreational shooting (plinking), which is facilitated by human developments and road access (Ingles 1965). Many species of ground squirrels are local endemics; these small, isolated populations may be especially vulnerable to recreational shooting and potentially severe reductions or local extirpations of populations.

Roads often restrict the movements of small mammals (Mader 1984, Merriam and others 1988, Swihart and Slade 1984), and consequently can function as barriers to population dispersal and movement by some species (Oxley and Fenton 1974).

Many granivorous birds are attracted to grains and seeds along roadsides and as a result have high mortality from collisions with vehicles (Vestjens 1973). And pine siskens (*Carduelis pinus*) and white-winged crossbills (*Loxia leucoptera),* for example, are attracted to road salt, which can result in mortality from vehicle collisions (Ehrlich and others 1988).

Terrestrial vertebrates inhabiting areas near roads accumulate lead and other toxins that originate from motorized vehicles, with potentially lethal but largely undocumented effects (Bennett 1991).

In summary, no terrestrial vertebrate taxa seem immune to the myriad of road-associ-ated factors that can degrade habitat or increase mortality. These multifaceted effects have strong management implications for landscapes characterized by moderate to high densities of roads. In such landscapes, habitats are likely underused by many species

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that are negatively affected by road-associated factors. Moderate or high densities of roads sometimes index areas that function as population sinks that otherwise would function as source environments were road density low or zero.

Reliability, confidence, and limitations—General effects of roads and road-associated factors on a wide variety of vertebrate taxa are well documented from a broad range of studies conducted in North America, Europe, and other areas (Bennett 1991, Forman and Alexander 1998, Mader 1984, Trombulak and Frissell 2000, Vestjens 1973). Reliability of such effects at large, landscape scales, and for many taxa, is compelling and unequivocal. Reliability of site-specific, small-scale effects, with focus on single species, is less certain. For many species at local scales, the array of factors that could affect habitats or populations have been neither well studied nor documented. Despite such limitations, current knowledge of broad-scale effects on a variety of taxa is highly certain and provides an overarching paradigm from which likely or presumed effects on single species at local scales can be inferred. The many factors associated with roads suggests that mitigating such effects succeeds best at large scales, when focused on multiple species, and when based on a combination of aggressive road obliteration and protection of roadless areas (Trombulak and Frissell 2000).

Generalizability—Although the summary of road-associated effects on vertebrates described here is taken from research conducted in the interior Columbia River basin (Wisdom and others 2000), results likely apply to several species occupying a diversity of forest and rangeland environments in North America. At least four reasons account for this presumed high generalizability: the road and road-associated effects described by Wisdom and others (2000) were synthesized from research conducted across the world; the synthesis focused on multiple species encompassing diverse taxa and environmental requirements; the synthesis addressed an extreme range of environmental conditions on federal lands administered by the Forest Service, the Bureau of Land Management, and state, private, and tribal landowners; and the synthesis focused on large-scale, overarching effects common to many species and conditions.

Secondary links—Many road-associated effects on terrestrial vertebrates are intimately linked to managing human activities related to road access. Accordingly, mitigation of road-use effects requires effective control of human access to roads related to managing livestock, timber, recreation, hunting, trapping, and mineral development.

Conclusions—Comprehensive mitigation of the full array of road-associated effects on terrestrial vertebrates of conservation concern poses one of the most serious of land management challenges. Balancing such mitigation with socioeconomic desires will be controversial and contentious. Comprehensive efforts to mitigate road-associated effects on terrestrial vertebrates is well suited to testing as a large-scale management experiment developed and implemented jointly by managers, researchers, and the public.

Road Kill

Issues—Large numbers of animals are killed annually on roads. In selected situations, such as for some amphibians with highly restricted home ranges, populations of rare animals may be reduced to dangerous sizes by road kills.

Findings—An estimated 1 million vertebrates a day are killed on roads in the United States (Lalo 1987). Studies show that the number of collisions between animals and vehicles is directly related to the position of the nearest resting and feeding sites (Carbaugh and others 1975). Because most forest roads are not designed for high-speed travel, and the speed of the traffic is directly related to the rate of mortality, direct mortality on forest roads is not usually an important consideration for large mammals

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(Lyon 1985). An exception is forest carnivores, which are especially vulnerable to road mortality because they have large home ranges that often include road crossings (Baker and Knight 2000). Forest roads pose a greater hazard to small, slowly moving, migratory animals, such as amphibians, making them highly vulnerable as they cross even narrow forest roads (Langton 1989). Nearly all species of reptiles use roads for cooling and heating, so many of them are killed by vehicles. Highways and other roads with moderate- to high-speed traffic function as population sinks for many species of reptiles, resulting in reduced and increasingly isolated populations (Wisdom and others 2000). Predators and scavengers are killed while they feed on road-killed wildlife, as are other species attracted to roads because of salts or vegetation, or because roads facilitate winter travel (Baker and Knight 2000). Although countless animals are killed on roads every year, documented road-kill rates are significant in reducing populations of only a few rare species in North America, and these kills generally are on high-speed highways (Forman and others 1997).

Reliability, confidence, and limitations—A large body of data documents annual road kill, and wildlife science can describe the factors that put wildlife at risk, but little research has focused on how to mitigate the effects on wildlife populations.

Generalizability—Most road-kill questions will be related to individual species and geographic sites, but general principles such as the frequency of travel between known resting and feeding areas for individual species can be used in project decisions.

Secondary links—Road-kill issues link to habitat fragmentation, predation, and access issues.

Conclusions—The issues can be addressed based on site and species. Difficulty will arise in integrating road kill with the social and economic issues related to mitigation.

Forest Diseases

Issues—In general, the existence of roads seems to have little effect on forest tree diseases, but there are some examples where building or using roads caused significant local effects. Nearly always, the negative effects can be ameliorated through simple modifications in how they are built and used. The one benefit of roads, as it pertains to tree diseases, is to provide access for silvicultural activities that protect resources, such as the ability to inoculate decay fungi into trees to create wildlife habitat (Bull and others 1997). One negative effect includes the movement of people on the roads, which allows the pests to be introduced. Road building also may set the stage for an insect attack that further stresses the trees and then a disease outbreak that kills them (Boyce 1961).

Findings—A significant forest disease problem associated with roads is Port-Orford-cedar root disease. This disease of Port-Orford-cedar (*Chamaecyparis lawsoniana* (A. Murr.) Parl.) is a root disease caused by the fungus *Phytophthora lateralis*. Spores of the fungus are carried in water or contaminated soil to uninfected areas. Roads of any sort in the very limited geographic range of the primary host provide a way to move soil—along with the fungus—from infected to uninfected areas. Spread of the fungus can be checked by careful planning to reduce entry to uninfected areas, road closures, partial road closures during wet weather, attention to road surfaces and drainage of possibly contaminated water to streams, wash stations to remove soil from vehicles before entry to uninfected areas, and sanitation strips to remove host plants from near roadsides (Kliejunas 1994, Roth and others 1987, Zobel and others 1985). Building and maintaining roads may exacerbate root diseases. Wounded trees and conifer stumps created and not removed during road building provide infection courts for annosus root disease; the disease may then spread through root contacts to kill a patch of trees