2018 MINNESOTA SPRUCE GROUSE SURVEY

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SUMMARY OF FINDINGS

The first annual spruce grouse (*Falcipennis canadensis)* survey in Minnesota was initiated in 2018 with the help of dozens of cooperators and citizen volunteers. Spruce grouse fecal pellets were surveyed on 65 routes throughout spruce grouse range in Minnesota. Spruce grouse pellets were detected at 88 (32%) sites, with a mean of 14.7 spruce grouse pellet groups counted at used sites. The overall probability of spruce grouse site use, adjusted for imperfect detection, was 0.59 (95% CRI: 0.48 – 0.71). Probability of site use was related to the amount of black spruce (*Picea mariana*) and jack pine (*Pinus backsiana*) and geographic location, with the highest use in the northwest portion of the survey region, followed by the northeast, and then the southcentral portion. The probability of detecting $\geq$1 pellet, given a site was used by spruce grouse, was positively related to the proportion of spruce grouse cover types along survey transects and days since the last snow fall, but declined with each successive visit. We will continue to conduct repeat visits for a few years to determine whether the detection process varies among years and may need to be estimated each year to improve the population index. Citizen volunteers will be important contributors to refining the survey and conducting surveys in areas where staffing shortages limit cooperator ability to complete routes. The survey is expected to be able to detect meaningful changes in the population over a 10-year period.

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INTRODUCTION

Spruce grouse, *Falcipennis canadensis*, are a conifer-dependent gamebird in Minnesota and are expected to experience a range contraction due to climate change-induced habitat loss (Scheller and Mladenoff 2005, Prasad et al. 2007, Iverson et al. 2008). Thus, spruce grouse will likely have a more limited distribution in the southern portions of their range, which includes Minnesota and the Great Lakes region, in the future. Minnesota is unique among the Great Lakes states in that it still permits spruce grouse hunting. The spruce grouse is considered a Species of Special Concern in Michigan (Michigan DNR 2005) and was listed as threatened in Wisconsin in 1997 (Wisconsin DNR 2004). Yet, the only data the Minnesota Department of Natural Resources (MNDNR) collected on spruce grouse before 2018 was estimated total harvest as part of the annual Small Game Harvest Mail Survey (Dexter 2016). Estimated total harvest of spruce grouse has been 10,000–27,000 birds/year since 2006 (Dexter 2016). However, spruce grouse harvest may be more reflective of ruffed grouse hunter numbers than spruce grouse numbers; thus these harvest data cannot be used as a population index (Gregg et al. 2004).

During 2014-2017, we developed survey methodology to provide an index of the spruce grouse population (Roy et al. 2014, 2015, 2016, 2017). We evaluated an auditory survey using playback of female cantus calls, which is the most common approach to survey spruce grouse (Fritz 1979, Boag and McKinnon 1982, Schroeder and Boag 1989, Whitcomb et al. 1996, Lycke et al. 2011). We also evaluated fecal pellet surveys as a means to monitor populations because we noticed that sign was easily detected in winter while walking in stands where spruce grouse were detected. As the snow pack dissipates in late winter/early spring, pellets that have been deposited and frozen during winter become abundant on the snow surface and indicate spruce grouse use of forest stands. We surveyed on- and off-road sites using both types of survey methods to examine possible road effects on spruce grouse use of forest stands and also examined whether the presence of habitat, defined as black spruce (*Picea mariana*), jack pine

(*Pinus backsiana*), balsam fir (*Abies balsamea*), red pine (*Pinus resinosa*), white spruce (*Picea glauca*), tamarack (*Larix lariana*), and white cedar (*Thuja occidentalis*) $\geq$6 years old, on both sides of the road was important. Our research concluded that the pellet survey was more efficient and had higher detection rates than the auditory survey and that road effects were negligible in high-use cover types (e.g., jack pine and black spruce). The presence of spruce grouse habitat on both sides of the road was positively related to site use. Thus, we designed a monitoring program based on a roadside survey of sites centered on road-based points (hereafter, survey "sites") located in spruce grouse cover and dispersed across the range of spruce grouse in Minnesota. More information about the development of the survey design can be found in Roy et al. (2014, 2015, 2016, 2017).

During late winter through early spring 2018, the spruce grouse pellet survey was launched with the cooperation of biologists from the Chippewa National Forest, Grand Portage Band of Lake Superior Chippewa, Leech Lake Band of Ojibwe, Minnesota Department of Natural Resources, Red Lake Band of Chippewa Indians, Superior National Forest, 1854 Treaty Authority, Vermilion Community College, and dozens of citizen volunteers. This survey is intended to provide population information (status and distribution) that can be used to make more informed management decisions. The spruce grouse pellet survey is expected to be able to detect meaningful changes in the population over a 10-year period.

METHODS

We used a Geographic Information System to identify 1,809 potential survey sites with >30% spruce grouse cover and located within 150 m of accessible secondary roads. Survey-site centers were spaced $\geq$400 m apart to simplify logistics for survey cooperators. We scouted 1,426 sites in 2017 for access issues (i.e., deep ditches, private land, wetlands, streams, steep topography) and appropriateness of cover types for spruce grouse. We asked survey cooperators for input about accessibility during winter and early spring, recent and planned timber harvest, and appropriateness for inclusion in the survey. We also examined aerial images to verify that habitat occurred on both sides of the road and removed sites where timber harvest had occurred recently or where planned harvest in the next 5 years would reduce habitat below the 30% threshold used for site selection. Thus we reduced the number of potential survey sites to 1,369. From these sites, we identified 197 sites in high-use cover types (i.e., jack pine and black spruce) that were not planned for harvest in the next 5 years to serve as potential seed points for constructing routes. We used a Generalized Random Tessellation Stratified Sampling approach (Stevens and Olsen 2004) to randomly select 69 seed points, which we used to construct a spatially balanced set of survey routes consisting of 4-5 sites/route. We dropped 16 seed points after considering proximity to nearby points, planned harvest, and habitat, and replaced them with 12 seed points that were selected manually based on the same selection criteria. This set of 65 seed points was used to construct 65 potential survey routes consisting of 4-5 survey sites per route. We again solicited input from cooperators, which resulted in adding 2 more routes and moving one route because of access issues. Our final sample contained 321 survey sites organized into 67 survey routes.

Observers used a Global Positioning System (GPS) to walk a circular transect with a 100-m radius (i.e., 628-m length) centered on roadside sampling points. Observers recorded single grouse pellets and roost piles $\leq$1 m on either side of transects. Multiple pellets within a 30-cm diameter circle were considered a "roost" for the purpose of this survey, and the minimum number of "roosts" to characterize an area of scattered pellets was recorded. This standardization of the method was necessary because spruce grouse often roost in trees during winter and pellets fall to the ground in poorly defined roost piles. Ruffed grouse pellets were distinguished from spruce grouse pellets on the basis of length, thickness, uric acid wash, and color. Ruffed grouse pellets tend to be shorter, thicker, and usually have a uric acid wash, whereas spruce grouse pellets are longer, thinner, and infrequently have a uric acid wash. Spruce grouse pellets are also darker green in color when spruce grouse are consuming conifer needles (during winter), but color changes depend on diet; spruce grouse pellets can have a similar color to ruffed grouse pellets later in the spring. At each site observers also recorded various covariates for detection of grouse pellets, including the proportion of the 628-m transect that was located in spruce grouse cover types; days since last snow fall; whether snow cover was complete, partial, or gone; and survey conditions on a scale of 0-10 with 10 being the best conditions to survey. Surveys were repeated up to 5 times on different days at a subset of sites (where staff and/or volunteers were available) to allow modeling of the detection process and to help determine whether repeat visits will be necessary to improve estimation of the population index.

In our analysis we also considered several variables that might influence use of sites by grouse and detection of pellets (i.e., single pellets and roosts combined). For site use, we evaluated the potential effects of 1) the presence of $\geq$30% black spruce and/or jack pine stands $\geq$6 years old, 2) the proportion of the survey transect located in any type of spruce grouse cover, and 3) geographic location of survey sites. For the detection process we considered 1) the proportion of the transect in spruce grouse cover, 2) days since last snowfall because snow covers the pellets and melting also influences pellet exposure, 3) overall survey conditions (on a scale 0-10 with 10 being very good), 4) observer type (i.e., trainer, natural resource agency staff, citizen volunteer), 5) an indicator variable for previous detections at the site, 6) survey date, and 7) visit number (i.e., a “time” covariate that reflects the cumulative effect of multiple time-varying processes that might influence the probability of detecting $\geq$1 pellet).

We used a single season occupancy model (sensu MacKenzie et al. 2018) with 3 visits to identify a reasonable covariate structure for the probability of site use and the detection process. We fit our models in the R programming language (R Core Team 2018) using the ‘occu’ function in the R package ‘unmarked’ (Fiske and Chandler 2011), and compared models (covariate structure) using the Akaike Information Criterion (Akaike 1973) computed with the ‘modSel’ function. We then refit our top model in a Bayesian framework (Kéry and Schaub 2012, Su and Yajima 2015), which allowed us to include and evaluate a random effect for the clustering of survey sites into routes. We first fit a hierarchical model without random effects to verify that it matched previous results, then we added random effects. We examined the 95% credible interval for random effects (variance parameter) and used the Deviance Information Criterion (DIC) to compare models with and without random effects. We used the model with the lowest DIC for inference.

RESULTS AND DISCUSSION

In 2018, 65 of 67 routes were surveyed by 20 cooperators and 40 citizen volunteers between 1 March and 20 May (Table 1). Spring was very late in 2018, with snow cover persisting into May in much of the survey region. Seventeen sites could not be surveyed due to access issues, and 25 sites that were surveyed were discarded due to access issues or sparse spruce grouse cover. A subsample of sites (n = 87; 32%) were revisited 2–5 times. Most (78%) revisits were conducted by volunteers, whereas training sessions and staff surveys comprised 66% of initial visits. Revisit effort was not uniformly distributed among cooperators but rather was skewed towards cooperators near population centers (Duluth, Two Harbors, Tofte, Grand Marais, Ely; Table 1), with 18 sites revisited >3 times.

Cooperators and volunteers detected spruce grouse pellets at 79 (29%) of 273 survey sites during the initial visit and at 88 (32%) sites when revisit surveys were included. On average 15.2 spruce grouse single pellets and roosts were detected at “used” sites in initial visits (range = 1–174; Table 1), but for all visits the average was 14.7 pellets/used site. Ruffed grouse pellets and roosts were detected at 142 (52%) sites in initial visits and more used sites were detected in repeat visits (160 sites, or 59%). The mean count of ruffed grouse pellets in initial visits at “used” sites was 7.0 detections/site (range: 1–120) and was slightly lower (6.3 detections/site) when all visits were combined. Pellets of both species were detected at 55 sites (20%), whereas 80 sites (29%) had no pellet detections for either species.

Spruce grouse use of sites was best explained by geographic location and the presence of >30% jack pine and/or black spruce cover types (Figs. 1a,b and 2). The probability of detecting at least 1 pellet, given that a site was used, was best explained by the proportion of the survey transect in spruce grouse cover (Fig. 3), days since last snowfall (Fig. 4), and visit (Fig. 5); with the probability of detection positively related to spruce-grouse cover and time since last snowfall, and negatively related to visit number (time). The model with random effects had a lower DIC than the model without random effects (502.2 vs 676.1), so the model with random effects (to account for the clustering of survey sites) was used for inference.

The overall probability of spruce grouse site use, adjusted for imperfect detection, was 0.59 (95% CRI: 0.48 – 0.71). However, the mean probability of use varied geographically. When survey sites were grouped by ecological section, the Northern Minnesota and Ontario Peatlands had the highest probability of site use (mean = 0.86, 95% CRI: 0.69 – 1.00), followed by the Northern Superior Uplands (mean = 0.57, 95% CRI: 0.44 – 0.73), and the Northern Minnesota Drift & Lake Plains (mean = 0.22, 95% CRI: 0.10 – 0.49).

Our naïve estimate of spruce grouse use (the proportion of sites where $\geq$1 pellet was detected in the initial survey) was much lower (0.29) than our model-based estimate of site use (0.59). This difference is the result of imperfect detection (i.e., many of the sites classified as "unused" probably had pellets that were present but not detected). If the conditional probability (i.e., given a site was truly used) of detecting $\geq$1 pellet was close to 1, then a naïve estimate of site use based on a single-visit survey would be sufficient for monitoring spruce grouse populations and their distribution. However, if the mean conditional probability of detection is relatively low and/or the detection process (described by the distribution of covariate values) varies greatly over space or time, then a naïve estimate of site use might be misleading.

We estimated that the mean conditional probability of detection for a single-visit survey was 0.50 (95% CRI: 0.38 – 0.63), which means that 50% of survey sites classified as "unused" in the initial survey probably had spruce grouse pellets present but they were missed (overlooked) or not available for detection (e.g., buried in the snow). Conducting 2 follow-up surveys improved the conditional probability of detection to 0.69 (95% CRI: 0.55 to 0.81), which allows us to compute a better estimate of site use. In other words, by finding additional pellets in subsequent visits (or not finding pellets at sites where they were detected previously), a correction factor can be applied to account for missed pellets and produce a more accurate estimate of true site use.

We will continue to do repeat surveys for the next few years to determine if detection and the detection process varies among years or if it is relatively constant. If relatively consistent for several years, then an index based on a single-visit survey may be adequate for the purpose of monitoring population trends over time. Citizen volunteers will be extremely important in helping us execute repeat visits because of staff workload limitations. These repeat surveys will help us refine the survey for long-term monitoring purposes. We anticipate using the overall probability of site use, adjusted for detection, as the primary monitoring metric in annual surveys.

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Table1. Spruce grouse (SPGR) routes and sites surveyed in 2018 by cooperators and volunteers, and detections of SPGR and ruffed grouse (RUGR) pellets (singles and roosts per used site) during all visits. Citizen volunteers assisted with surveys in most survey areas.

Cooperator Area	No. citizen volunteers	Routes	Sites surveyed	Proportion sites used by SPGR	Mean no. SPGR pellets	Proportion sites used by RUGR	Mean no. RUGR pellets
Aurora SNF[1]	2	3	13	0.46	2.4	0.85	3.8
Baudette DNR[2]	0	4	16	0.31	18.4	0.63	5.3
Bemidji DNR	1	2	10	0.00	0.0	0.30	2.8
Cook SNF	2	2	9	0.11	1.0	0.22	3.5
Chippewa Nat'l Forest	3	4	19	0.16	5.5	0.47	5.9
Duluth DNR	6	2	9	0.22	15.5	1.00	5.6
Ely SNF	7	5	21	0.52	10.8	0.57	4.8
Grand Marais DNR	4	3	9	0.22	32.5	1.00	19.6
Grand Marais SNF	0	3	14	0.14	4.5	0.07	2.0
Grand Portage Band	0	3	12	0.00	0.0	0.67	22.9
Grand Rapids DNR	0	1	4	0.00	0.0	0.50	11.5
Internat'l. Falls DNR	3	3	9	0.22	12.5	0.44	4.8
Leech Lake Band	0	2	9	0.00	0.0	0.67	2.0
Orr DNR	3	5	18	0.39	5.3	0.61	3.0
Red Lake Band	0	3	14	0.36	5.0	0.64	8.4
Red Lake WMA	1	5	25	0.68	41.1	0.56	5.5
1854 Treaty Authority	0	4	19	0.47	7.1	0.63	5.2
Tofte SNF	4	5	20	0.25	5.2	0.55	4.6
Two Harbors DNR	5	3	11	0.36	1.6	1.00	4.9
Tower DNR	4	3	12	0.58	12.6	0.50	2.7
Total	40[3]	65	273	0.32	14.7	0.59	6.3

[1]SNF = Superior National Forest

[2]DNR = Minnesota Department of Natural Resources –Section of Wildlife

[3]Some volunteers worked in groups on the same route, and some volunteers did routes in >1 work area.

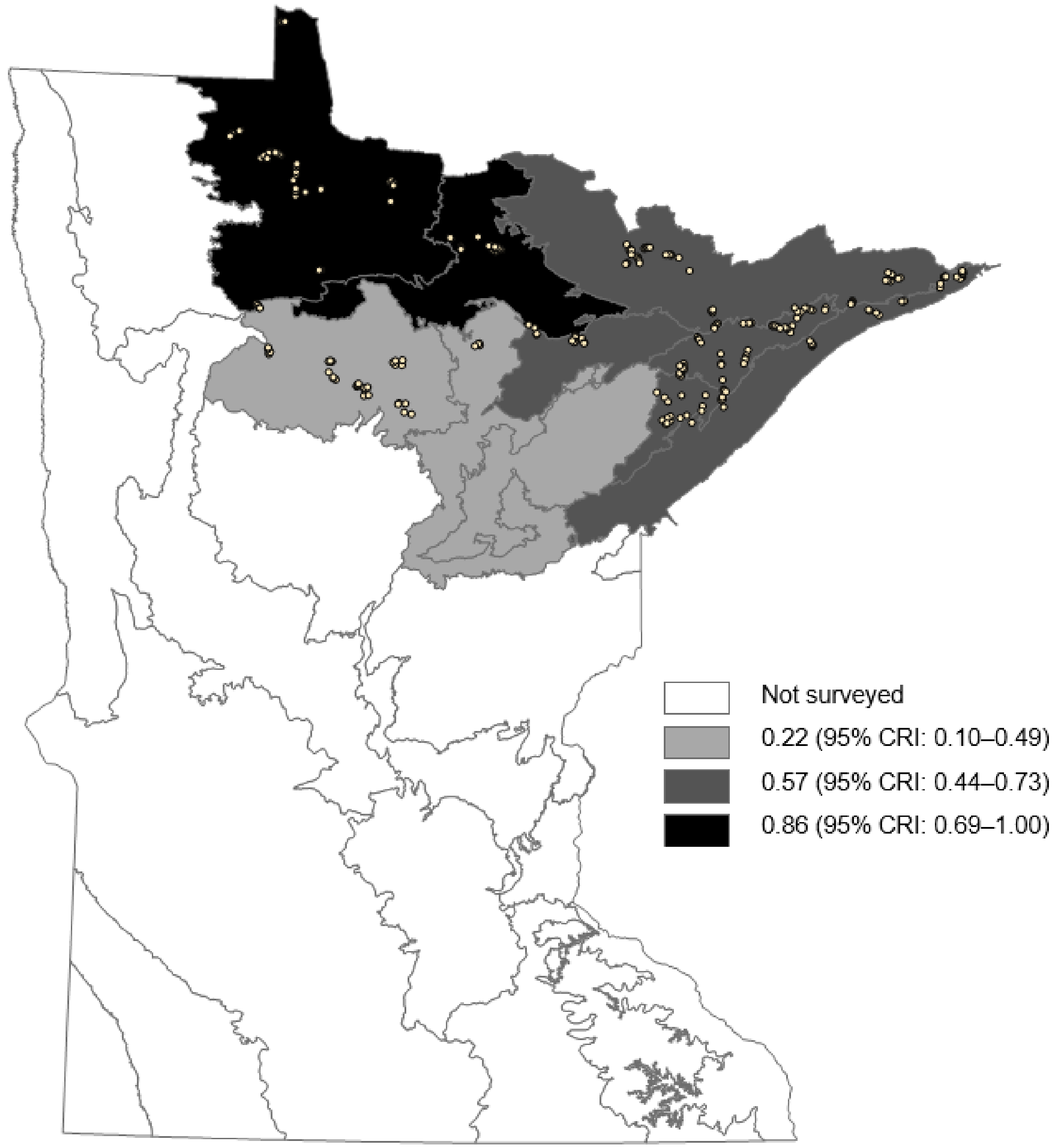

Figure 1a. Estimates of mean spruce grouse site use, adjusted for detection, with credible intervals (CRI) in 2018. Ecological Classification System sections included were the Northern Minnesota and Ontario Peatlands (n = 75 sites) in the northwest, the Northern Superior Uplands (n = 154 sites) in the east, and the Northern Minnesota Drift and Lake Plains (n = 44 sites) in the southcentral survey region. Subsection boundaries are also shown.

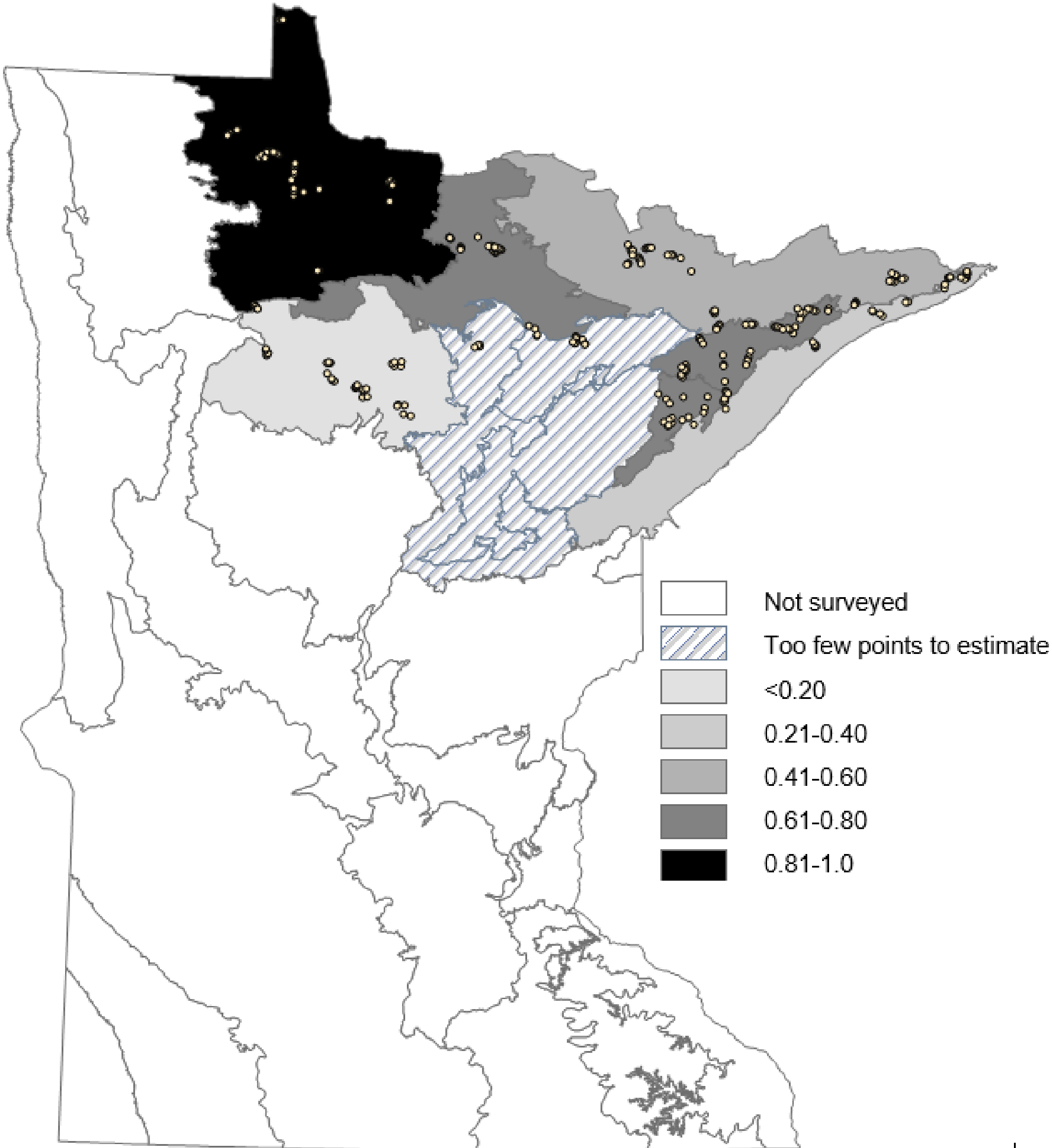

Figure 1b. Estimates of mean spruce grouse site use, adjusted for detection, in each Ecological Classification System subsection in 2018. Sites surveyed in 2018 are indicated on the map, but for subsections with fewer than 20 sites surveyed, estimates of site use were not produced.

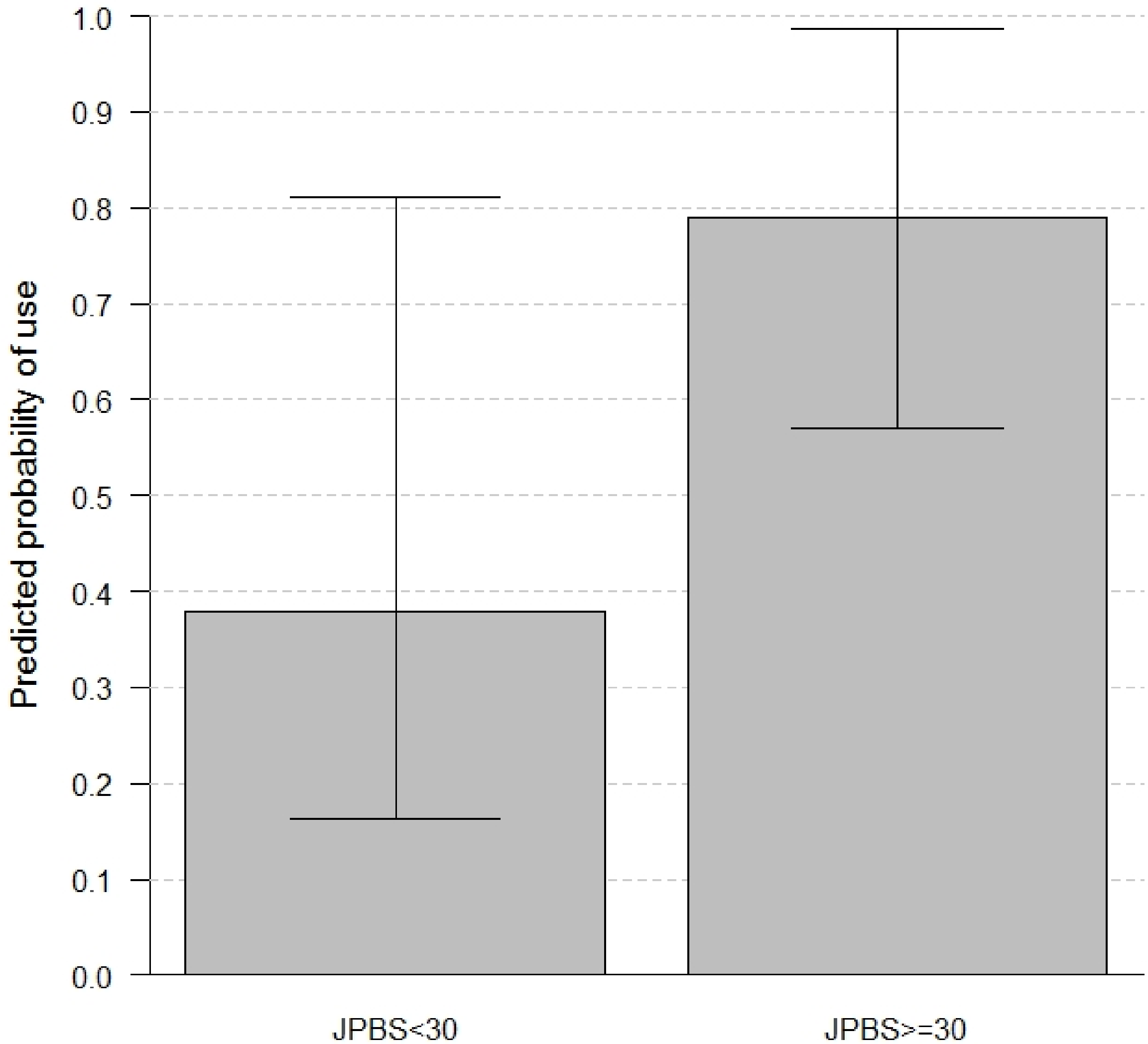

Figure 2. The mean predicted probability of site use by spruce grouse, adjusted for detection, as a function of whether jack pine [JP] and/or black spruce [BS] comprises < or >= 30% of the cover within 150 m of a survey point.

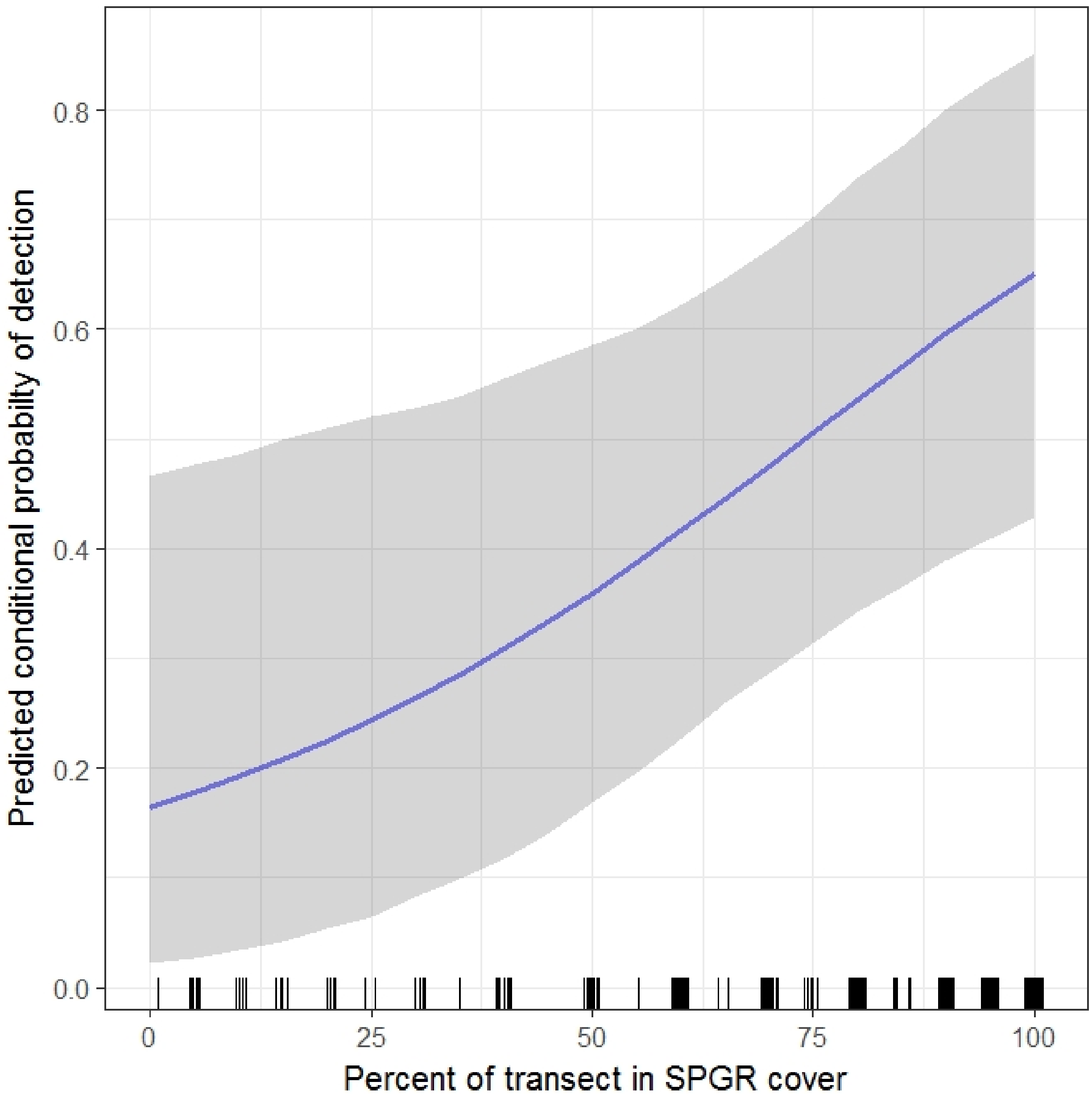

Figure 3. The predicted probability of detecting at least 1 spruce grouse pellet, given a site is truly used, as a function of the proportion of the survey transect located in spruce grouse cover (i.e., all cover types). The blue line denotes the predicted mean, the gray polygon denotes the 95% credible interval, and the rug on the bottom axis shows the distribution of measured covariate values. The prediction is conditional on a single-visit survey to used sites with other covariates held at mean values.

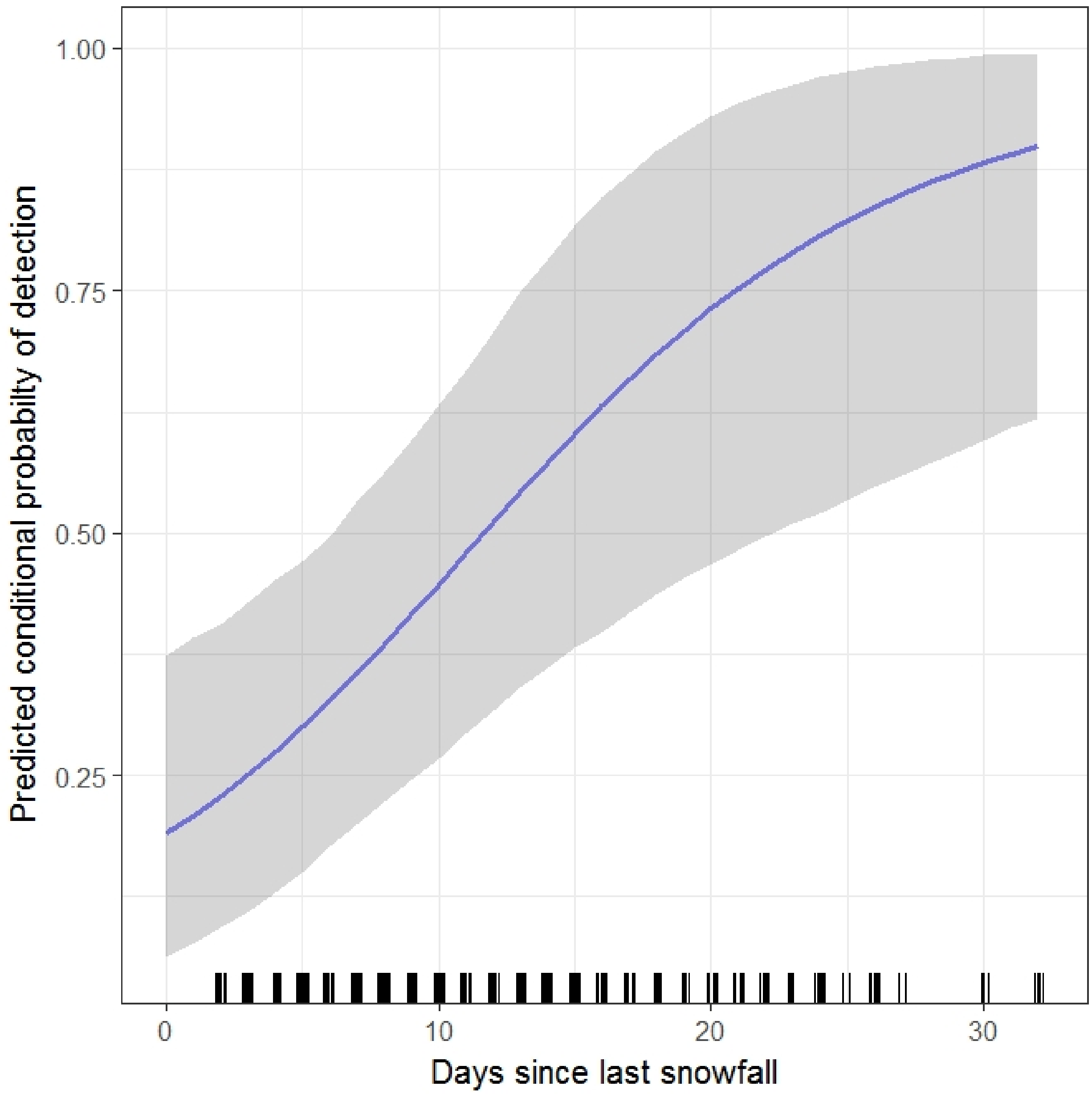

Figure 4. The predicted probability of detecting at least 1 spruce grouse pellet, give a site is truly used, as a function of the days since last snowfall. The blue line denotes the predicted mean, the gray polygon denotes the 95% credible interval, and the rug on the bottom axis shows the distribution of measured covariate values. The prediction is conditional on a single-visit survey to used sites with other covariates held at mean values.

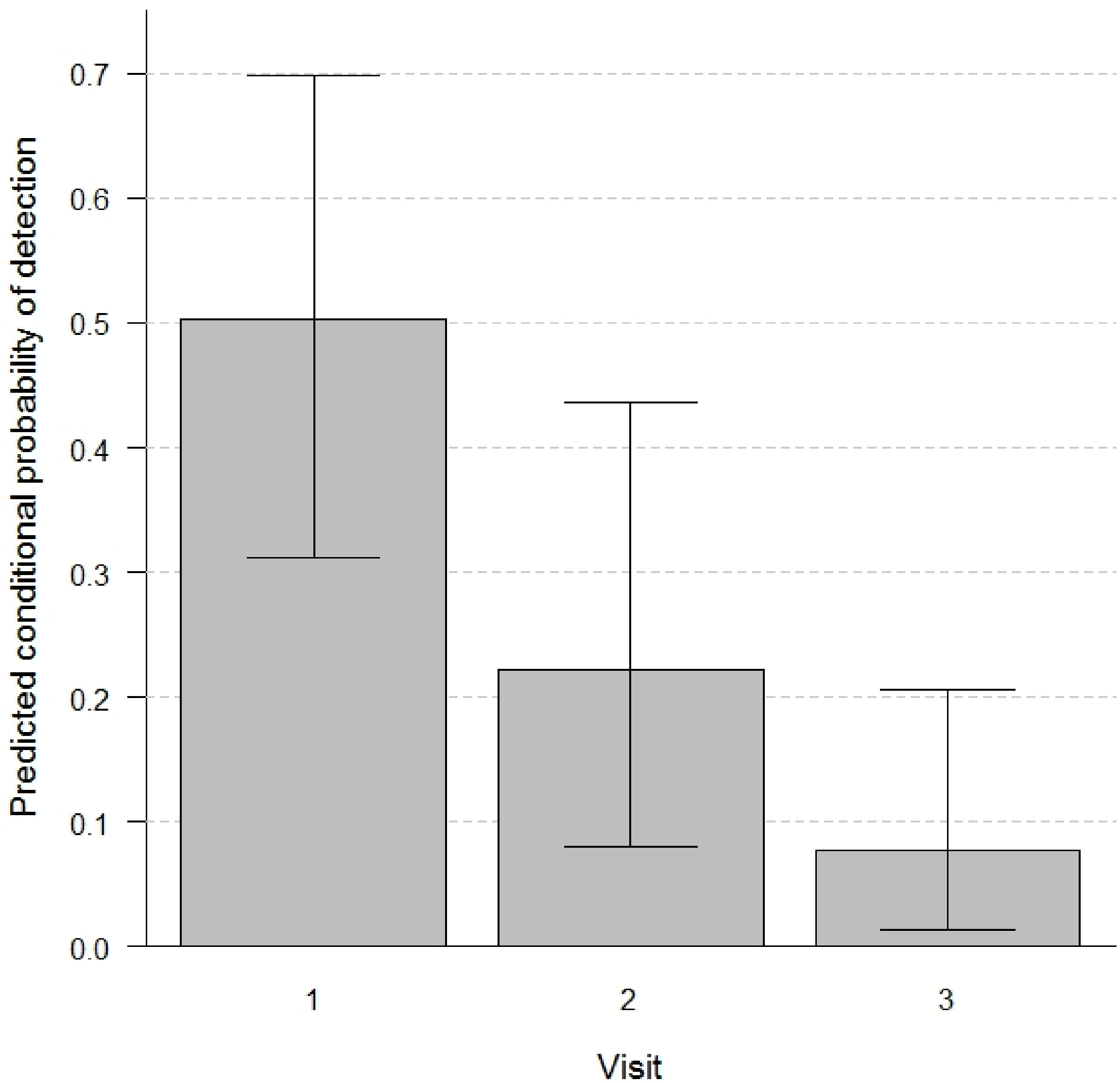

Figure 5. The predicted probability of detecting at least 1 spruce grouse pellet, given a site is truly used, as a function of sequential visits (time). The prediction is conditional on other covariates (days since last snow and proportion of transect in spruce grouse cover) held at mean values. The error bars denote 95% credible intervals.