## 2019 MINNESOTA SPRUCE GROUSE SURVEY

Charlotte Roy, John Giudice, Chris Scharenbroich
Forest Wildlife Populations and Research Group
Minnesota Department of Natural Resources
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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. In the second year of the survey, additional effort was invested to determine sources of variation in fecal pellet detection through repeat surveys. Participants surveyed for spruce grouse pellets at 273 sites in 2018 and 314 sites in 2019. Spruce grouse pellets were detected at 79 sites in 2018 (proportional use = 0.29; 95% CI: 0.24–0.34) and 87 sites in 2019 (0.28; 95% CI: 0.23–0.33). Participants counted a mean of 15.2 (95% CI: 8.8–21.6) and 22.0 (95% CI: 14.7–29.3) pellet groups at used sites in 2018 and 2019, respectively. Based on revisit surveys, we found that probability of site use was related to the presence of >30% black spruce (*Picea mariana*) and jack pine (*Pinus backsiana*) cover types 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 ≥1 pellet, given a site was used by spruce grouse, was positively related to the proportion of spruce grouse cover types along the survey transect. We also found evidence of observer effects on the detection process. However, despite these sources of variation in the detection process, the estimated mean detection probability was similar in 2018 and 2019 (mean = 0.26 [95% CRI: 0.21–0.32] and 0.23 [95% CRI: 0.19–0.27], respectively). This is important because if annual variation in detection probability was large, then we would likely need to consider conducting revisit surveys each year or at least

periodically. When adjusted for probability of detection, the estimated probability of site use was 0.80 (95% CR: 0.74–0.84) in 2018 and 0.79 (95% CRI: 0.73–0.85) in 2019. We also found very little turnover in site use between years (i.e., probability of a site changing status between 2018 and 2019 was 0.03, 95% CRI: 0.00–0.07). Thus, based on the 2-year dataset, the spruce grouse population appeared to be stable (mean finite rate of change = 0.99 [95% CRI: 0.94–1.04], where 1 denotes a stable population). Citizen volunteers will be important contributors to refining the survey and conducting surveys in areas where agency staffing levels limit cooperator ability to complete routes. This survey is expected to be able to detect meaningful changes in the population over a 10-year period (e.g., a ≥15% decline).

**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, variation in spruce grouse harvest among years may be more reflective of the number of ruffed grouse (*Bonasa umbellus*) hunters; thus these harvest data cannot be used as a population index for spruce grouse (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 visible 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.

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 (i.e., status and distribution) that can be used to make management decisions. The spruce grouse pellet survey is expected to be able to detect meaningful changes in the population over a 10-year period (e.g., $\geq$15% decline).

**METHODS**

We used a Geographic Information System (GIS) 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. 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. In 2019, 7 additional sites were dropped due to access issues or inadequate habitat, resulting in 314 sampling points.

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 covariate data 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 detect pellets. Surveys were repeated up to 5 times at a subset of sites (where seasonal technicians and/or volunteers were available) to allow modeling of the detection process and to help determine whether repeat visits will be necessary to account for annual variation in the detection process.

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 based on GPS coordinates. 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., seasonal technician, natural resource agency staff, citizen volunteer), 5) an indicator variable for previous detections at the site, 6) survey date, 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), 8) a categorical variable for snow extent (i.e., complete, partial, none), 9) number of observers, and 10) an indicator variable for overall year effects (that were not explained by variation in other predictors).

We used a multi-season dynamic occupancy model (sensu MacKenzie et al. 2018) to identify reasonable covariate structures for the probability of site use and the probability of detection. We fit our models in the R programming language (R Core Team 2018) using the 'colext' 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 examined the 95% credible intervals (CRI) around estimates.

## RESULTS AND DISCUSSION

In 2019, 67 of 67 routes (median 5 points per route, range: 3-5) were surveyed by 25 cooperating biologists, 38 citizen volunteers, and 2 seasonal technicians between 5 March and 24 May (Table 1). Spring was very late in both 2018 and 2019, with snow cover persisting into May in much of the survey region. A larger subsample of sites was revisited up to 4 times in 2019 (n = 270, or 86%; 69% of sites were visited $\geq$3 times) compared to 87 sites, or 32%, being revisited in 2018. Most revisits (78%) in 2018 were conducted by volunteers and were skewed to be near population centers (i.e., Duluth, Two Harbors, Tofte, Grand Marais, Ely; Table 1), whereas in 2019 seasonal technicians conducted 77% of revisit surveys, which were more evenly distributed across the survey region.

Observers detected spruce grouse pellets at 87 (28%) of 314 survey sites during the initial visit and at 57 (18%) sites in revisit surveys. On average 22.0 (95% CI: 14.7–29.3) spruce grouse single pellets and roosts were detected in initial visits (range = 1–162). Similarly, ruffed grouse pellets and roosts were detected at 180 (57%) sites in initial visits with a mean count of 9.7 (95% CI: 8.2–11.2) pellets/used site (range: 1–75). Pellets of both species were detected at 109 sites (35%), whereas 39 sites (12%) 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, similar to findings in 2018 (Fig. 1). In 2018, 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, days since last snowfall, and visit number, with the probability of detection positively related to spruce-grouse cover and time since last snowfall, and negatively related to visit number (time). However, using a dynamic occupancy model with 2 years of data, detection was best explained by the proportion of the survey transect in spruce grouse cover (Fig. 2), whether pellets had been detected in a previous survey the same year (Fig. 3), observer effects, and an indicator variable for overall year effects (not accounted for by variation in other predictors).

The overall probability of spruce grouse site use, adjusted for imperfect detection, was 0.80 (95% CRI: 0.74–0.84) in 2018 and 0.79 (95% CRI: 0.73–0.85) in 2019 (Fig. 4). When survey sites were grouped by ecological section, the Northern Minnesota and Ontario Peatlands had the highest probability of site use (mean = 0.98, 95% CRI: 0.92–1.00), followed by the Northern Superior Uplands (mean = 0.85, 95% CRI: 0.77–0.91), and the Northern Minnesota Drift & Lake Plains (mean = 0.18, 95% CRI: 0.11–0.30). The estimated mean finite rate of population change during 2018-2019 was 0.99 (95% CRI: 0.94 – 1.04), indicating a stable population.

Our naïve estimate of spruce grouse use (the proportion of sites where ≥1 pellet was detected in the initial survey) was much lower (0.28) than our model-based estimate of site use (0.79, Figs. 4A and 4B). This difference is the result of imperfect detection (i.e., many of the sites classified as “unused” after the initial survey probably had pellets that were present but not detected). If the conditional probability (i.e., given a site was truly used) of detecting ≥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 the detection process varies greatly over space or time (described by the distribution of covariate values), then a naïve estimate of site use might be misleading.

We estimated that the mean probability of detection for a single-visit survey as 0.26 (95% CRI: 0.21–0.32) in 2018 and 0.23 (95% CRI: 0.19–0.27) in 2019, which means that ~75% 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 for a total of 3 visits improved the conditional probability of detection to 0.65 (95% CRI: 0.59 to 0.70), which allows us to compute a better estimate of true 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. Based on 2 years of data with repeat surveys, annual variation in the detection process appeared to be negligible (i.e., 0.26 vs 0.22 in 2018 and 2019, respectively).

We will continue to do repeat surveys for another year 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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Table 1. Spruce grouse (SPGR) routes and sites surveyed in 2019 by cooperators and volunteers, and detections of SPGR and ruffed grouse (RUGR) pellets (singles and roosts per used site) during initial visits. Citizen volunteers assisted with surveys in most survey areas.

| Cooperator Area | No. citizen volunteers | Routes | Sites surveyed | Proportion sites used by SPGR | Proportion sites used by RUGR |
|---|---|---|---|---|---|
| Aurora SNF[1] | 3 | 3 | 14 | 0.29 | 0.64 |
| Baudette DNR[2] | 1 | 4 | 19 | 0.26 | 0.42 |
| Bemidji DNR | 4 | 2 | 10 | 0.00 | 0.40 |
| Chippewa Nat'l Forest | 2 | 4 | 19 | 0.00 | 0.63 |
| Cook SNF | 5 | 4 | 20 | 0.20 | 0.55 |
| Duluth DNR | 3 | 2 | 7 | 0.29 | 0.43 |
| Ely SNF | 10 | 5 | 24 | 0.21 | 0.54 |
| Grand Marais DNR | 3 | 3 | 12 | 0.08 | 0.92 |
| Grand Marais SNF | 0 | 3 | 14 | 0.50 | 0.93 |
| Grand Portage Band | 0 | 3 | 15 | 0.00 | 1.00 |
| Grand Rapids DNR | 0 | 1 | 4 | 0.00 | 0.25 |
| Internat'l. Falls DNR | 2 | 3 | 13 | 0.62 | 0.54 |
| Leech Lake Band | 0 | 2 | 9 | 0.00 | 0.44 |
| Orr DNR | 2 | 4 | 17 | 0.53 | 0.77 |
| Red Lake Band | 0 | 3 | 14 | 0.36 | 0.64 |
| Red Lake WMA | 0 | 5 | 25 | 0.20 | 0.12 |
| 1854 Treaty Authority | 0 | 4 | 20 | 0.45 | 0.60 |
| Tofte SNF | 3 | 6 | 30 | 0.50 | 0.50 |
| Two Harbors DNR | 5 | 3 | 14 | 0. 14 | 0.64 |
| Tower DNR | 2 | 3 | 14 | 0.43 | 0.57 |
| Total | 38[3] | 67 | 314 | 0.28 | 0.57 |

[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.

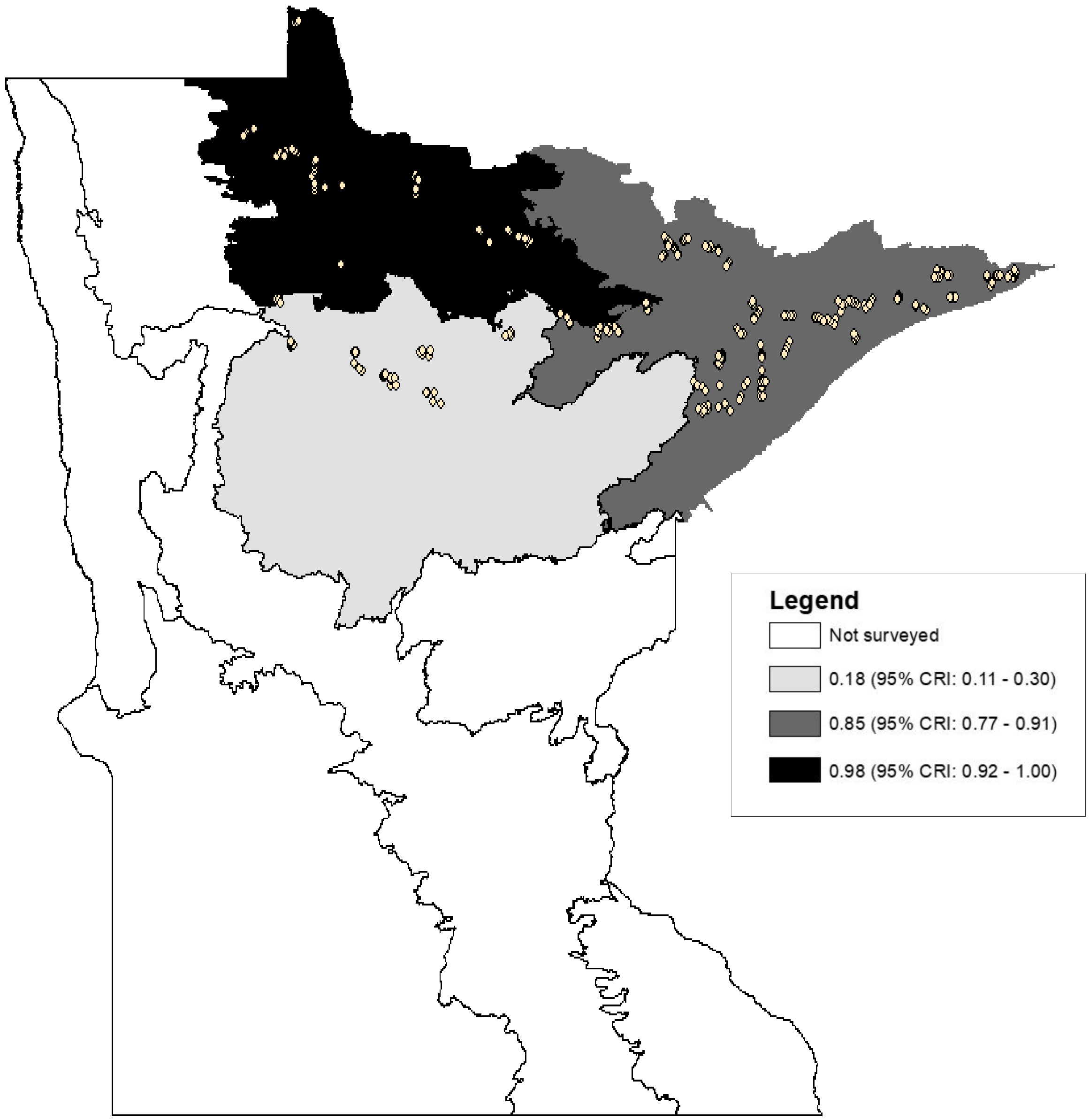


Figure 1. Estimates of mean spruce grouse site use, adjusted for detection, with credible intervals (CRI) in 2019. Ecological Classification System sections included were the Northern Minnesota and Ontario Peatlands (n = 84 sites) in the northwest, the Northern Superior Uplands (n = 186 sites) in the east, and the Northern Minnesota Drift and Lake Plains (n = 44 sites) in the southcentral survey region.

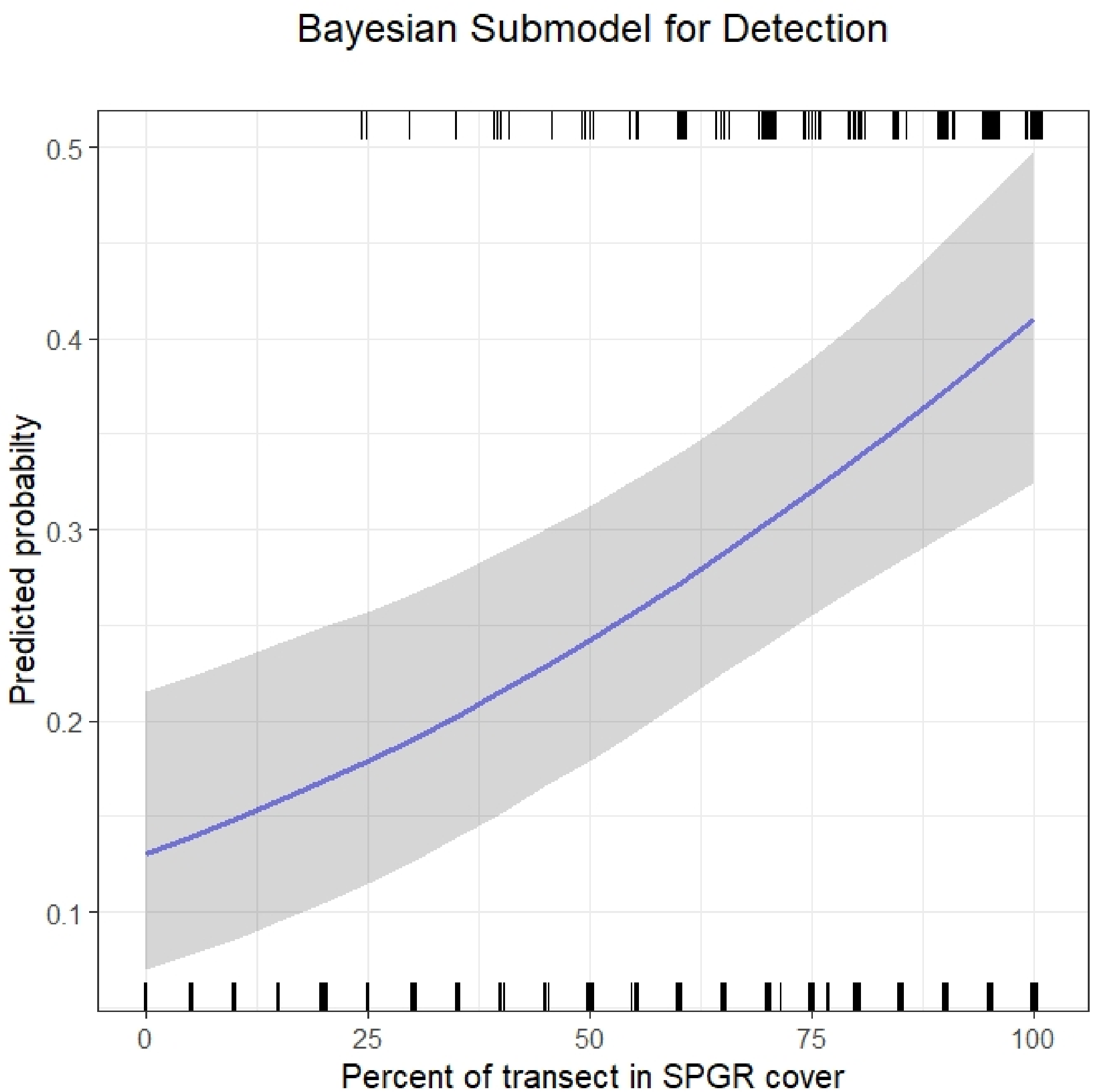


Figure 2. The predicted probability of detecting at least 1 spruce grouse pellet, given a site is truly used, as a function of the proportion of the survey transect located in spruce grouse (SPGR) cover (i.e., all cover types). The blue line denotes the predicted mean, the gray polygon denotes the 95% credible interval, the lower rug shows the distribution of measured covariate values for sites where pellets were not detected and upper rug shows covariate values at sites where pellets were detected. The prediction is conditional on a single-visit survey to used sites with other covariates held at mean values.

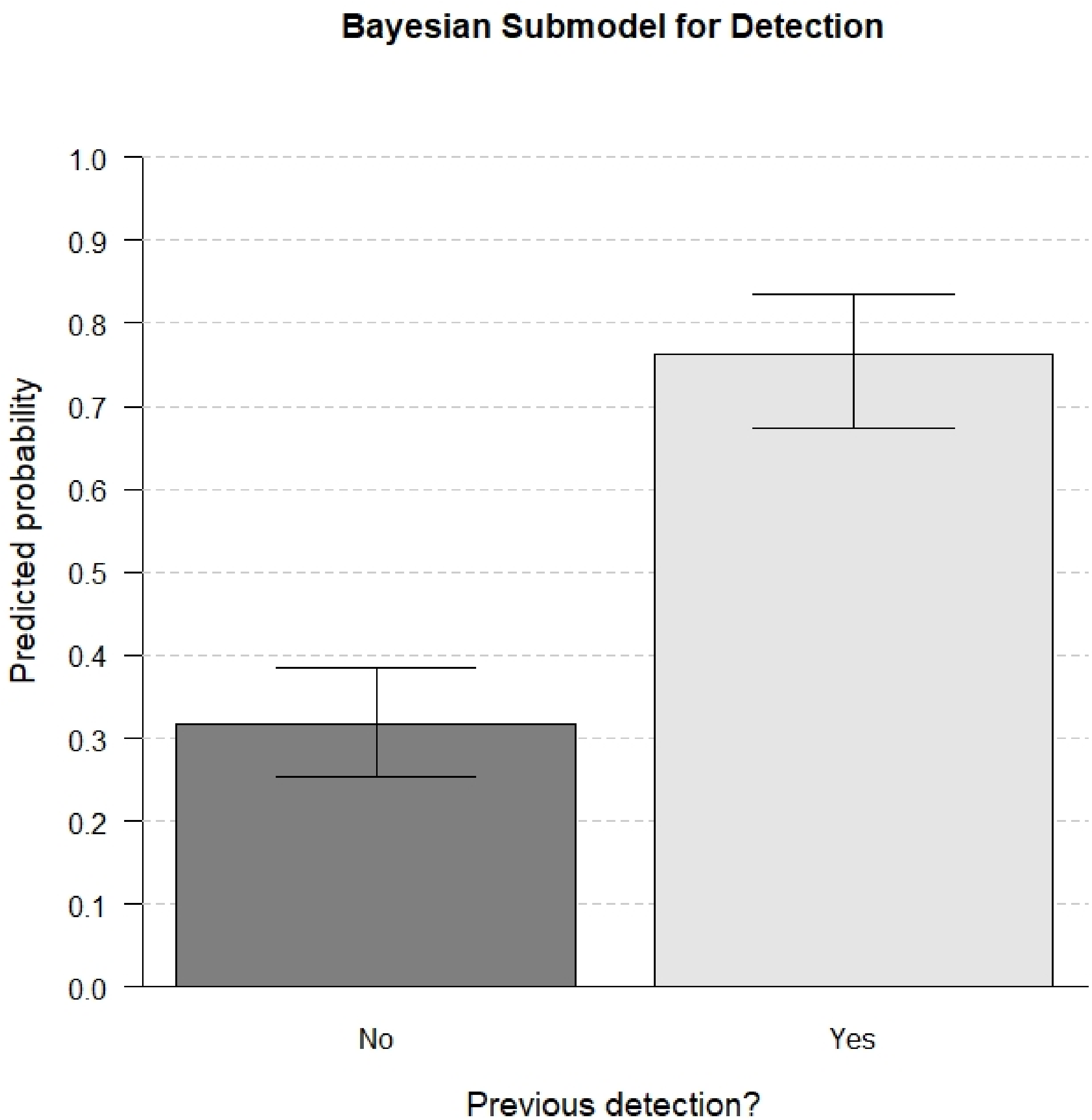


Figure 3. The predicted probability of detecting at least 1 spruce grouse pellet, given a site is truly used, as a function of previous detections. The prediction is conditional on other covariates held at mean values. The error bars denote 95% credible intervals.

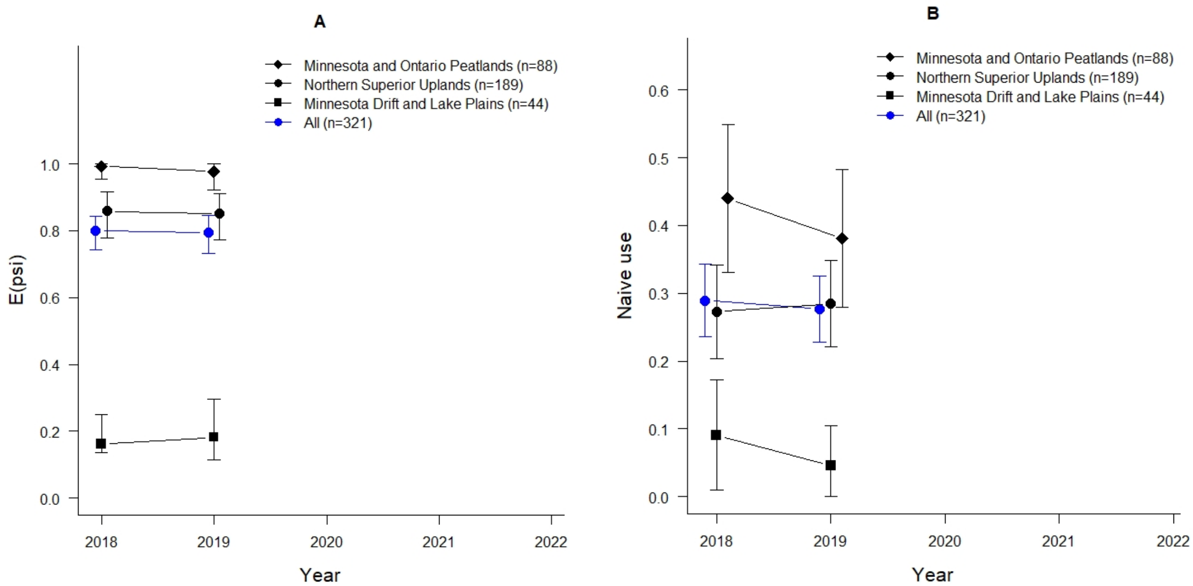


Figure 4. Example of potential monitoring plots based on A) E(psi) from the hierarchical dynamic occupancy model, and B) naïve use (proportion of sites where pellets were detected) assuming a single-visit operational survey. Error bars denote 95% credible intervals and 95% confidence intervals, respectively.