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Evaluation of Population Monitoring Procedures for Sharp-tailed Grouse in the Eastern Upper Peninsula of Michigan

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Abstract

We conducted sharp-tailed grouse (*Tympanuchus phasianellus*) surveys along perimeter roads of 37, 1-mi² sections in the eastern Upper Peninsula of Michigan and visited each section three times during the period April-May, 2009. We estimated sharp-tailed grouse occupancy and detection probabilities using 14 different models and used model-weighting to obtain overall estimates of these parameters. Our top-ranked models suggested little difference in grouse occupancy rates of sections randomly selected from 167 sections with < 50% forest cover and sections that we surveyed because they were occupied one or more years since 1995. Models that related detection probabilities to the amount of interfering noise, time from sunrise, date, and wind speed received the highest weights, but a model with a constant detection probability was also among the five best models. Our model-weighted estimate of occupancy was 0.55 (SE = 0.11) and our estimate of detection probability was 0.54 (SE = 0.11). Our occupancy rate estimates suggest about 93 mi² (95% confidence interval: 58 – 125 mi²) of occupied sharp-tailed grouse range within our study area. Simulations suggest that three visits per section per year was a relatively efficient survey design, but relatively large sample sizes (i.e., exceeding 100 sections) would be required to achieve highly precise (coefficient of variation < 10%) estimates of annual occupancy rates. However, survey efforts approximating those implemented in our study may be adequate to monitor trends over three-year or longer planning cycles, depending on management goals. If a sharp-tailed grouse hunting season is reopened in the eastern Upper Peninsula, we recommend annual population monitoring through implementation of survey protocol used in our study along with a relatively conservative harvest strategy leaving a portion of the study area closed to hunting. We also recommend utilizing survey data to evaluate impacts of landscape-scale habitat modification on sharp-tailed grouse distribution.

Introduction

Michigan is on the eastern edge of the occupied sharp-tailed grouse range in the United States, although these birds occupy habitats as far east as Quebec in Canada (Silvey and Hagen 2004). The primary sharp-tailed grouse range in Michigan during the 1990s was the eastern

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Upper Peninsula where distribution and abundance was associated with availability of relatively large grassland and grassland-shrub complexes (Maples and Soulliere 1996).

There is public interest in the status of sharp-tailed grouse populations in Michigan because of existing viewing opportunities and the potential for re-establishing recreational hunting. Wildlife managers have additional motivation for monitoring sharp-tailed grouse, as this species is sensitive to loss of contiguous nonforested habitats and its presence may be representative of opening sizes that indicate minimum thresholds for other associated wildlife species. Although there is no established population objective for sharp-tailed grouse in Michigan, wildlife biologists hope to maintain a viable population of sharp-tailed grouse that could support both hunting and non-consumptive recreational activities in the eastern Upper Peninsula. The sharp-tailed grouse population was thought to be declining in Michigan during the 1990s, but existing population monitoring procedures may not adequately represent underlying changes in distribution and abundance. Historic monitoring of sharp-tailed grouse populations largely relied on counts at established leks (Maples and Soulliere 1996) and these surveys lacked a defined sampling and data analysis framework to minimize bias in population trends inferred from lek count indices. Also, there is some evidence that sharp-tailed grouse populations are cyclic over about ten-year intervals (Ammann 1957), so decades of monitoring may be required to resolve changes in abundance associated with short-term cycles versus longer-term changes in population dynamics. The Department of Natural Resources (DNR) Wildlife Division recognized a need to evaluate sharp-tailed grouse monitoring procedures and supported research conducted by Michigan Technological University during 2005-07 to study sharp-tailed grouse lekking behavior (Drummer et al. 2008). The purpose of our study was to develop and evaluate revised procedures for monitoring sharp-tailed grouse in the eastern Upper Peninsula. Specific objectives were to: 1) estimate sharp-tailed grouse occupancy rates within potentially suitable habitats, 2) account for factors that might influence habitat occupancy or detection of sharp-tailed grouse, and 3) simulate the effects of sampling intensity on precision of occupancy rate estimates.

Study Area and Methods

We focused our sampling on largely unforested lands within eastern Upper Peninsula Townships north of 42N and east of 3W (Fig. 1). Using existing geographic information system land use/land cover data (1998 USGS digital Orthophoto Quadrangles), we randomly selected 20 sections (1 mi²) among 167 sections meeting the criterion of $\leq 50\%$ forest cover; this landscape composition was considered potentially suitable sharp-tailed grouse habitat (Ammann 1957). The forest cover criterion likely eliminated some occupied sections, but our intent was to avoid conducting surveys in many sections unlikely to contain sharp-tailed grouse leks so that sampling would be more efficient. In addition to the 20 randomly selected sections, we identified 17 sections for sampling that contained one or more leks since the mid-1990s (Fig. 1). Based on discussion with wildlife and land managers, we identified an area east of Interstate 75 being considered for a sharp-tailed grouse hunting season in the future. Thus, our sampling resulted in a total of 37 sections for survey, 23 sections within the potential hunt area and 14 west or south of the potential hunt area.

We designated April 15–May 5 as the survey period, and directed survey participants to avoid mornings when high winds (> 15 mph) or precipitation were predicted, although meeting these criteria was not always possible. Each observer was assigned three sections to survey each morning and they began surveying one of the three sections one-half hour before sunrise; each set of three sections was surveyed on three separate mornings and observers varied the order sections were surveyed on different mornings. We distributed eight listening/observation stops along roads bordering each section and provided maps showing locations of survey stops to observers. Some sections did not have roads around the entire border, so for those sections,

we distributed eight stops along available roads. Observers began at the southwest section corner (stop 1) and at each stop (approximately every one-half mile) exited the vehicle and listened and watched for sharp-tailed grouse for four minutes before departing for the next stop. When sharp-tailed grouse were detected, observers used a compass to measure bearings of the direction birds were seen or heard. Observers also recorded start and end times, wind speed at the beginning of the survey, and noise potentially interfering with detection of sharp-tailed grouse vocalizations (0 = none, 1 = low, or 2 = high noise).

Our data analysis considered section as the sampling unit (as opposed to survey stops) and we classified sections as occupied or unoccupied for each morning based on the following criteria:

1. **Occupied sections:** observer visually detected sharp-tailed grouse at ≥ 1 stops, or bearings of vocalizations indicated birds were located within the survey section.
2. **Unoccupied sections:** observer either did not visually detect sharp-tailed grouse on any stop or bearings of all vocalizations indicated occupancy was within adjacent sections.

We estimated the proportion of sections occupied (Ψ) and detection probabilities (ρ) using the analytical methods described by MacKenzie et al. (2002) and used the computer program PRESENCE to conduct the analysis (Hines 2006). We analyzed a series of different models and considered two covariates for occupancy: the covariate “random” was coded 1, if the site was chosen randomly and 0 if the site was previously occupied by sharp-tailed grouse (i.e., section had a lek documented in previous years). We also modeled occupancy as a function of “hunt” which was 1 if the section was within the area being considered for a hunting season and 0 otherwise. We also considered models which allowed detection probabilities to vary among surveys and which related detection probabilities to the following covariates: survey start times relative to sunrise (timefrsunrise), wind speed (wind), Julian date (date), completeness of road coverage (roads = 1, if section was bordered by roads on all sides, 0 if otherwise), and the sum (over all stops within a section) of noise rankings recorded within a morning (noise). We added a variable post-hoc to the analysis which represented the standardized residuals of a linear model contrasting noise rankings among observers (noisestand); we suspected a large degree of variability in how observers ranked noise so we included this variable to help account for different perceptions of noise among observers. We ranked all models using Akaike’s information criterion (AIC) and used model-averaging to estimate overall occupancy and detection probabilities (Burhnam and Anderson 2002).

We used model-averaged occupancy and detection probabilities and associated variances to simulate results assuming sampling plans different from that used in this study. We varied the number of sections surveyed from 20 to 60 and the number of visits per section from two to six per year. We ran each simulation 1000 times and calculated coefficients of variation (SE (estimate) / estimate x 100) for each survey scenario (30 sample size-visits/section combinations).

Results and Discussion

The spatial distribution of sample sections was not uniform across the study area and the previously occupied sections were distributed more northerly compared to the distribution of randomly selected sites (Fig. 1). We constrained random sampling to sections with > 50% openland, so this limited our inference to 167 sections that met this criterion. The spatial distribution of all surveyed sections approximated the spatial coverage of high quality habitat as defined by a sharp-tailed grouse habitat model developed by Mike Donovan (Michigan DNR, Lansing MI, class values 6-8 upland types, unpublished model output). The noticeable lack of

randomly selected and previously occupied sections near the center of the study area (Fig. 1) is associated with the Munuscong State Forest, which is largely forested.

Twelve observers completed 111 sharp-tailed grouse surveys (37 sections, each surveyed three times) during the period April 16–May 4, 2009. Survey starting times ranged from 40 minutes before sunrise to 150 minutes after sunrise; lek attendance of sharp-tailed grouse in Michigan peaks near sunrise and then declines by about 20% within three hours after sunrise (Drummer et al. 2008). If detection probabilities vary with degree of lek activity, then we would expect variation in detection probabilities among surveys because of the protracted survey period. The mean time required to survey an individual section was 48 minutes (range = 35 – 76 minutes; SD = 6.7 minutes). Observers detected sharp-tailed grouse one or more times within 18 sections (48.6 %); however, sharp-tailed grouse were detected on all three survey visits within only four sections.

The most complex model we fit to our data included all covariates associated with occupancy and detection probabilities and this was the lowest-ranked model (AIC weight, $w_i = 0.002$) among the 14 we considered (Table 1); however, there was no evidence indicating a lack of fit for this model ($\hat{c} = 0.35$). The top-ranked model ($w_i = 0.492$) included constant occupancy while detection probabilities varied with noise ratings. Although this model was at first intuitively appealing, the direction of noise effect was reverse of what we expected—higher detection probabilities associated with higher noise rankings. The model which included the noise variable standardized to observers ranked much lower ($w_i = 0.034$). Since ratings of interfering noise are likely quite variable among observers, it is possible the model with the unstandardized noise ratings ranked highly because the noise variable may have also captured variation associated with other observer effects. There may also be reasons why detection probabilities would be higher under certain atmospheric conditions which are conducive to sound transfer (e.g., cold, calm conditions) that would also increase transfer of interfering noises. The second, third, and fourth-ranked models were moderately supported (Table 1) and indicated that detection probabilities could have been constant (third-ranked model) or decreasing with later survey start times (second-ranked model) or survey dates (fourth-ranked model). There was some evidence randomly selected sections had lower sharp-tailed grouse occupancy rates compared to sections historically occupied, but this model received no more weight than one suggesting higher occupancy of sections within the proposed hunt area. Our choice of model sets seems unlikely to have dramatically affected our overall parameter estimates as the individual model estimates of occupancy were relatively stable (range 0.52 – 0.58) among the models we considered (Table 2). Also, the model-averaged estimate of occupancy was 0.55 (SE = 0.11), which is near the middle of the range of individual model estimates (Table 2). The model-averaged estimate of detection probability was 0.54 (SE = 0.11; Table 2) and this estimate highlights the need to do replicate surveys of each section and to account for imperfect detection when estimating sharp-tailed grouse occupancy rates. Our occupancy rate estimates suggest about 93 mi² (95% confidence interval: 58 – 125 mi²) of occupied sharp-tailed grouse range within the study area.

A simulated estimate ($\hat{\Psi} = 0.56$; SE[$\hat{\Psi}$] = 0.10) of occupancy based on the sample size (N = 37) and three visits per section as used in our study was similar to our model-averaged estimate. Simulations over a range of other survey designs showed decreasing coefficients of variation (CV's) of occupancy estimates with increasing numbers of sites surveyed and increasing visits to each site (Fig. 2). There were no simulations in which the CV's went below ten percent and there was a declining rate of reduction in CV's with increased sample size; additional simulations not represented in our figures suggest that over 100 sections would have to be surveyed three times per year to achieve a CV near ten percent. We advise against reducing the number of visits from three to two per season as there is substantial gain in precision by having three versus two visits per site (Fig. 2). Survey cost and effort can be

approximated by multiplying number of sites by visits per site (survey units). When survey units are plotted against CV's it is apparent that three visits per site is a relatively efficient sampling design compared to other alternatives (Fig. 3). This analysis also suggests that rate of improvement in precision as a result of increasing sample size declines rapidly after about 200-250 survey units.

Management Implications

The potential for reopening a sharp-tailed grouse hunting season in the eastern Upper Peninsula increases the need to implement revised monitoring procedures for this population. Although obtaining highly precise estimates of annual change in occupancy is likely to be cost-prohibitive, trends over periods of three or more years would likely be reliable, but the level of precision needed will depend largely on management goals. We did not incorporate estimates of abundance into this survey, however, positive occupancy-abundance relationships are thought to be robust as changes in occupancy rates have been found to generally follow changes in local abundance for a variety of species and over different spatial scales (Zuckerberg et al. 2009). We recommend estimating abundance within a sample of occupied sections in future surveys so that the relation between abundance and occupancy can be evaluated for sharp-tailed grouse in the eastern Upper Peninsula. A relatively conservative harvest strategy that includes opening only a portion of the range to hunting would allow biologists to monitor overall occupancy in the eastern Upper Peninsula as well as occupancy within areas open and closed to hunting. The sharp-tailed grouse season could be opened in a portion of the range whenever occupancy rate point estimates remained above some threshold level. Similarly, the sharp-tailed grouse season could be closed if occupancy within the area open to hunting declines below the threshold. If this relatively risk-averse harvest strategy were adopted, then models incorporating temporal changes in occupancy within areas closed and open to hunting (i.e., an interaction between hunt and year) would be of particular interest for assessing the impacts of a hunting season. Our study also has implications for evaluating impacts of habitat management as we would expect distribution of sharp-tailed grouse to expand or contract in response to changes in distribution and quality of habitat patches and how they are arranged across the landscape. We recommend incorporating landscape-scale habitat covariates into future analysis of occupancy rates and to evaluate impacts of habitat management on sharp-tailed grouse distribution and abundance in the eastern Upper Peninsula.

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Table 1. Candidate models considered for estimating sharp-tailed grouse occupancy (ψ) and detection probabilities (ρ) during surveys of 1 mi² sections in the eastern Upper Peninsula of Michigan, April-May, 2009. For each model, we report number of parameters (K), Akaike's information criterion (AIC), difference in AIC relative to smallest AIC in the model set (Δ_i), and AIC weight (w_i).

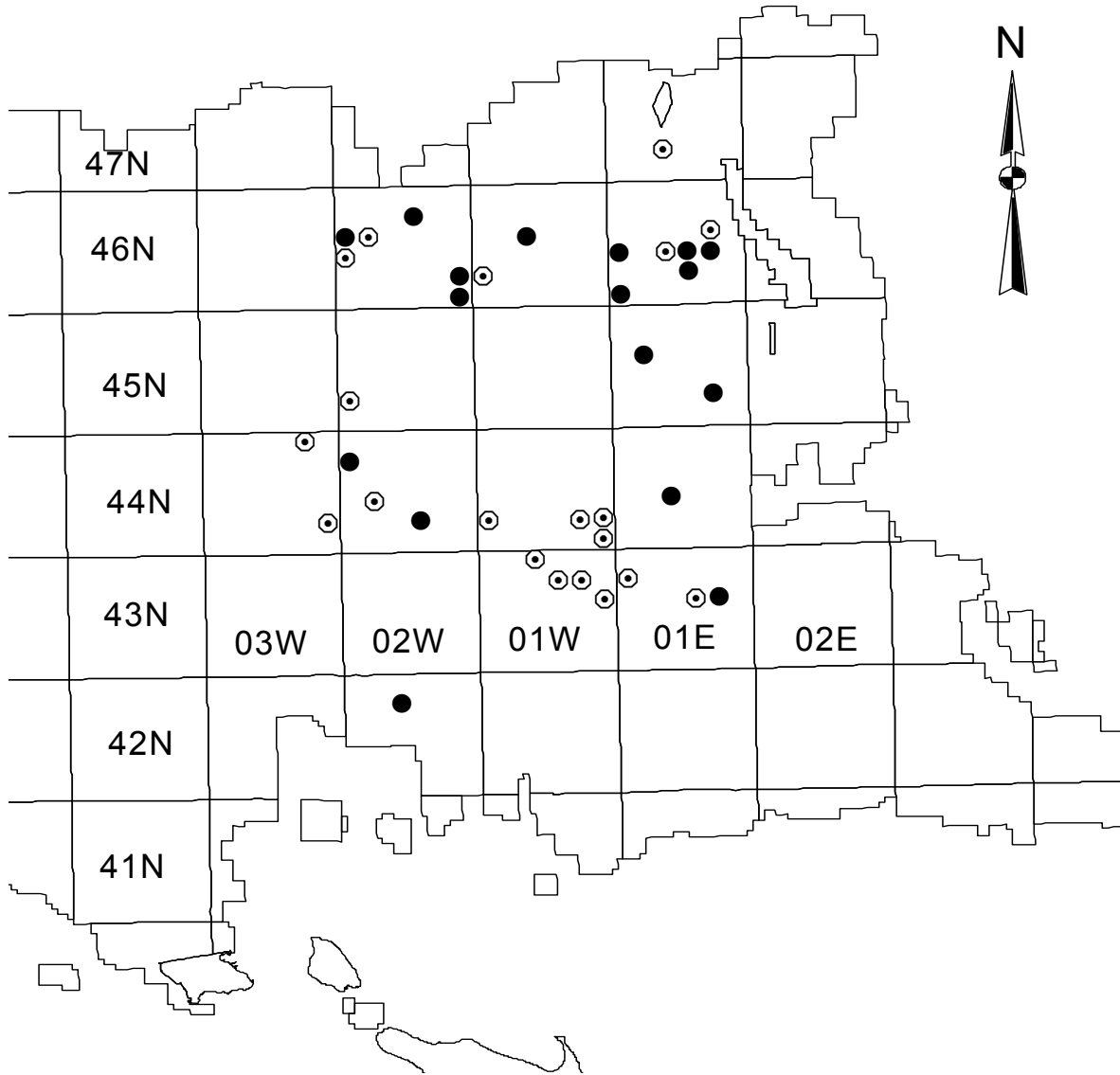
Model ¹	K	AIC	Δ_i	w_i
Ψ (.), ρ (noise)	3	120.7	0.00	0.492
Ψ (.), ρ (timefrsunrise)	3	124.0	3.27	0.096
Ψ (.), ρ (.)	2	124.2	3.54	0.084
Ψ (.), ρ (date)	3	124.3	3.64	0.080
Ψ (.), ρ (wind)	3	125.6	4.88	0.043
Ψ (.), ρ (roads)	3	125.7	4.98	0.041
Ψ (hunt), ρ (.)	3	125.9	5.24	0.036
Ψ (random), ρ (.)	3	126.0	5.31	0.035
Ψ (.), ρ (noisestand)	3	126.1	5.36	0.034
Ψ (.), ρ (wind, timefrsunrise, noisestand, date)	6	126.9	6.25	0.022
Ψ (.), ρ (survey-specific)	4	127.7	6.98	0.015
Ψ (random, hunt), ρ (.)	4	127.7	6.98	0.015
Ψ (.), ρ (roads, Wind, timefrsunrise, noisestand, date)	7	128.9	8.20	0.008
Ψ (random, hunt), ρ (roads, Wind, timefrsunrise, noisestand, date)	9	132.0	11.31	0.002

¹ All models which include covariates also include an intercept parameter. Models with parenthetical period [i.e., (.)] indicate that either occupancy or detection probabilities were constant. Noise = sum of noise rankings across all listening stops for each section (e.g., 0 = no noise, 1 = low noise, and 2 = high noise); noisestand = standardized residuals from a linear model predicting noise level by observer; timefrsunrise = start time of survey relative to local sunrise; date = Julian date of survey; wind = wind speed ranking (1 = no wind, 2 = 1-3 mph wind, 3 = 4-7 mph wind, 4 = 8-12 mph wind, and 5 = 13-18 mph wind); roads = 1 if roads border entire section, = 0 if road coverage incomplete; hunt = 1 if section is within area being considered for opening to hunting, = 0 if outside proposed hunt area; random = 1 if section was randomly selected for survey, = 0 if section was chosen because of historic lek location; survey-specific = detection probabilities could vary among the three surveys completed for each section.

Table 2. Candidate models considered and associated estimates of sharp-tailed grouse occupancy ($\hat{\Psi}$) and detection probabilities ($\hat{\rho}$) during surveys of 1 mi² sections in the eastern Upper Peninsula of Michigan, April-May, 2009.

Model	$\hat{\Psi}^1$	SE ($\hat{\Psi}$)	$\hat{\rho}^1$	SE($\hat{\rho}$)
Ψ (.), ρ (noise)	0.585	0.109	0.499	0.101
Ψ (.), ρ (timefrsunrise)	0.529	0.093	0.573	0.099
Ψ (.), ρ (.)	0.524	0.092	0.584	0.079
Ψ (.), ρ (date)	0.530	0.093	0.576	0.080
Ψ (.), ρ (wind)	0.519	0.090	0.589	0.107
Ψ (.), ρ (roads)	0.530	0.094	0.576	0.110
Ψ (hunt), ρ (.)	0.524	0.126	0.584	0.079
Ψ (random), ρ (.)	0.524	0.127	0.584	0.079
Ψ (.), ρ (noisestand)	0.524	0.091	0.585	0.101
Ψ (.), ρ (wind, timefrsunrise, noisestand, date)	0.535	0.094	0.565	0.135
Ψ (.), ρ (survey-specific)	0.523	0.091	0.586	0.120
Ψ (random, hunt), ρ (.)	0.524	0.154	0.585	0.079
Ψ (.), ρ (roads, Wind, timefrsunrise, noisestand, date)	0.537	0.094	0.565	0.152
Ψ (random, hunt), ρ (roads, Wind, timefrsunrise, noisestand, date)	0.547	0.160	0.559	0.149
Model-averaged	0.555	0.108	0.540	0.106

¹For models with covariates or survey-specific estimates, we averaged occupancy or detection probability estimates across sites and survey periods to obtain study area and survey-wide estimates.



Sharp-tailed Grouse Study Area Legend
 ● Previously occupied survey sections
 ⊙ Randomly selected survey sections
 □ Township Boundaries

Figure 1. Sharp-tailed grouse survey area in the eastern Upper Peninsula of Michigan, 2009. Surveys were conducted along roads bordering; 1) a sample of 17 previously occupied (sites with leks in previous years) 1 mi² sections (solid circles), and 2) a random sample of 20 sections (bulleted circles) selected from 167 sections containing > 50% open land cover (nonforested).

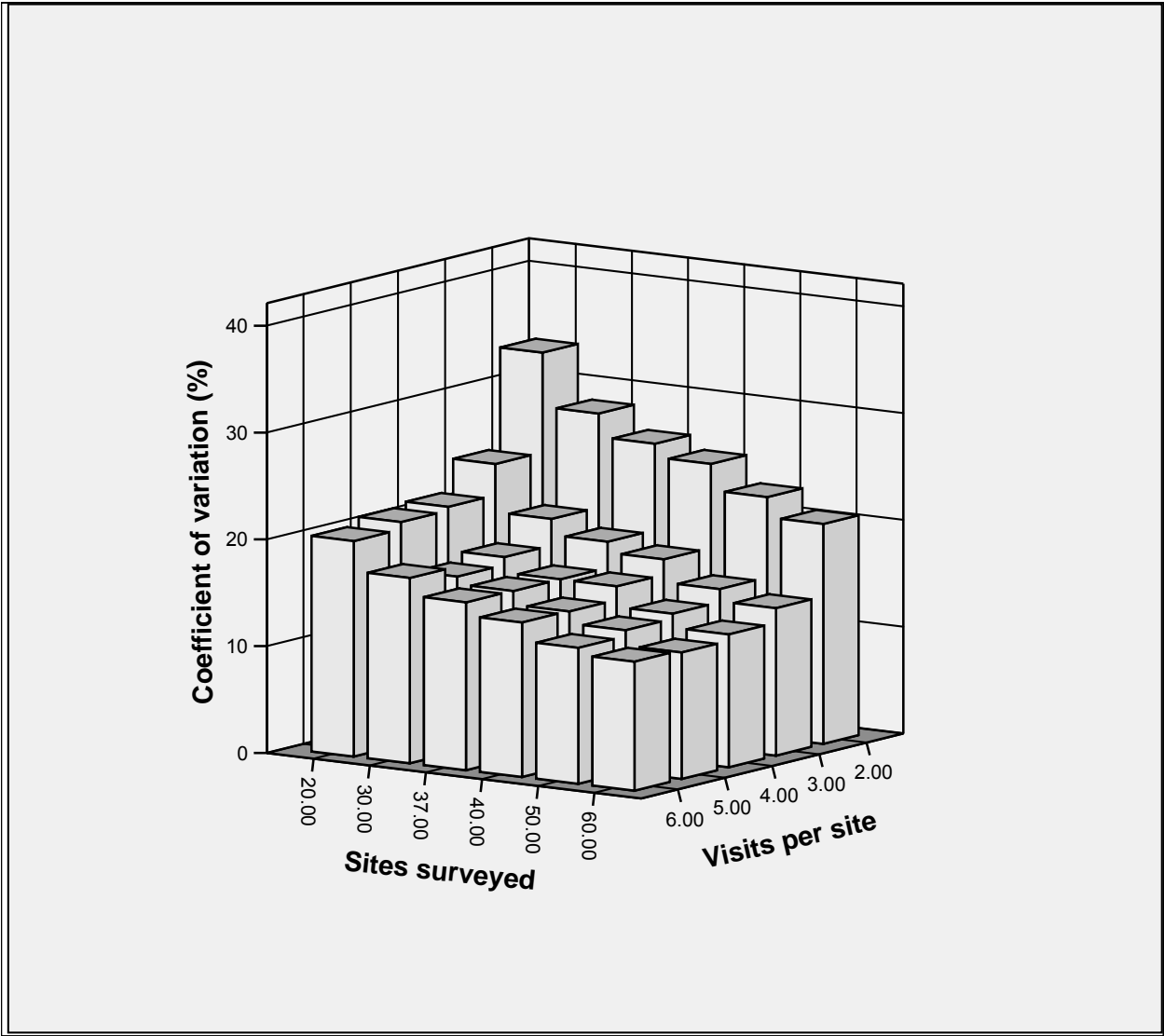


Figure 2. Simulated coefficients of variation for sharp-tailed grouse occupancy rates in the eastern Upper Peninsula of Michigan under sampling plans that vary with number of sites (sections) surveyed and number of site visits per year.

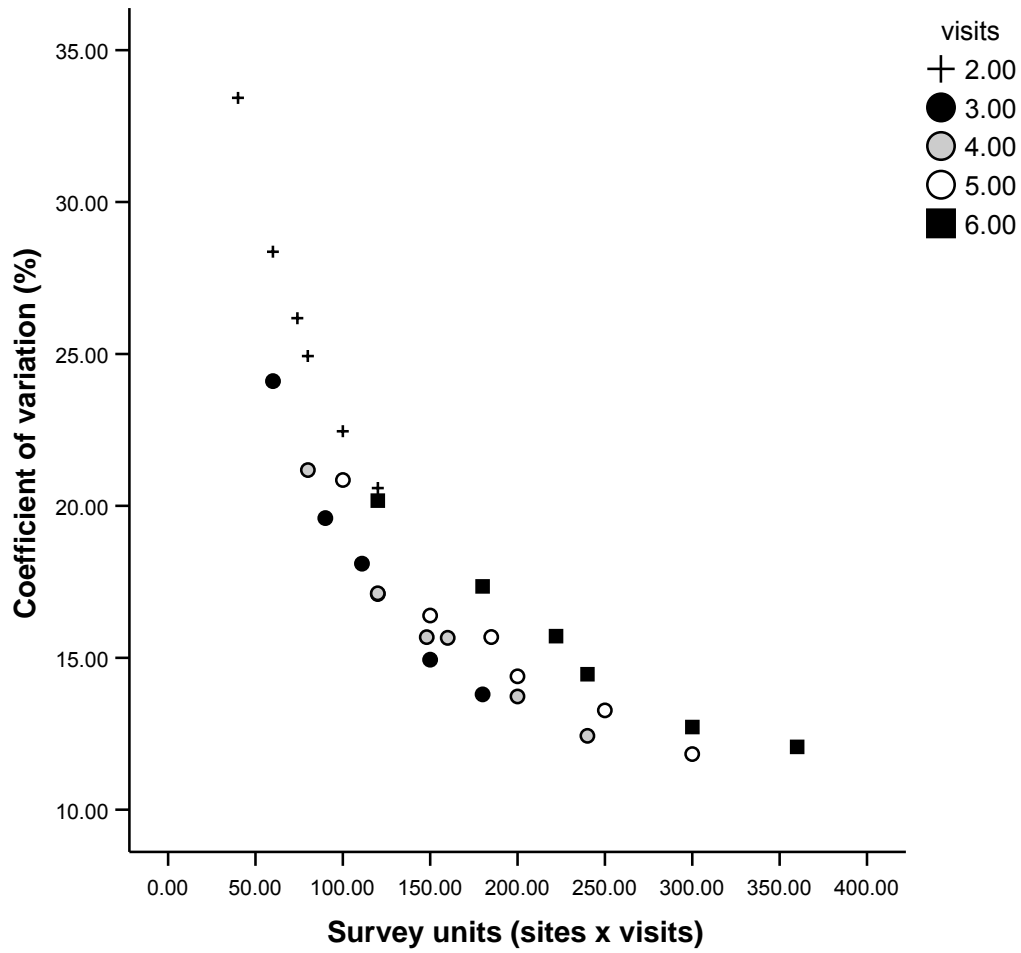


Figure 3. Simulated coefficients of variation for sharp-tailed grouse occupancy rates in the eastern Upper Peninsula of Michigan as a function of the number of survey units and number of visits per site.