Monitoring Ruffed Grouse in the Black Hills: Protocol and User's Manual for the Occupancy Spreadsheet Program

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Abstract

Monitoring ruffed grouse (*Bonasa umbellus*) in the Black Hills National Forest is a priority for forest managers due to the bird's status as the management indicator species for quaking aspen (*Populus tremuloides*) and its value to hunters and other recreational groups. We conducted drumming surveys, estimated occupancy, and assessed the influence of sampling and site variables to determine benchmark levels of precision for ruffed grouse occupancy and detection probability estimates. Using these estimates and simulations, we developed a monitoring protocol for ruffed grouse in the Black Hills. We then created a user-friendly program that uses monitoring data in Microsoft Excel to calculate ruffed grouse occupancy and detection probability estimates. (The program is available at http://www.fs.fed.us/rm/forest-grassland-lab/products/ruffed-grouse-occupancy.) The user's manual herein briefly describes the theory behind occupancy modeling and explains how to enter and analyze data and interpret results from drumming surveys. Additionally, we provide recommendations on which type of occupancy and detection probability estimates should be calculated, depending on the needs of the investigator. The program does not provide precision estimates for heterogeneous occupancy or detection probabilities.

***Keywords*:** detection probability, indicator species, monitoring, occupancy, quaking aspen, ruffed grouse

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Monitoring Protocol for Ruffed Grouse in the Black Hills National Forest

Introduction

Ruffed grouse are a popular game species that depend on the health and availability of specific habitats (Barber and others 1989, Madison 1969). Ruffed grouse inhabit early successional deciduous forests with inclusions of mature vegetation (e.g., aspen [*Populus* spp.]) for cover from predators and acquisition of food (Kubisiak 1985, Maxson 1989, Sharpe and others 1997). Because ruffed grouse depend on specific vegetation (usually aspen) for food and dense woody cover, they are considered an important indicator species for the condition and abundance of aspen communities (Barber and others 1989). As a result, ruffed grouse were selected as the management indicator species for quaking aspen (*Populus tremuloides*) in the Black Hills National Forest (BHNF) (U.S. Forest Service 1997).

Fire suppression, cattle grazing, and pine (*Pinus* spp.) expansion for timber harvest have caused extensive changes in the vegetation composition in the BHNF (Froiland 1990, Bartos and Shepperd 2003). In particular, aspen communities have declined and have been replaced by either white spruce (*Picea glauca*) or ponderosa pine (*Pinus ponderosa*). Thus, management strategies such as burning, cutting, and fencing have been used in the last 20 years in an attempt to halt and reverse aspen declines (U.S. Forest Service 1997, Bartos and Shepperd 2003). To evaluate whether aspen management and associated strategies have been effective in increasing the extent of aspen and ruffed grouse in the BHNF, monitoring is a necessity. Monitoring will provide managers with information on ruffed grouse status, trends, and habitat associations as it relates to implementation of the BHNF Forest Plan.

Past monitoring activities of ruffed grouse in the BHNF have not effectively evaluated ruffed grouse population trends because of inconsistent surveys, bias from conducting surveys only in vegetation types where ruffed grouse were expected to occur, and the failure to consider imperfect detection (SAIC 2005, M. A. Rumble, U.S. Forest Service, personal communication). Occupancy modeling is one alternative for monitoring ruffed grouse in the BHNF that overcomes some of these deficiencies. Occupancy models have recently become popular because they do not assume all individuals are detected, only require the investigator to determine the presence or absence of the species from repeated surveys, and can be robust predictors of the proportion of the study area occupied when appropriate predictor variables are considered (MacKenzie and others 2002, Crossland and others 2005, MacKenzie and others 2006). Additionally, using a multi-year design, an examination of the metapopulation dynamics of the species is possible by evaluating local extinction and colonization probability trends in the study area (Hanski 1994, MacKenzie and others 2003, MacKenzie and others 2006). These trends might also be useful for future monitoring purposes as well as prescribing effective management strategies.

Drumming surveys (Petraborg and others 1953, McBurney 1989) paired with occupancy modeling were used to estimate ruffed grouse occupancy and detection probabilities in 2007 and 2008 (Hansen and others *in press*). Those estimates were used in multi-year sample site simulations to determine the required number of sites and surveys to meet occupancy precision benchmarks (Hansen 2009). We used the results from Hansen (2009) to develop a monitoring protocol that will provide statistically defensible results on the status and trends of ruffed grouse in the BHNF. We describe how to complete this protocol below.

Sample Site Determination

To use an occupancy modeling design for monitoring, the investigator must define the sampling unit (i.e., site) and decide how the presence or absence of the species will be determined at each site (MacKenzie and Royle 2005). The most widely used monitoring technique for ruffed grouse is roadside drumming counts (Petraborg and others 1953, McBurney 1989). This technique involves stopping at established points along roads during the spring to listen for male ruffed grouse drumming. This is an efficient and effective method because male ruffed grouse drum consistently throughout the early morning (approximately every 2-4 minutes), making it easy to determine the presence of a ruffed grouse at a listening point (McBurney 1989). This technique is also particularly well suited for use in the BHNF given the high road densities of 3.2 km/km^2 (Rumble and others 2005).

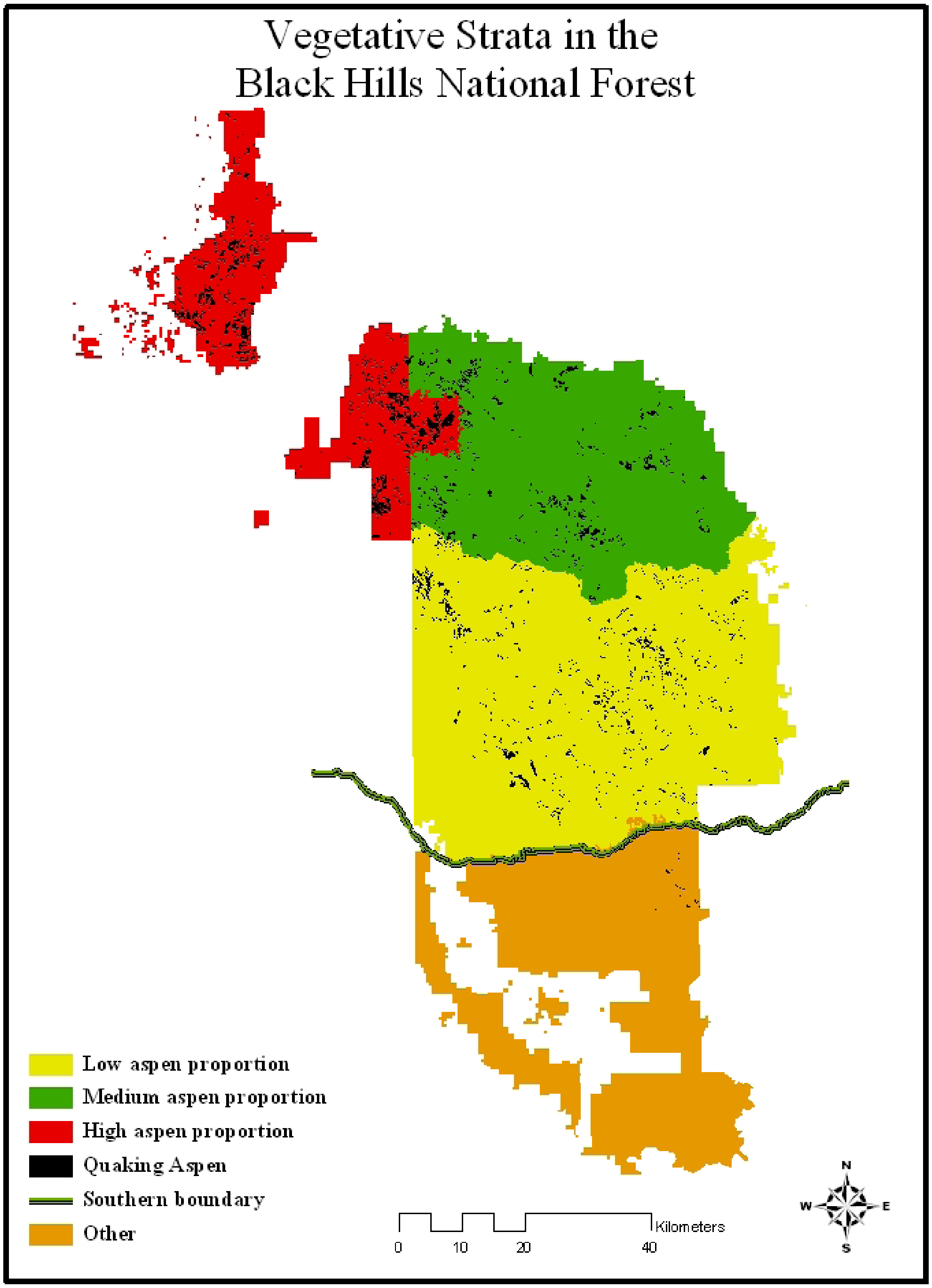
For drumming surveys, the most appropriate sampling unit is the radial area surrounding an established listening point. The radius is determined as the farthest distance at which a ruffed grouse can be heard. During 2007 and 2008 ruffed grouse drumming surveys in the BHNF, Hansen (2009) found that the farthest distance at which he could hear a ruffed grouse was 550 m. Thus, investigators should consider the 550 m radius surrounding each survey point (95 ha area) as the site.

Determining Survey and Site Requirements

Estimating the number of repeat surveys and the number of sites to survey during a monitoring season necessitates prior knowledge of the occupancy and detection probability of the study species in the study area (MacKenzie and Royle 2005, MacKenzie and others 2006). Using occupancy and detection probability estimates from 2007 and 2008 (Hansen and others *in press*), Hansen (2009) found that three repeat surveys were the most efficient when detection probabilities were >0.3 during the monitoring season. Because the probability of detecting ruffed grouse in the BHNF was 0.27 (Hansen and others *in press*), and because this probability will increase if surveys are completed during optimal detection conditions, investigators should conduct at least three surveys at each site during future monitoring practices.

To calculate the appropriate number of sites to survey, the investigator must first decide upon a sampling design. Hansen (2009) found that conducting the same number of repeat surveys at each site and surveying the same sites each year was the most efficient monitoring design for ruffed grouse in the BHNF. Next, the investigator must determine whether sites will be stratified throughout the study area or be randomly distributed. In the BHNF, Hansen and others (*in press*) found that ruffed grouse occupancy probabilities differed across strata defined by extent of aspen (Map 1). Therefore, it will be most efficient to stratify the sample and calculate separate site requirements for each stratum.

Using occupancy estimates for each stratum, an average detection probability, and three repeat surveys, the investigator may estimate the number of sites necessary to achieve the desired precision by entering the appropriate values into the multi-season application in Program GENPRES (Bailey and others 2007; http://www.mbr-pwrc.usgs.gov/software/presence.html). Hansen (2009) found that 70, 171, and 455 sites should be surveyed each year for at least four consecutive years in high, medium, and low strata, respectively, to achieve an occupancy estimate within ± 50% of the true population occupancy, 95% of the time (given occupancy and detection probability estimates in the BHNF in 2007 and 2008). Ultimately, the sampling requirements will be determined by the desired amount of precision and the occupancy and detection probabilities of ruffed grouse in the BHNF.



Map 1. Vegetation strata in the Black Hills National Forest. Strata were delineated by district with slight modifications to district boundaries. Strata represented low, medium, and high proportions of quaking aspen.

Cost

The primary costs associated with ruffed grouse monitoring will be manpower and vehicles. For future monitoring, we assume surveys will be completed from 1 May to 1 June and surveys will be conducted 5 days each week. Thus, there will be a maximum of 21 days available to complete surveys, assuming surveys will not be completed on days with inclement weather. If the number of sites recommended by Hansen (2009) (70, 171, and 455 sites in high, medium, and low strata, respectively) are surveyed three times each, then the necessary number of survey events will equal:

3 surveys * (70 high strata sites + 171 medium strata sites + 455 low strata sites) = 2,088 survey events

If each technician/volunteer can complete 10 surveys each day (Hansen 2009), then the estimated number of technicians/volunteers needed to complete all survey events will be:

2,088 survey events / (21 survey days * 10 surveys/day/technician) ≈ 10 technicians/volunteers

Each technician/volunteer will also need either a Forest Service or personal 4x4 vehicle to reach survey sites. During 2007 and 2008 surveys, each technician drove an average of 80 miles/day, depending on the distance to the survey routes (Hansen 2009). If 10 technicians drive 80 miles/day for 21 days, then 16,800 miles will be driven each year.

Finally, there will be equipment and maintenance costs such as All-Terrain Vehicles, Global Positioning Systems units, wind meters, thermometers, tire repair, oil changes, and so on. Total costs for a monitoring season will depend upon the amount technicians are paid and the number of volunteers recruited, the cost of gas and reimbursement rate, and the cost of equipment each season.

Note: These sample size estimates are on the high side. Our sample size estimates are based on occupancy and detection probability estimates from 2007 and 2008. Further, sample size estimates assume occupancy estimates are within ± 50% of the true population occupancy, 95% of the time (Hansen 2009). Managers might consider several sampling strategies given the numerous trade-offs among available personnel, sample size estimates, and monitoring costs. For example, annual monitoring in the high and medium strata will offer insight into the general status of ruffed grouse in the BHNF. Because monitoring in the low strata requires substantially more sampling effort than the medium and high strata, managers might consider relaxing the precision for monitoring this stratum. While site requirements and cost are high to achieve the benchmarks used by Hansen (2009), the estimated number of sites to achieve a particular level of precision will decline if occupancy of ruffed grouse increases. Sample site estimates and cost will also reduce if detection probability is maximized by monitoring during the month of May, during low wind speeds, near sunrise, and during good weather conditions (Hansen and others *in press*). Finally, multiple years of monitoring will reduce sample size estimates and cost, thus, a long-term commitment to monitoring is necessary. In summary, if fewer sites are surveyed, then fewer technicians/volunteers will be needed and less fuel will be consumed, which will reduce overall costs.

Site Identification

Once the sample size has been estimated, the investigator must then decide how and where to distribute the sites throughout the study area. To increase efficiency for 2007 and 2008 ruffed grouse surveys, Hansen (2009) placed survey sites along secondary (i.e., gravel) and primitive (i.e., dirt) roads using a stratified random sampling design, without replacement. Strata were defined by the proportion of aspen (low, medium, and high) compared to other vegetation, and a simple random sample was drawn within each stratum. Sites were not included along primary roads (i.e., paved and upgraded gravel roads) because traffic could interfere with the ability to hear drumming ruffed grouse. Further, Hansen (2009) constrained survey sites to be >1 mile apart to ensure independence among sites. Assuming the maximum distance a ruffed grouse can be heard is 550 m (Hansen 2009), approximately 91% of the BHNF is represented alongside these road systems.

We recommend that survey sites be selected from a random sample of the sites in each stratum monitored during 2007 and 2008 (Hansen 2009; Appendix A). There is a high degree of confidence that these sites are accessible and there is already two years of data on these sites, which will make occupancy trends more robust. However, if more sites are necessary in a stratum than what was previously sampled, sites should be randomly placed along secondary and primitive roads at least one mile apart using ArcGIS (Environmental Systems Research Institute, Redlands, California, USA). We also recommend dividing sites into regions and routes for organizational purposes and to maximize efficiency while monitoring. Region and route information are included for each site surveyed during 2007 and 2008 (Appendix A).

Survey Strategy

Survey conditions

It is important to conduct ruffed grouse drumming surveys during optimal detection conditions. In the BHNF, the optimal conditions for sampling ruffed grouse were between 1 May and 1 June, during wind speeds <10 mph, early in the morning (near sunrise), and when no precipitation (rain or snow) was occurring (Hansen and others *in press*). Thus, drumming surveys should be completed during May from half an hour before sunrise until 5 hours after sunrise and should not be conducted during poor weather such as high winds (>10 mph) or moderate to heavy precipitation.

Drumming surveys

At each site, the investigator should listen for drumming ruffed grouse for 5 minutes on each survey and record, on provided data sheets (Appendix B), whether or not a grouse was detected drumming. A standardized 5 minute survey is used because ruffed grouse typically drum every 2-4 minutes during the breeding season (McBurney 1989). If one or more grouse are detected, the investigator should record a "1" under the "presence/absence" column for the corresponding survey on the data sheet. If grouse are not heard, the investigator should record a "0." Other data that may be recorded at each site include date, time, temperature, weather conditions, and average wind speed (using a hand-held wind meter) during each survey. Although it is not necessary for monitoring, there is also space on the data sheet to record the azimuth and estimated distance (<50 m, between 50 and 150 m, >150 m) to the drumming ruffed grouse.

All sites should be surveyed once before the second survey is initiated. This order of surveys has some flexibility, but overall this should be the protocol. In total, at least 3 repeat surveys should be conducted at each site. Repeat surveys at individual sites should be spread across the sampling season (early May, mid-May, late May) and each repeat survey should be conducted at different times of the morning (at least an hour apart) to ensure that the time of survey does not influence detection of ruffed grouse. Additionally, repeat surveys should be conducted by different individuals to remove observer bias that may be associated with experience or ability to hear ruffed grouse drum.

Calculating Occupancy and Detection Probabilities

Once all surveys have been completed at all sites, the investigator should calculate occupancy and detection probability estimates using the Occupancy Spreadsheet Program described in Part II or other free software such as Program PRESENCE (MacKenzie and others 2006) or Program MARK (White and Burnham 1999). The Occupancy Spreadsheet Program calculates estimates for occupancy and detection probability, provides the ability to view results from previous years, and offers guidance for how to interpret results. It does not, however, calculate occupancy and detection probability trends using regression methods such as estimating the percent incline or decline within a certain confidence limit. If the investigator desires to calculate occupancy and detection probability trends using regression methods, we suggest consulting literature (e.g., Sauer and Droege 1990, Dixon and others 1998) to determine which method of trend estimation is most appropriate to meet the needs of the investigator.

Part II.

User's Manual for the Ruffed Grouse Occupancy Spreadsheet Program

Overview

Occupancy and detection probability estimates can typically be calculated using free software such as Program PRESENCE (MacKenzie and others 2006) and Program MARK (White and Burnham 1999). However, learning how to use these programs can be time consuming and difficult. To simplify the calculation of occupancy and detection probability estimates, we have developed a spreadsheet program in Microsoft Excel that makes all the necessary calculations. This program calculates occupancy and detection probability estimates for ruffed grouse in the Black Hills National Forest (BHNF) using data from annual monitoring that is recorded into the spreadsheet. The user may download the program at http://www.fs.fed.us/rm/forest-grassland-lab/products/ruffed-grouse-occupancy.

Description

The occupancy modeling spreadsheet program uses a maximum likelihood estimation approach and multinomial likelihood framework to calculate single-season occupancy and detection probability estimates for ruffed grouse in the BHNF using detection histories (presence/absence data) and covariate (variable) values recorded during each survey at the survey site. The model can be executed in either Microsoft Excel 2003 (XP) or 2007, and the majority of functions are executed using Visual Basic for Applications (VBA) code in modules attached to the Excel workbook. All covariates included in the model (e.g., date, wind speed, time, precipitation, area of quaking aspen [*Populus tremuloides*] and white spruce [*Picea glauca*] surrounding the site) are the parameters that were most influential on occupancy and detection probability during 2007 and 2008 spring ruffed grouse drumming surveys (Hansen and others *in press*).

This program includes separate worksheets for entering detection histories, sampling covariates that influence detection probability, and site covariates that influence occupancy. Each of these worksheets includes the 402 sites that were surveyed during 2007 and 2008 ruffed grouse drumming surveys (Hansen 2009) and 101 extra sites in case sample size increases in the future. Associated with each site are four survey events, allowing the user to complete up to four repeat surveys at each site, which was consistent with the level of sampling used and suggested by Hansen (2009). Each worksheet has a "Continue" or "Back" button which allows the user to move forward or back through the worksheets in the program. Also, each worksheet has either a "Help" (?) or "Interpretation" option if directions or results are confusing. Finally, the "Read Me" section on the title worksheet provides further information about the program and occupancy modeling if the help and interpretation options in the program are not sufficient.

Occupancy Modeling

To properly estimate occupancy, two critical aspects of sampling animal populations must be accounted for: detectability and spatial variability in occupancy (MacKenzie and others 2006). Occupancy models assume the species of interest is detected imperfectly

(MacKenzie and others 2002). In other words, it is assumed that animals are not detected during each survey, even if they are present. Thus, to estimate occupancy accurately, repeat surveys are necessary at each site to obtain estimates of detection probability. Repeat visits to a survey site produce "detection histories." These detection histories form the basis for analysis because they allow the investigator to estimate a detection probability as well as an occupancy probability where the likelihood (*L*) can be written as:

$$L(\Psi, p \mid X_1, ..., X_n) = \prod_{i=1}^{n} \Pr(X_i) \quad (1)$$

where

Ψ is the occupancy probability,

p is the detection probability, and

X_i, i =1,..., n are the detection histories for n number of surveyed sites (Mackenzie and others 2006).

To account for spatial and temporal variability in occupancy and detection probability, covariates may be included in the analysis. It is important to appropriately model covariates that cause heterogeneity in occupancy or detection probabilities because neglecting to do so might result in biased estimates of occupancy and detection probabilities and reduced inference about factors that influence these metrics (MacKenzie and others 2006).

Detection Histories

To calculate occupancy and detection probability estimates using this program, the user must first enter the detection histories for each site sampled in the "Detection History" worksheet, entering a "1" if a ruffed grouse was detected at the site during the specific survey, a "0" if a ruffed grouse was not detected, or a "-" if a survey was missed or a site was not surveyed.

Covariates

Next, the user may enter values for sampling covariates that influence detection probability estimates. During 2007 and 2008 surveys, Hansen and others (*in press*) found the factors that had the highest influence on the probability of detecting ruffed grouse were date, wind speed, time, and precipitation. Thus, the user may enter the date (mm/dd/yyyy), average wind speed (mph), time at the beginning of the survey (hh:mm), and whether or not precipitation occurred during the survey (coded as "1" for precipitation and "0" for no precipitation) at each site during each survey in the worksheet. The program automatically converts the date to an ordinal date and time to number format (for computational purposes) and then standardizes the date, wind speed, and time values into Z-scores using:

$$Z - score = \frac{x - \bar{x}}{\hat{\sigma}} \quad (2)$$

where

x is the value,

$\bar{x}$ is the mean value, and

$\hat{\sigma}$ is the sample standard deviation (Donovan and Hines 2007).

The program standardizes these values because if the values are too high or if there is too large a range in values, the program can have a difficult time converging on a solution. By standardizing, 99% of the data fall between -3 and +3 (Donovan and Hines 2007). No standardization is necessary for the precipitation data because precipitation is a categorical variable.

The user may also enter site covariate values that influence occupancy on a separate worksheet ("Site Characteristics"). Hansen and others (*in press*) found that the spatial extent of aspen and spruce occurring within 550 m of the sample site was related to ruffed grouse occupancy. As a result, these covariates were included in the worksheet. In this worksheet, there are no repeat surveys because it is assumed that vegetation characteristics do not change throughout the sampling season. Thus, each site should have one value for each vegetation type for that monitoring season. Currently, the spatial extent of each vegetation type for sites from 2007 and 2008 surveys (Hansen 2009) are entered into the worksheet. However, vegetation attributes will change from year to year, so when ArcGIS BHNF vegetation layers have been updated, the user should update the values in the worksheet (see Appendix C). Once entered, these data are also automatically standardized into Z-scores. Using the detection histories and covariate values that were entered by the user, the program calculates occupancy and detection probability estimates by using the "Solver" option in Excel to maximize the likelihood of acquiring a particular detection history, given the histories and covariate values provided.

Calculating Constant Occupancy

Occupancy and detection probability estimates may be calculated for various situations, depending upon the biology of the study species, characteristics of the study area, and the needs of the investigator. If the investigator hypothesizes that site attributes are not influencing the presence of the study species throughout the study area, then it may be appropriate to only calculate one occupancy estimate for the study area. Similarly, if the investigator assumes that date, weather condition, observer, and so on have no influence on detecting the species, then one estimate of detection probability may also be appropriate. For this reason, this program provides the option of calculating both a constant occupancy and detection probability. Conversely, the presence of the species at a site might be influenced by the attributes of that site, and the probability of detecting the species might be influenced by sampling variables such as time, date, and weather conditions. In this case, the probability of the site being occupied will vary among sites and the probability of detecting the species on successive surveys will also vary. As a result, this program provides two options for calculating occupancy and detection probabilities that are a function of covariates. Because ruffed grouse select some vegetation attributes over others and the probability of detecting a ruffed grouse is influenced by time and sampling conditions (Hansen and others *in press*), calculating constant occupancy and detection probability estimates might not be the most appropriate for this species.

Calculating Occupancy as a Function of Strata

When calculating sampling effort for ruffed grouse surveys in the BHNF, Hansen and others (*in press*) hypothesized that ruffed grouse occupancy would depend upon the extent of aspen vegetation surrounding the site. As a result, he stratified the BHNF into high, medium, and low aspen proportion strata. Hansen and others (*in press*) also found that the probability of detecting ruffed grouse was a function of date, wind speed, time, and precipitation. This program gives the user the option to calculate occupancy as a function of vegetation strata and detection probability as a function of date, wind speed, time, and precipitation. If this option is selected, the model outputs an occupancy estimate for each of the three strata in the BHNF and an average detection probability estimate. Also, the user may view survey-specific detection probability estimates and graphs that display how date, wind speed, time, and precipitation influenced the probability of detecting ruffed grouse.

Calculating Occupancy as a Function of Vegetation Covariates

Hansen and others (*in press*) discovered that the area of aspen and spruce within 550 m of a survey point influenced ruffed grouse occupancy. Consequently, this program allows the user to calculate occupancy as a function of the spatial extent of aspen and spruce surrounding the survey point. This option provides the user with an occupancy estimate for each site as well as an average occupancy value. Also, this option assumes detection probability is a function of date, wind speed, time, and precipitation; thus, the user is provided with a detection probability estimate for each survey and an average detection probability estimate. This option is more robust than the previous two because it allows the user to estimate the probability that each site is occupied and determine at what times and conditions detection probability is maximized.

Viewing Qualitative Occupancy and Detection Probability Trends

The previous three options for calculating occupancy and detection probability provide the user with a "snapshot" of the state of ruffed grouse in the BHNF. Because trend information is typically much more useful to managers, the program is equipped with an option that allows the user to view the trend in occupancy and detection probability estimates since 2007 ("View Occupancy and Detection Trends"). This option will be useful because managers will easily have a qualitative view of whether occupancy and detection probabilities of ruffed grouse have been increasing, decreasing, or remaining stable, which will aid in prescribing effective management strategies. This option does not provide estimates of precision for occupancy and detection probability; thus, the user must use other occupancy software such as Program PRESENCE or Program MARK if precision estimates are desired.

Opening and Starting the Program

Download the program from http://www.fs.fed.us/rm/forest-grassland-lab/products/ruffed-grouse-occupancy.

When opening the program from Windows Explorer or through the "file open" option in Excel, a security warning screen will appear. On this security screen, "Enable macros" should be selected to ensure all modules are available for use. If there are problems opening the program, the security level might be set too high on the computer.

This program uses the "Solver" option in Microsoft Excel to calculate occupancy estimates. Thus, "Solver" must be added to the Excel spreadsheet and referenced in VBA for this calculation to be possible.

Instructions for enabling macros, adding "Solver," and referencing "Solver" in VBA differ between versions of Microsoft Excel. Thus, the user should use the following instructions, conditional on the version of Excel he/she is using.

Microsoft Excel 2003

To check the security level in Microsoft Excel 2003, select "tools," "macro," and "security." Click the "Security" tab, and select "medium." This will ensure access to the macros available in this program.

To add "Solver" in Microsoft Excel 2003, select "Tools" and "Add-ins" from the drop-down window once the spreadsheet has been opened. Then, check the box next to "Solver Add-in."

To reference "Solver" in VBA for Microsoft Excel 2003 (once the spreadsheet has been opened):

-Click on the Tools tab, point to "Macro," and select "Visual Basic Editor"
-Click on Tools, then References
-Click Browse and navigate to:
C:\Program Files\Microsoft Office\Office10\Library\SOLVER
-Under "Files of type:" select "Microsoft Office Excel Files"
-Select SOLVER
-Click "Open"
-Make sure "SOLVER" is checked under "Available References"
-If "MISSING:SOLVER.XLA" is checked under "Available References", **uncheck** it
-Click "OK," close Visual Basic Editor, and return to the Excel spreadsheet.

Microsoft Excel 2007

To check the security level in Microsoft Excel 2007 (once the spreadsheet has been opened):

-Click on the Microsoft Office button in the top left hand corner of the screen
-Click "Excel Options"
-Click "Trust Center" on the left side of the screen
-Click "Trust Center Settings"
-Click "Macro Settings"
-Select "Enable all macros" to ensure access to the macros available in this program
-Click "OK"
-Click "Trust Center Settings" again
-Click "ActiveX Settings"
-Select "Enable all controls without restrictions and without prompting"
-Click "OK" and exit out of the "Trust Center" and "Excel Options" windows

To add "Solver" in Microsoft Excel 2007 (once the spreadsheet has been opened):

-Click on the Microsoft Office button in the top left hand corner of the screen
-Click "Excel Options"
-Click "Add-Ins" on the left side of the screen
-In the "Manage" box near the bottom of the screen, select "Excel Add-ins"
-Click "Go"
-In the "Add-Ins Available" box, check "Solver Add-In"
-Click "OK"

To reference "Solver" in VBA for Microsoft Excel 2007 (once the spreadsheet has been opened):

-Click on the Microsoft Office button in the top left hand corner of the screen
-Click "Excel Options"
-Check "Show Developer tab in the Ribbon" under "Top options for working with Excel"
-Click "OK"
-Select the Developer tab at the top of the screen
-Select Visual Basic (located underneath the Microsoft Office button)
-Click on "Tools," then "References"
-Click Browse and navigate to:
C:\Program Files\Microsoft Office\Office12\Library\SOLVER
-Under "Files of type:" select "Microsoft Office Excel Files"
-Select SOLVER.XLAM
-Click "Open"

-Make sure “SOLVER” is checked under “Available References”
-If “MISSING:SOLVER.XLA” is checked under “Available References,” **uncheck** it
-Click “OK” and return to the Excel spreadsheet

Warning: Occasionally “Solver” encounters errors and needs to be uninstalled and reinstalled. This may be the case if the message “Solver encountered an error in a target or constraint cell” appears. To uninstall “Solver,” follow the directions above to install solver; however, uncheck the “Solver” box and click “OK.”. Then, navigate back to the “Solver” box, re-check it, and click “OK.”. This should refresh the “Solver” tool and permit its use.

Note: If buttons in the program do not work after reducing the security level and referencing Solver in VBA, try saving, closing, and restarting the program.

Using the Program

Title Worksheet

The first worksheet that is displayed after opening the program is the title worksheet, which shows a ruffed grouse drumming and reads, “Ruffed Grouse Occupancy in the Black Hills National Forest.” This worksheet also contains two buttons: “Start” and “Read Me!” (Figure 1). Before beginning, we advise the user to review the “Read Me” to ensure he/she understands how to use the program and how to interpret occupancy and detection probability estimates. Selecting “Start” will prompt the user with a question, asking whether he/she has read the “Read Me” or user’s manual. If “No” is selected, the program will not allow the user to continue. However, if “Yes” is selected, the program will automatically direct the user to the “Detection History” worksheet.

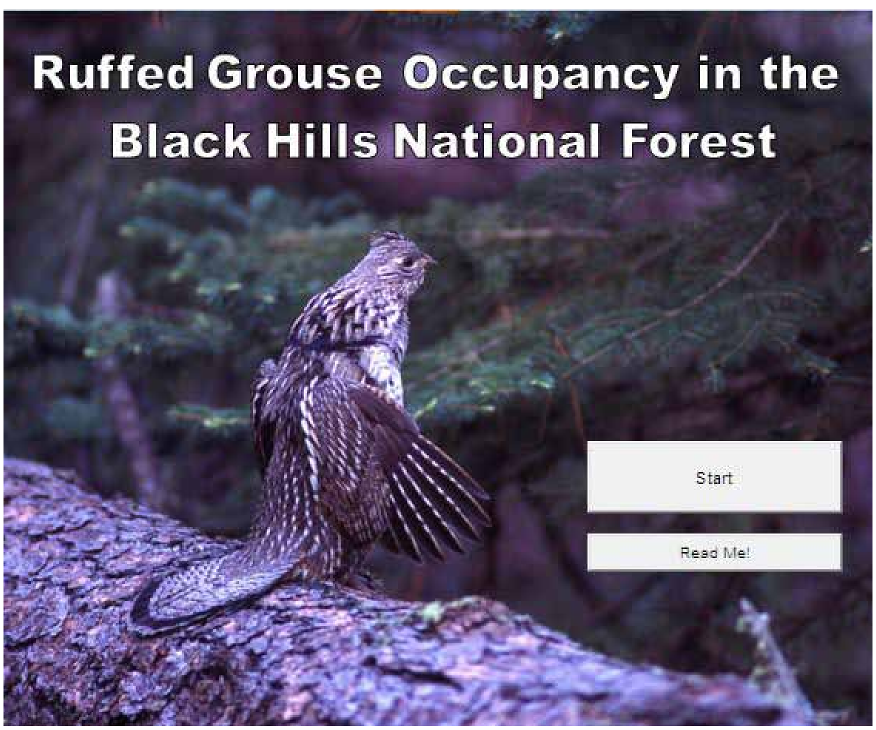


Figure 1. View of the title worksheet of the ruffed grouse occupancy spreadsheet program. The user may select “Start” to begin the program or select “Read Me!” to learn more about the program.

Detection Histories Worksheet

The "Detection Histories" worksheet (Figure 2) is the location where presence/absence data are entered. Provided in this worksheet is the strata and site identifications for 402 sites that were previously monitored (Hansen 2009). The strata identified in the previously surveyed sites represent three vegetation strata (high, medium, and low proportions of aspen) that largely represent the Bear Lodge, Northern Hills, Mystic, and Hell's Canyon Ranger Districts. Therefore, each site in the worksheet has a unique ID, starting with an H, M, or L, which represents the vegetation strata (high, medium, or low) where the site resides. These sites were located along secondary (gravel) and primitive (dirt) roads at least one mile apart in the portion of the BHNF north of Highway 16. Sites south of Highway 16 were not surveyed because of the extremely low occurrence of aspen and ruffed grouse (M. A. Rumble, U.S. Forest Service, personal communication). **Also provided in this worksheet are 101 sites named "Extra." If the user surveys more sites than were surveyed in 2007 and 2008, he/she may use these "Extra" sites to enter the remaining data. The user should then give the new sites a unique identification in the "Site ID" cell and enter the name of the strata in which the site resides in the "Strata" cell.**

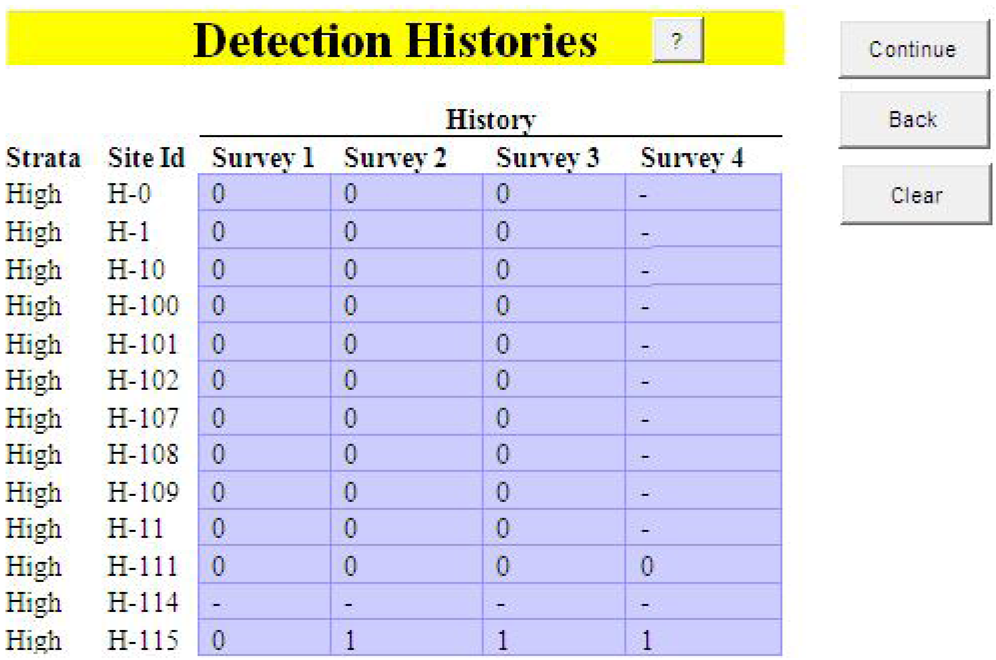
Sites should be surveyed multiple times because the probability of detecting a species during a survey is almost always less than 100% (MacKenzie and others 2002). Hansen (2009) found that conducting three repeat surveys was the most efficient for ruffed grouse drumming surveys in the BHNF when detection probability was >0.3, and conducting four repeat surveys was the most efficient when detection probability was <0.3. Because the probability of detecting ruffed grouse was 0.27 in 2008 (Hansen and others *in press*), we have provided space in the "Detection Histories" worksheet to input data for up to four repeat surveys.

Occupancy studies require the observer to determine the presence or absence of a species by detecting any sign of the species of interest (MacKenzie and others 2002, 2006). This protocol relies on drumming surveys of ruffed grouse. Therefore, to complete the "Detection Histories" worksheet, the user must record whether a ruffed grouse was detected (1) or not (0) at a site for each survey. **If more than one ruffed grouse are detected at a site, only record "1" (this value does not signify the number of grouse heard, rather the fact that grouse were detected at that site).** If a site was missed or not all four surveys were completed for the site, a "-" should be entered in the spreadsheet cell for those surveys. For example, in Figure 2, site H-115 has the detection history: 0111. Thus, a ruffed grouse was not detected drumming during the first survey, but was detected during survey 2, 3, and 4. Detection histories must be completed for each site surveyed; otherwise, occupancy estimates will be inaccurate.

Note: It is not necessary to survey all sites for occupancy estimates to be calculated correctly. The user must simply enter "-" in each of the survey cells for the sites not surveyed (e.g., site H-114 in Figure 2).

Warning: Only "1", "0", or "-" should be entered into cells in this worksheet. If any other numbers or symbols are entered into these cells or cells are left blank, occupancy estimates will not be computed correctly. Also, accurate occupancy estimates assume that the data for sites and strata are entered correctly. If entered incorrectly, an error message will appear that will read, "Occupancy estimates have not been calculated correctly! Check detection histories and covariates for empty cells or detection history values other than '1', '0', or '-'."

After entering detection histories, the user may select "Continue," "Back," or "Clear." Selecting "Continue" will direct the user to the next worksheet. Selecting "Back" will move the user back to the title worksheet and selecting "Clear" will clear all the detection histories from the worksheet. After selecting “Clear,” the user is prompted with the question “Are you sure you want to clear all detection histories?” Selecting “OK” will clear all detection histories and automatically enter “-” in each of the cleared cells. Selecting “Cancel” will return the user to the “Detection Histories” worksheet without any alterations to the data.



		History			
Strata	Site Id	Survey 1	Survey 2	Survey 3	Survey 4
High	H-0	0	0	0	-
High	H-1	0	0	0	-
High	H-10	0	0	0	-
High	H-100	0	0	0	-
High	H-101	0	0	0	-
High	H-102	0	0	0	-
High	H-107	0	0	0	-
High	H-108	0	0	0	-
High	H-109	0	0	0	-
High	H-11	0	0	0	-
High	H-111	0	0	0	0
High	H-114	-	-	-	-
High	H-115	0	1	1	1

Figure 2. View of the “Detection Histories” worksheet in the occupancy spreadsheet (with example data). Users are provided with 402 unique sites and 101 extra sites with four repeat surveys for each site. An entry of “1” represents a ruffed grouse drum was heard during the survey, “0” represents no drum was heard, and “–” represents a survey that was not completed.

Covariates Worksheet

Selecting "Continue" directs the user to the "Covariates" worksheet, which provides the option of entering the date, average wind speed, time, precipitation, and site characteristics (Figure 3). Selecting "Date" will direct the user to a worksheet in which the date of each survey at a site may be entered (Figure 4). The user must enter the date in the format mm/dd/yyyy and enter the year surveys were conducted underneath the cell labeled "Year." If a site was not surveyed, or less than 4 surveys were completed at a site, the user must enter a "-" for that cell.

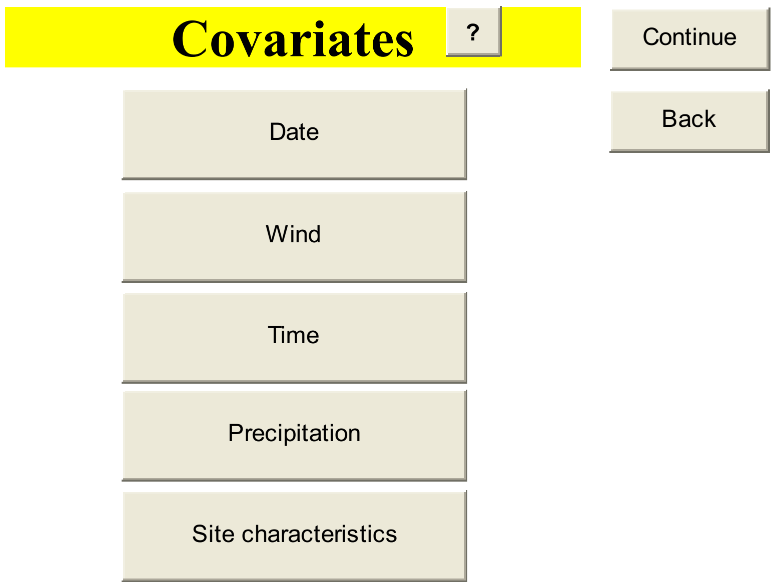


Figure 3. View of the "Covariates" worksheet that displays the five options for covariates to enter (date, wind, time, precipitation, and site characteristics).

Date ?

Site Id	Survey 1	Survey 2	Survey 3	Survey 4
H-0	5/8/2008	5/9/2008	5/28/2008	-
H-1	4/29/2008	5/9/2008	5/21/2008	-
H-10	5/6/2008	5/15/2008	5/20/2008	-
H-100	5/17/2008	5/23/2008	5/28/2008	-
H-101	5/20/2008	5/29/2008	6/3/2008	-

Year
2008

Back

Clear

Figure 4. View of the "Date" covariate worksheet in the occupancy spreadsheet (with example data) in which users enter survey dates for up to four surveys at 503 sites and the year surveys were conducted.

Selecting "Wind" will direct the user to a worksheet in which the average wind speed (mph) may be entered for each survey at each site (Figure 5). Average wind speeds should be collected during each survey using a hand-held wind meter. If a site was not surveyed, or less than 4 surveys were completed at a site, the user must enter a "-" for that cell.

Wind ?

Back

Clear

Site Id	Survey 1	Survey 2	Survey 3	Survey 4
H-0	0	0.3	0	-
H-1	0.3	0	0.1	-
H-10	0.9	1.2	0	-
H-100	0	0.5	0	-
H-101	1.3	0	0.4	-

Figure 5. View of the "Wind" covariate worksheet in the occupancy spreadsheet (with example data) in which users enter average wind speeds (mph) for up to four surveys at 503 sites.

Selecting "Time" will direct the user to a worksheet in which the time of the beginning of the survey may be entered for each site (Figure 6). The user must enter the time in the format hh:mm. If a site was not surveyed, or less than 4 surveys were completed at a site, the user must enter a "-" for that cell.

Time ?

Back

Clear

Site Id	Survey 1	Survey 2	Survey 3	Survey 4
H-0	07:38	09:39	06:16	-
H-1	06:58	08:38	08:12	-
H-10	06:17	09:46	08:21	-
H-100	06:11	09:13	09:48	-
H-101	09:26	05:35	09:21	-

Figure 6. View of the "Time" covariate worksheet in the occupancy spreadsheet (with example data) in which users enter the time of the beginning of the survey for up to four surveys at 503 sites.

Selecting "Precipitation" will direct the user to a worksheet in which the user may enter whether or not precipitation (e.g., mist, rain, or snow) occurred during the survey (Figure 7). If precipitation occurred at any time during the survey, the user should enter "1" and if no precipitation occurred, the user should enter "0." If a site was not surveyed, or fewer than four surveys were completed at a site, the user must enter a "-" for that cell.

Precipitation ?

Back

Clear

Site Id	Survey 1	Survey 2	Survey 3	Survey 4
H-0	0	0	0	-
H-1	0	0	0	-
H-10	0	0	0	-
H-100	0	1	0	-
H-101	0	0	0	-

Figure 7. View of the "Precipitation" covariate worksheet in the occupancy spreadsheet (with example data) in which users enter whether precipitation occurred during the survey for up to four surveys at 503 sites. A "1" signifies precipitation occurred during the survey and a "0" signifies no precipitation occurred.

Selecting "Site Characteristics" from the covariates worksheet directs the user to a worksheet for entering the acreage of aspen and spruce within 550 m of the site (Figure 8). Instructions for calculating vegetation areas within 550 m of the site can be found in Appendix C. For any sites that do not contain a vegetation type, a "0" should be entered in the cell. However, for sites that were not surveyed, a "-" should be entered in each cell.

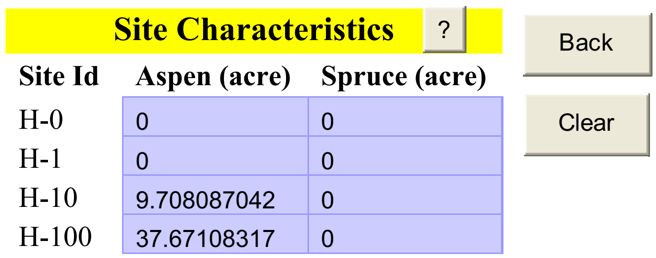


Figure 8. View of the "Site characteristics" covariate worksheet in the occupancy spreadsheet (with example data) in which users may enter the acreage of aspen and spruce within 550 m of a site for up to 503 sites.

Occupancy Worksheet

After completing the covariates worksheets, the user must select "Continue," which will direct him/her to a worksheet with four options for calculating occupancy: "Calculate Constant Occupancy," "Calculate Occupancy as a Function of Strata," "Calculate Occupancy as a Function of Covariates," and "View Occupancy and Detection Trends" (Figure 9). Each of these options uses the "Solver" tool within Microsoft Excel to find beta values for occupancy and detection probability that maximize the log-likelihood of obtaining the detection histories entered. Upon selecting one of these options, "Solver" will converge upon a solution and, after a few seconds, a message box will appear, reading: "Solver has converged to the current solution. All constraints are satisfied." Clicking "OK" on this message box will direct the user to the occupancy and detection probability estimate output worksheets.

Note: If, after one of the occupancy options is selected, the solver message box appears and says "Solver encountered an error in a target or constraint cell," the solver may not have been added to the spreadsheet or the solver needs to be uninstalled and re-installed. To do this, the user should refer to the "Opening and Starting the Program" section above.

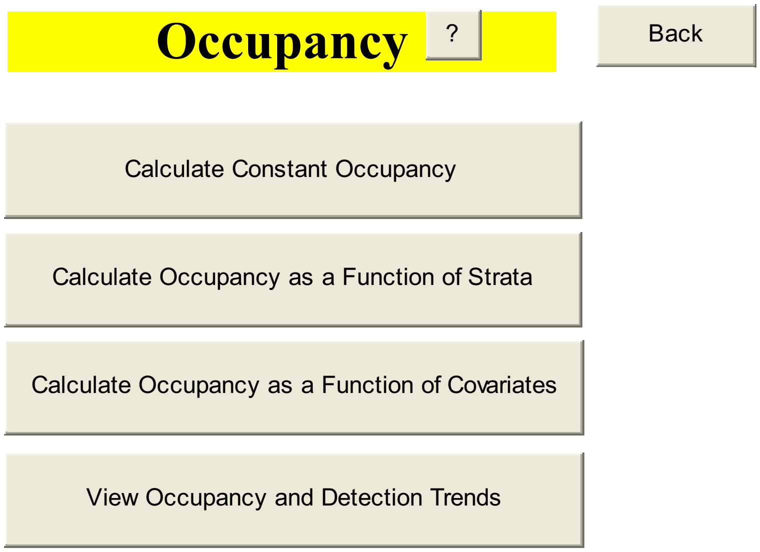


Figure 9. View of the "Occupancy" worksheet that provides four options for calculating occupancy: "Calculate Constant Occupancy," "Calculate Occupancy as a Function of Strata," "Calculate Occupancy as a Function of Covariates," and "View Occupancy and Detection Trends."

"Calculate Constant Occupancy" option

The assumption when calculating a "constant" occupancy and detection probability is that occupancy and detection probabilities do not vary in time, space, or weather conditions (MacKenzie and others 2002). Selecting the "Calculate Constant Occupancy" option will provide the user with one occupancy and detection probability estimate, two measures of precision (standard error [SE] and the coefficient of variation [CV]), and the total number of sites surveyed (Figure 10). This option is usually not appropriate for ruffed grouse because ruffed grouse select aspen vegetation for life requirements and they typically drum during specific times and conditions (Gullion 1966, Zimmerman and Gutiérrez 2007, Hansen and others *in press*). However, the advantage of calculating constant occupancy and detection probabilities is that it is possible to calculate a measure of precision for occupancy estimates. There is not a way, using this program, to calculate precision estimates for occupancy or detection probabilities that are not constant. For this reason, we recommend the user only use this option if estimates of precision are required.

Note: Estimates of precision can be obtained when occupancy and detection probability are heterogeneous (i.e., not constant) using free software such as Program PRESENCE (<http://www.mbr-pwrc.usgs.gov/software/presence.html>) or Program MARK (<http://welcome.warnercnr.colostate.edu/~gwhite/mark/mark.htm>).

"Calculate Occupancy as a Function of Strata" option

In the BHNF, sites were divided among three strata based on the extent of aspen described previously (Hansen 2009). Thus, selecting "Calculate Occupancy as a Function of Strata" provides the user with an estimate of occupancy for each stratum (Figure 11). This option also assumes detection probability is a function of date (quadratically), wind and time (linearly), and precipitation (categorically) because these variables influenced the probability of detecting ruffed grouse during 2007 and 2008 monitoring (Hansen and others *in press*). As a result, survey-specific detection probabilities can be estimated and viewed by selecting "View Survey-Specific Detection Probabilities." This option also provides a graph of the distribution of detection probabilities throughout the sampling period

(Figure 12). Finally, by selecting "View Detection Probability Graphs" the user may view four graphs demonstrating the influence of date, wind speed, time, and precipitation on detection probabilities (Figure 13).

To calculate sample size estimates for future ruffed grouse monitoring, it is necessary to have an occupancy estimate for each stratum. Therefore, we recommend using this occupancy calculation option when sample size calculations for each stratum are necessary. Unfortunately, this program cannot calculate estimates of sample size for multi-year monitoring. However, estimates of sample size can easily be calculated using Program GENPRES (Bailey and others 2007), which can be downloaded for free from: http://www.mbr-pwrc.usgs.gov/software/presence.html.

Note: Because occupancy and detection probabilities were not constant using this option, SE and CV cannot be calculated for occupancy estimates using this program.

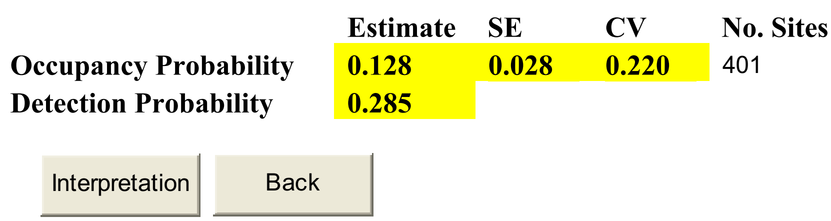


Figure 10. View of example output after selecting "Calculate Constant Occupancy." One estimate of occupancy and detection probability is provided, including a standard error (SE) and coefficient of variation (CV) estimate.

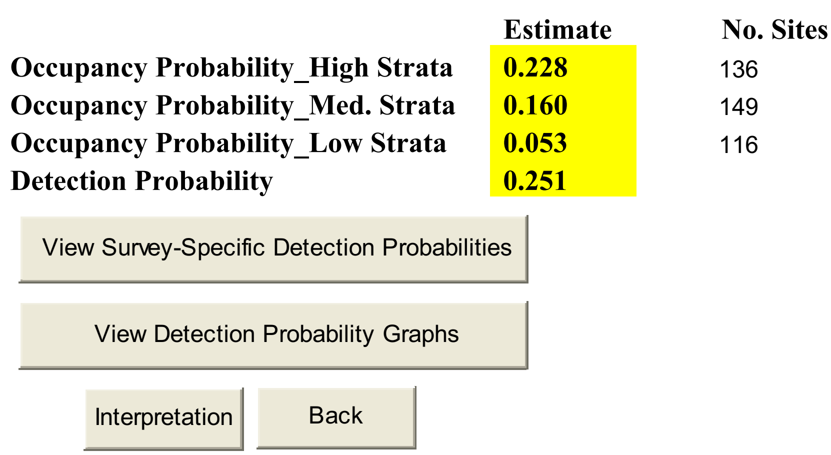


Figure 11. View of example output after selecting "Calculate Occupancy as a Function of Strata." Estimates of occupancy for each stratum and average detection probability are provided, including the options for viewing survey-specific detection probabilities and detection probability graphs.

Survey-Specific Detection Probabilities

Interpretation

Back

Site Id	p_1	p_2	p_3	p_4
H-0	0.255601	0.252945	0.463989	-
H-1	0.041323	0.286134	0.498862	-
H-10	0.127988	0.28892	0.508502	-
H-100	0.478124	0.443142	0.463989	-
H-101	0.332442	0.445722	0.272367	-
H-102	0.017784	0.225289	0.492201	-
H-107	0.14803	0.509054	0.492201	-
H-108	0.255601	0.274785	0.463989	-
H-109	0.069539	0.362187	0.492201	-
H-11	0.286134	0.46692	0.492201	-

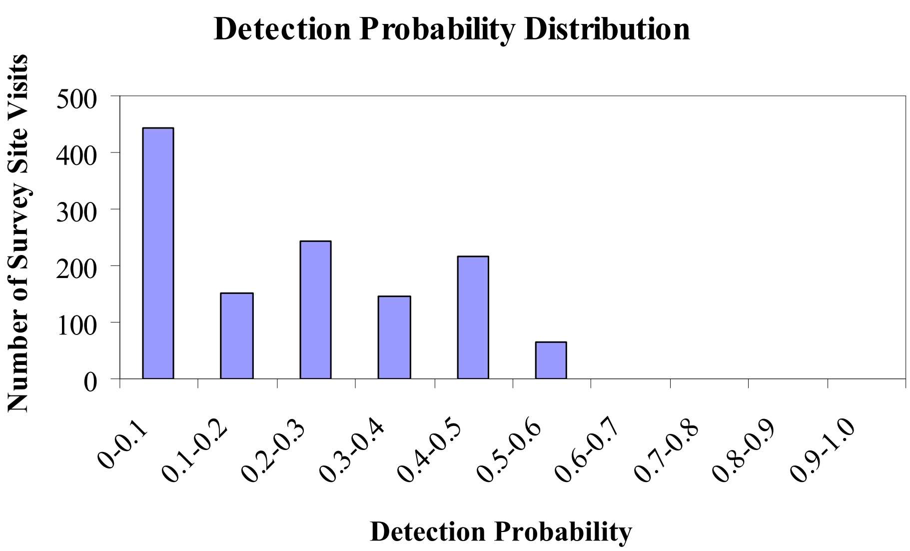


Figure 12. View of example survey specific detection probability (p_n) estimates and detection probability distribution bar graph; provided after selecting "View Survey Specific Detection Probabilities" on the "Occupancy as a Function of Strata" output worksheet (Figure 11).

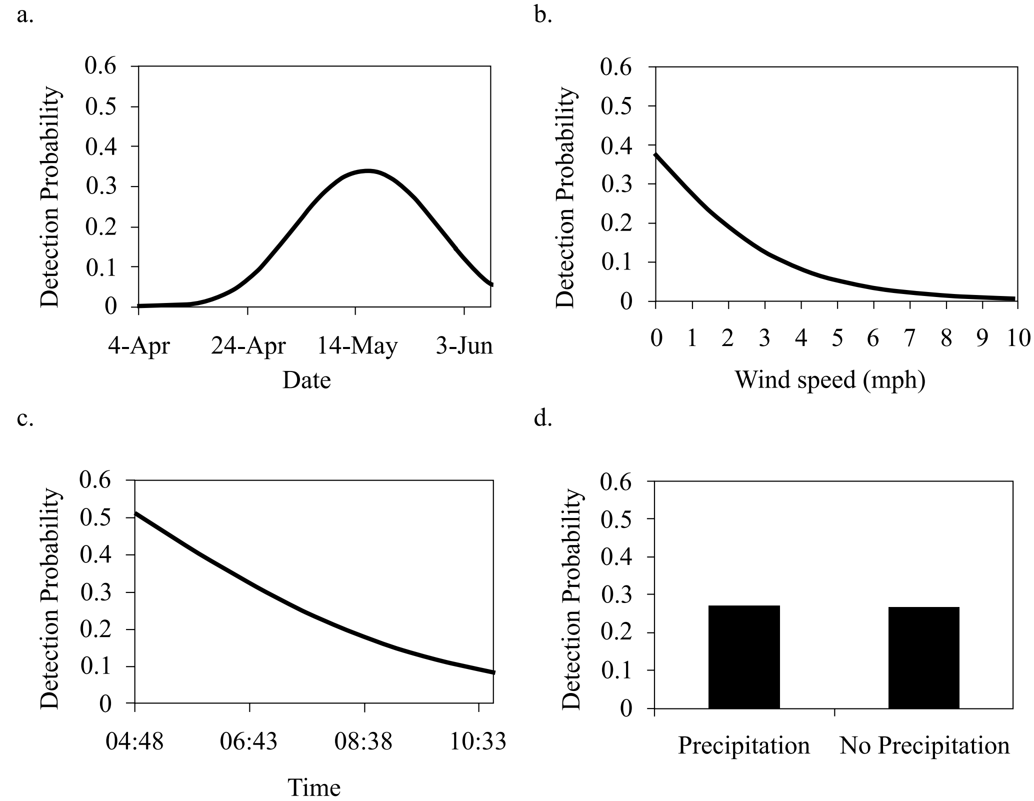


Figure 13. View of example graphs representing the influence of date (a.), wind speed (b.), time (c.), and precipitation (d.) on the probability of detecting ruffed grouse during drumming surveys. These graphs can be viewed after selecting "View Detection Probability Graphs" on the "Occupancy as a Function of Strata" output worksheet (Figure 11).

"Calculate Occupancy as a Function of Covariates" option

Occupancy estimates that incorporate site covariates provide a robust view of the heterogeneity and distribution of occupancy probabilities across the study area (MacKenzie and others 2006). Selecting "Calculate Occupancy as a Function of Covariates" provides the user with ruffed grouse occupancy estimates in the BHNF that are a function of the area of aspen and spruce within 550 m of the survey site. Also, similar to "Calculate Occupancy as a Function of Strata," selecting this option provides detection probability estimates that are a function of date in a quadratic form, wind and time in a linear form, and precipitation categorically. On the output worksheet, average estimates of occupancy and detection probability are provided (Figure 14). Also, by selecting "View Site- and Survey-Specific Occupancy and Detection Probabilities" the user is provided with estimates of occupancy at each site and the detection probability during each survey (Figure 15). Selecting "View Detection Probability Graphs" displays four graphs that demonstrate the effects of date, wind speed, time, and precipitation on detection probability, similar to those created for the "Calculate Occupancy as a Function of Strata" option (Figure 11). Selecting "View Occupancy Probability Graphs" displays a graph that demonstrates the influence of the area of aspen and spruce on occupancy probability (Figure 16).

Including the covariates described above improved the performance of the ruffed grouse occupancy model and reduced bias in occupancy estimates (Hansen and others *in press*). That is, including the covariates explained more variation than other candidate models that excluded the covariates. As a result, we recommend using this option because it will provide occupancy and detection probability estimates with the least bias and provide crucial information about when and during what conditions the probability of detecting ruffed grouse is maximized. By maximizing detection probability, sample site estimates for future surveys will reduce (Hansen 2009).

Note: Because occupancy and detection probabilities were not constant using this option, SE and CV cannot be calculated for occupancy estimates using this program.

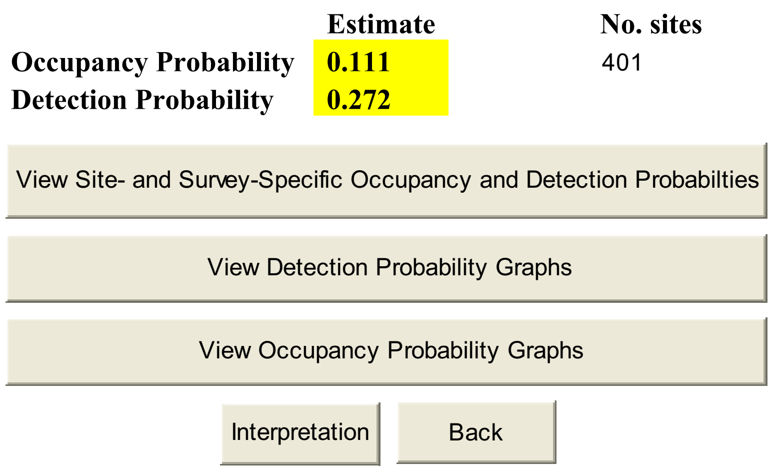


Figure 14. View of example output after selecting "Calculate Occupancy as a Function of Covariates." Average estimates of occupancy and detection probability are provided, including the option of viewing site- and survey-specific probabilities, detection probability graphs, and occupancy probability graphs.

Site- and Survey-Specific Probabilities

Site Id	p_1	p_2	p_3	p_4	Occupancy Probability
H-0	0.295489	0.288311	0.473545	-	0.072611126
H-1	0.05732	0.325651	0.515211	-	0.118830882
H-10	0.153127	0.307425	0.527056	-	0.132270644
H-100	0.50253	0.454215	0.473545	-	0.287458286
H-101	0.342325	0.454774	0.27781	-	0.112687671
H-102	0.023363	0.264902	0.503143	-	0.316509391
H-107	0.177321	0.52193	0.503143	-	0.096486505
H-108	0.295489	0.312925	0.473545	-	0.407428459
H-109	0.082186	0.369348	0.503143	-	0.054990694
H-11	0.325651	0.478038	0.503143	-	0.079318934
H-111	0.084242	0.264902	0.325651	0.503143	0.139192552
H-114	0.084242	0.055405	0.083296	-	0.108538026
H-115	0.054236	0.136985	0.529821	0.473545	0.071251813

Occupancy Probability Distribution

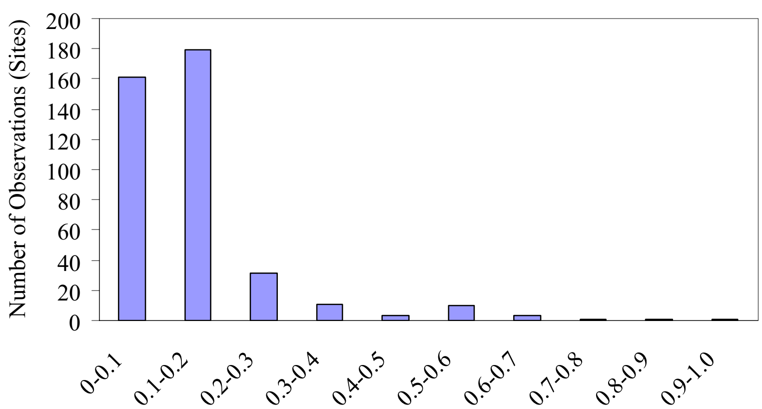


Figure 15. View of example site-specific occupancy and survey-specific detection probability (p_n) estimates and occupancy probability distribution bar graph; provided after selecting "View Site- and Survey-Specific Occupancy and Detection Probabilities" on the "Occupancy as a Function of Covariates" output worksheet (Figure 14). A detection probability distribution graph is also provided, which resembles the graph presented in Figure 12.

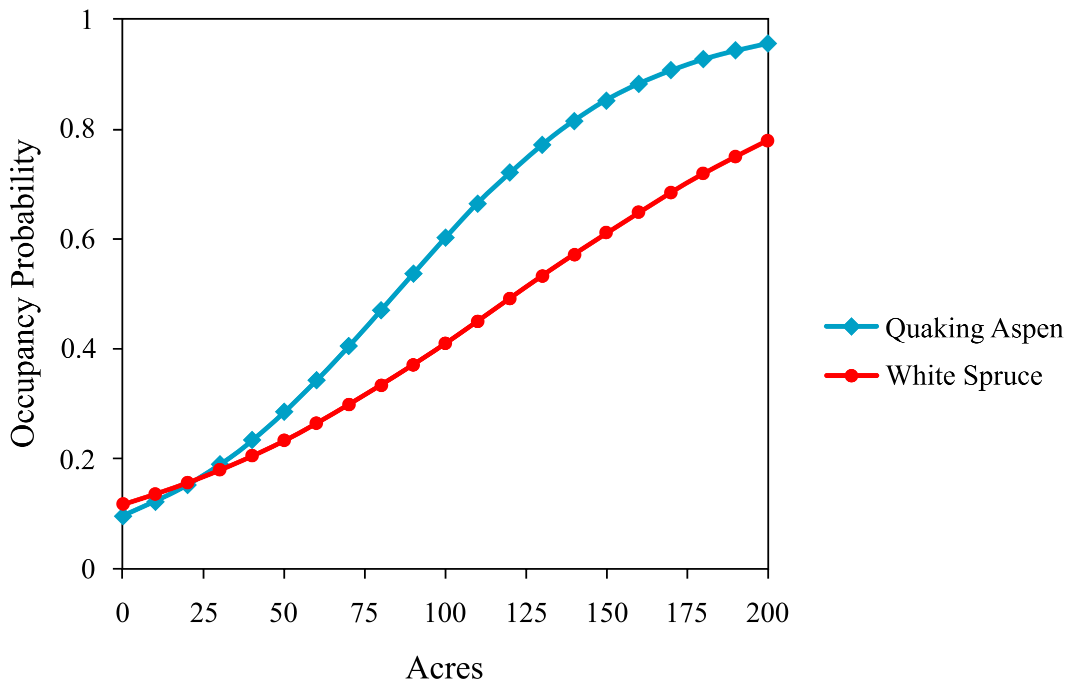


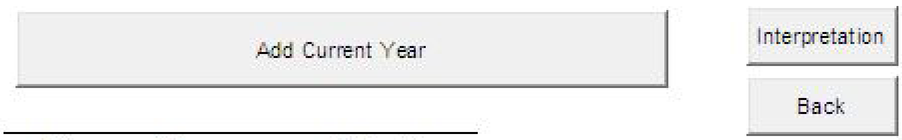
Figure 16. View of an example graph demonstrating the influence of the area of quaking aspen and white spruce within 550 m of a survey point on ruffed grouse occupancy probability. This graph can be viewed after selecting "View Occupancy Graphs" on the "Occupancy as a Function of Covariates" output worksheet (Figure 14).

"View Occupancy and Detection Probability Trends" option

The reason for monitoring management indicator species is to evaluate trends in occupancy over time. As a result, we've included a worksheet that displays the trends in occupancy and detection probability. Selecting "View Occupancy and Detection Trends" directs the user to a worksheet that includes a table and graph with occupancy and detection probability estimates from previous years of surveys (Figure 17). To include the current year's occupancy and detection probability estimates, the user may select "Add Current Year." Selecting this option will calculate occupancy and detection probability estimates using the "Calculate Occupancy as a Function of Covariates" option because this option provided estimates with the least bias. If the user desires precision estimates for occupancy and detection probability trend data, we recommend using either Program PRESENCE or Program MARK (see above for URL addresses).

Note: This worksheet is meant to provide a qualitative analysis of trends in occupancy and detection probability over time. If the user desires to calculate occupancy and detection probability trends using regression methods (e.g., Sauer and Droege 1990, Dixon and others 1998), other software such as Program R (**http://www.r-project.org/**) or Statistical Analysis System (SAS, **http://www.sas.com/**) should be used.

Warning: After entering detection histories, covariate values (date, wind speed, and so on), or estimating occupancy trend data, the spreadsheet must be saved; otherwise, all the data will be lost.



Year	Occupancy	Detection
2007	0.110	0.282
2008	0.128	0.244

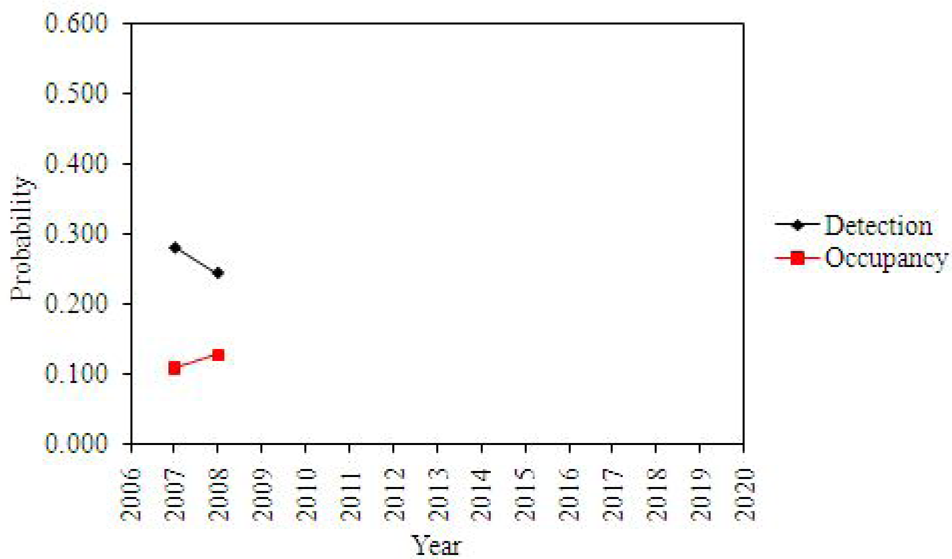


Figure 17. View of example data after selecting "View Occupancy and Detection Trends" on the "Occupancy" worksheet (Figure 9). Data from the current year may be added by selecting "Add Current Year."

Literature Cited

Bailey, L. L., J. E. Hines, J. D. Nichols, and D. I. MacKenzie. 2007. Sampling design trade-offs in occupancy studies with imperfect detection: examples and software. Ecological Applications 17:281-290.

Barber, H. L., R. Kirkpatrick, J. Kubisiak, D. Rusch, F. A. Servello, S. K. Stafford, D. F. Stauffer, and F. R. Thompson III. 1989. The ecological niche. Pages 15-20 *in* S. Atwater and J. Schnell, editors. The Wildlife Series: Ruffed Grouse. Stackpole Books, Harrisburg, Pennsylvania, USA.

Bartos, D., and W. Shepperd. 2003. Aspen regeneration in the Western States. U. S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. Fort Collins, Colorado, USA <http://www.fs.fed.us/rm/aspen/>. Accessed 1 Sept. 2006.

Crossland, M. R., D. I. MacKenzie, and S. Holzapfel. 2005. Assessment of site-occupancy modeling as a technique to monitor Hochstetter's frog (*Leiopelma hochstetteri*) populations. Doc Research & Development Series 218, Science & Technical Publishing, Wellington, New Zealand.

Dixon, P. M., A. R. Olsen, and B. M. Kahn. 1998. Measuring trends in ecological resources. Ecological Applications 8:225-227.

Donovan, T. M., and J. Hines. 2007. Exercises in occupancy modeling and estimation. http://www.uvm.edu/envnr/vtcfwru/spreadsheets/occupancy.htm.

Froiland, S. G. 1990. Natural history of the Black Hills and Badlands. The Center for Western Studies, Sioux Falls, South Dakota, USA.

Gullion, G. W. 1966. The use of drumming behavior in ruffed grouse population studies. Journal of Wildlife Management 30:717-729.

Hansen, C. P. 2009. Occupancy modeling of ruffed grouse in the Black Hills National Forest. Thesis, University of Missouri, Columbia, Missouri, USA.

Hansen, C. P., J. J. Millspaugh, and M. A. Rumble. In press. Occupancy modeling of ruffed grouse in the Black Hills National Forest. Journal of Wildlife Management.

Hanski, I. 1994. A practical model of metapopulation dynamics. The Journal of Animal Ecology 63(1):151-162.

Kubisiak, J. 1985. Ruffed grouse habitat relationships in aspen and oak forests of Central Wisconsin. Department of Natural Resources, Technical Bulletin No. 151, Madison, Wisconsin, USA.

MacKenzie, D. I., J. D. Nichols, G. B. Lachman, S. Droege, J. A. Royle, and C. A. Langtimm. 2002. Estimating site occupancy rates when detection probabilities are less than one. Ecology 83(3):2248-2255.

MacKenzie, D. I., and J. A. Royle. 2005. Designing occupancy studies: General advice and allocating survey effort. Journal of Applied Ecology 42:1105-1114.

MacKenzie, D. I., J. D. Nichols, J. E. Hines, M. G. Knutson, and A. B. Franklin. 2003. Estimating site occupancy, colonization, and local extinction when a species is detected imperfectly. Ecology 84(8):2200-2207.

MacKenzie, D. I., J. D. Nichols, J. A. Royle, K. H. Pollock, L. L. Bailey, and J. E. Hines. 2006. Occupancy estimation and modeling. Academic Press, Burlington Massachusetts, USA.

Madison, J. 1969. Ruffed grouse. Winchester Press, East Alton, Illinois, USA.

Maxson, S. J. 1989. Patterns of activity. Pages 118-123 *in* S. Atwater and J. Schnell, editors. The Wildlife Series: Ruffed Grouse. Stackpole Books, Harrisburg, Pennsylvania, USA.

McBurney, R. S. 1989. Roadside drumming counts. Pages 208-209 *in* S. Atwater and J. Schnell, editors. The Wildlife Series: Ruffed Grouse. Stackpole Books, Harrisburg, Pennsylvania, USA.

Petraborg, W. H., E. G. Wellein, and V. E. Gunvalson. 1953. Roadside drumming counts: A spring census method for ruffed grouse. Journal of Wildlife Management 17:292-295.

Rumble, M. A., L. Benkobi, and R. S. Gamo. 2005. Elk responses to humans in a densely roaded area. Intermountain Journal of Science 11:10-24.

Sauer, J. R., and S. Droege, editors. 1990. Survey design and statistical methods for the estimation of avian population trends. USDI Fish and Wildlife Service, Biological Report 90(1), Washington, DC, USA.

Science Applications International Corporation [SAIC]. 2005. Selection of management indicator species Black Hills National Forest phase II plan amendment. U.S. Department of Agriculture Forest Service Black Hills National Forest, Littleton, Colorado, USA.

Sharpe, P. B., A. Woolf, and D. D. Roby. 1997. Raising and monitoring ruffed grouse (*Bonasa umbellus*) for field studies. American Midland Naturalist 139:39-48.

U.S. Department of Agriculture Forest Service [USDAFS]. 1997. Revised land resource management plan for the Black Hills National Forest. U.S. Department of Agriculture, Forest Service, Custer, South Dakota, USA.

White, G. C., and K. P. Burnham. 1999. Program MARK: Survival estimation from populations of marked animals. Bird Study Supplement 46:120-138.

Zimmerman, G. S., and R. J. Gutiérrez. 2007. The influence of ecological factors on detecting drumming ruffed grouse. Journal of Wildlife Management 71:1765-1772.

Appendix A. Sample Sites for the 2007 and 2008 Ruffed Grouse Drumming Surveys in the Black Hills National Forest

Strata	Region	Route	Site	UTM_East	UTM_North
High	BL	H17	H_0	546706	4933132
High	BL	H10	H_1	559467	4903268
High	NW	H5	H_10	581629	4909010
High	BL	H7	H_100	571965	4918210
High	NW	H2	H_101	573943	4903874
High	BL	H20	H_102	548454	4950335
High	BL	H14	H_107	541355	4933705
High	BL	H17	H_108	547249	4934825
High	BL	H13	H_109	538334	4930583
High	BL	H14	H_11	541266	4937794
High	BL	H20	H_111	548687	4952679
High	BL	H3	H_114	566831	4906745
High	BL	H10	H_115	559201	4907096
High	BL	H14	H_116	540992	4935831
High	NW	H5	H_117	583424	4914497
High	BL	H7	H_119	567957	4922052
High	BL	H3	H_12	567071	4908465
High	BL	H11	H_121	547417	4923205
High	BL	H16	H_122	554847	4935764
High	BL	H20	H_124	550639	4950124
High	NW	H1	H_126	571506	4900597
High	NW	H1	H_128	571753	4896403
High	BL	H18	H_13	553134	4939327
High	BL	H19	H_131	550271	4946512
High	NW	H1	H_134	571170	4892597
High	BL	H18	H_135	555074	4940278
High	BL	H10	H_136	557923	4903959
High	NW	H4	H_137	571832	4908837
High	BL	H6	H_14	573552	4918453
High	BL	H20	H_140	553274	4947585
High	BL	H16	H_141	550821	4937061
High	NW	H5	H_142	578104	4912916
High	BL	H3	H_143	564423	4911387
High	BL	H14	H_145	540304	4931116
High	BL	H9	H_146	573138	4911292
High	BL	H21	H_147	548663	4956769
High	NW	H4	H_148	577064	4911610
High	BL	H3	H_15	568771	4907085
High	BL	H7	H_151	568540	4924102
High	BL	H21	H_152	550882	4956559
High	BL	H3	H_153	568095	4905317
High	NW	H4	H_154	573505	4909400
High	BL	H21	H_156	549678	4955264
High	BL	H14	H_158	543608	4939274

Strata	Region	Route	Site	UTM_East	UTM_North
High	NW	H4	H_159	579240	4909434
High	NW	H2	H_16	572734	4901993
High	BL	H10	H_160	560036	4911206
High	BL	H3	H_161	564492	4909427
High	BL	H18	H_162	548732	4942577
High	BL	H20	H_164	551911	4948536
High	BL	H15	H_165	546288	4939467
High	BL	H16	H_166	553044	4931407
High	BL	H10	H_168	562309	4905971
High	NW	H5	H_169	577537	4914651
High	BL	H20	H_170	550471	4953330
High	BL	H21	H_171	551993	4958151
High	BL	H11	H_173	541793	4922252
High	BL	H17	H_174	543841	4929345
High	BL	H11	H_176	548780	4921557
High	NW	H5	H_177	580937	4914711
High	NW	H2	H_179	573254	4905559
High	BL	H17	H_18	542305	4928268
High	BL	H12	H_180	546037	4928810
High	NW	H1	H_182	569610	4899377
High	NW	H4	H_19	575193	4907502
High	BL	H15	H_20	543696	4936709
High	BL	H10	H_21	560488	4906193
High	NW	H5	H_22	582323	4913029
High	BL	H21	H_23	551280	4960002
High	BL	H10	H_24	559742	4909414
High	BL	H9	H_25	567255	4912017
High	BL	H20	H_26	550249	4948158
High	BL	H14	H_27	542061	4930648
High	NW	H2	H_28	573712	4897311
High	NW	H1	H_3	570972	4894850
High	NW	H4	H_31	572679	4907411
High	NW	H1	H_32	570597	4898398
High	BL	H9	H_33	569668	4909929
High	BL	H12	H_35	544921	4925684
High	BL	H18	H_36	550358	4938945
High	BL	H17	H_37	546407	4930570
High	BL	H8	H_38	569010	4915587
High	NW	H1	H_4	575018	4894768
High	BL	H12	H_40	548790	4924575
High	BL	H6	H_42	574911	4916676
High	NW	H2	H_43	573091	4900297
High	BL	H18	H_44	550454	4941373
High	BL	H21	H_45	547367	4954824
High	BL	H16	H_46	547542	4929320
High	NW	H2	H_47	570137	4904080
High	BL	H13	H_48	539864	4928940
High	BL	H10	H_49	557706	4906222
High	BL	H12	H_5	544007	4927278
High	BL	H15	H_50	543133	4934455

Strata	Region	Route	Site	UTM_East	UTM_North
High	BL	H3	H_51	564332	4907441
High	BL	H9	H_52	565667	4913363
High	BL	H13	H_53	541526	4925949
High	BL	H11	H_54	545939	4920408
High	NW	H5	H_55	583094	4911376
High	BL	H8	H_56	571064	4912207
High	BL	H16	H_58	552839	4933109
High	BL	H21	H_59	549625	4958124
High	BL	H12	H_6	547049	4927322
High	NW	H2	H_60	570527	4906459
High	BL	H6	H_61	574511	4922644
High	BL	H8	H_62	570220	4913686
High	NW	H1	H_63	573372	4893802
High	BL	H14	H_64	543554	4932378
High	BL	H15	H_65	545802	4933828
High	NW	H4	H_67	576423	4908965
High	BL	H16	H_68	552476	4937066
High	BL	H7	H_69	571573	4922398
High	BL	H16	H_70	548924	4930539
High	BL	H8	H_71	568049	4913367
High	BL	H17	H_72	548253	4937685
High	BL	H3	H_73	564697	4905216
High	BL	H7	H_74	570534	4921211
High	NW	H2	H_75	575113	4905531
High	BL	H15	H_76	545529	4932055
High	BL	H11	H_77	548687	4919844
High	BL	H6	H_78	575387	4913298
High	NW	H5	H_8	579180	4914359
High	BL	H16	H_80	549742	4934814
High	BL	H16	H_82	550989	4931977
High	NW	H4	H_83	578683	4907888
High	BL	H19	H_84	553777	4945311
High	NW	H1	H_86	570100	4902282
High	BL	H8	H_87	566806	4918398
High	BL	H8	H_88	569350	4911997
High	BL	H12	H_89	545183	4923915
High	NW	H2	H_9	571996	4904258
High	BL	H11	H_92	545158	4922256
High	BL	H19	H_93	552519	4945540
High	BL	H18	H_94	551387	4942917
High	NW	H4	H_96	574790	4910849
High	NW	H5	H_98	580614	4910641
High	BL	H6	H_99	575091	4920947
Low	SW	L10	L_0	582365	4863400
Low	SW	L8	L_10	580824	4888263
Low	SW	L12	L_100	592716	4874143
Low	SE	L21	L_102	624603	4879583
Low	SW	L30	L_103	594198	4881839
Low	SW	L30	L_104	592012	4879990
Low	SE	L22	L_105	627870	4887619

Strata	Region	Route	Site	UTM_East	UTM_North
Low	SE	L23	L_106	630641	4873423
Low	SW	L16	L_107	599933	4858021
Low	SE	L27	L_108	619455	4869585
Low	SE	L1	L_109	617815	4849060
Low	SW	L10	L_11	577059	4861980
Low	SW	L7	L_111	586329	4854511
Low	SW	L3	L_112	602871	4849564
Low	SE	L24	L_113	624835	4866153
Low	SW	L5	L_114	586485	4843873
Low	SW	L13	L_115	596047	4869393
Low	SW	L7	L_116	584740	4857507
Low	SE	L2	L_117	607049	4848700
Low	SE	L28	L_118	609026	4879542
Low	SW	L5	L_119	584359	4844949
Low	SE	L20	L_12	625702	4886217
Low	SE	L1	L_120	616186	4849890
Low	SE	L23	L_121	631384	4876755
Low	SE	L29	L_122	609763	4867414
Low	SE	L21	L_123	620966	4881839
Low	SE	L19	L_124	612113	4881065
Low	SE	L24	L_125	633316	4865795
Low	SW	L14	L_126	595089	4861300
Low	SW	L17	L_127	601694	4865725
Low	SW	L17	L_128	600648	4863125
Low	SW	L11	L_129	585058	4882972
Low	SW	L10	L_13	578483	4865524
Low	SW	L13	L_130	594740	4872952
Low	SW	L9	L_131	577029	4870470
Low	SW	L7	L_132	586070	4856588
Low	SW	L11	L_133	587324	4882712
Low	SE	L20	L_14	620084	4886202
Low	SE	L24	L_15	628219	4865893
Low	SW	L7	L_16	582621	4858397
Low	SW	L4	L_18	596835	4844717
Low	SW	L8	L_19	576774	4889438
Low	SE	L23	L_2	629247	4875417
Low	SW	L13	L_20	592913	4868231
Low	SW	L12	L_21	592559	4872493
Low	SW	L8	L_22	577199	4882386
Low	SE	L1	L_23	619993	4848592
Low	SW	L30	L_24	600776	4884552
Low	SE	L18	L_25	600688	4879502
Low	SW	L5	L_26	588722	4842642
Low	SW	L6	L_27	583346	4853882
Low	SE	L21	L_3	622585	4880514
Low	SW	L15	L_30	592228	4857340
Low	SW	L9	L_31	581631	4874667
Low	SW	L10	L_32	577945	4856913
Low	SE	L2	L_33	606547	4846792
Low	SE	L27	L_35	616452	4873825

Strata	Region	Route	Site	UTM_East	UTM_North
Low	SE	L24	L_36	629944	4868702
Low	SE	L19	L_37	612746	4886914
Low	SW	L3	L_38	600338	4850252
Low	SW	L15	L_39	595569	4856275
Low	SW	L8	L_4	584166	4887818
Low	SE	L25	L_40	632705	4853778
Low	SE	L18	L_41	600950	4877333
Low	SW	L9	L_42	582502	4870817
Low	SW	L5	L_43	588826	4848004
Low	SE	L19	L_44	610869	4885419
Low	SE	L2	L_45	609556	4846911
Low	SW	L10	L_46	578403	4868323
Low	SW	L15	L_47	589399	4860631
Low	SE	L2	L_48	609253	4850697
Low	SW	L11	L_49	590558	4883686
Low	SE	L2	L_5	607074	4852705
Low	SW	L9	L_50	579593	4876524
Low	SW	L14	L_51	588843	4863854
Low	SE	L29	L_52	606313	4861000
Low	SW	L16	L_54	597870	4854180
Low	SW	L16	L_55	599309	4855062
Low	SE	L2	L_58	604603	4849448
Low	SE	L29	L_59	610240	4864700
Low	SE	L29	L_6	604842	4866783
Low	SW	L12	L_60	589123	4871559
Low	SE	L23	L_61	630453	4870474
Low	SW	L13	L_62	597332	4867092
Low	SW	L9	L_64	579895	4872759
Low	SE	L20	L_66	615700	4886616
Low	SW	L9	L_68	577154	4876521
Low	SW	L10	L_69	579249	4858699
Low	SW	L12	L_7	589789	4875759
Low	SW	L4	L_70	599930	4845780
Low	SE	L27	L_71	618763	4871522
Low	SW	L15	L_72	594038	4858579
Low	SW	L6	L_73	581057	4852368
Low	SW	L14	L_74	590622	4863303
Low	SE	L19	L_76	617466	4879615
Low	SW	L15	L_77	594941	4854487
Low	SW	L11	L_78	587212	4886379
Low	SE	L28	L_79	611994	4875295
Low	SW	L5	L_8	587420	4846391
Low	SE	L26	L_80	613734	4862499
Low	SE	L20	L_82	622976	4886248
Low	SW	L11	L_83	589690	4881821
Low	SE	L19	L_84	611015	4886853
Low	SW	L7	L_86	584495	4859986
Low	SE	L25	L_87	629133	4854779
Low	SE	L19	L_88	612412	4883697
Low	SW	L8	L_89	576739	4887047

Strata	Region	Route	Site	UTM_East	UTM_North
Low	SE	L29	L_9	604742	4870069
Low	SE	L25	L_90	630930	4863403
Low	SE	L23	L_91	624641	4874984
Low	SE	L23	L_92	632923	4875103
Low	SW	L3	L_93	603890	4846134
Low	SE	L29	L_94	605439	4864034
Low	SE	L18	L_96	604090	4874787
Low	SW	L14	L_97	592754	4859998
Low	SE	L29	L_99	606403	4865416
Medium	NW	M23	M_1	584182	4910122
Medium	NE	M10	M_10	612551	4891646
Medium	NW	M29	M_100	601562	4916916
Medium	NE	M21	M_101	613824	4913209
Medium	NE	M10	M_102	606282	4893423
Medium	NE	M31	M_103	620880	4898758
Medium	NW	M2	M_104	589581	4892012
Medium	NE	M14	M_105	607110	4898973
Medium	NE	M14	M_106	611239	4898167
Medium	NE	M11	M_109	620207	4888601
Medium	NW	M23	M_110	583842	4904929
Medium	NW	M1	M_111	581859	4893327
Medium	NE	M16	M_112	622235	4901121
Medium	NE	M12	M_113	619891	4894861
Medium	NW	M30	M_114	593685	4900061
Medium	NE	M18	M_115	616535	4910550
Medium	NW	M6	M_116	590351	4903705
Medium	NE	M12	M_117	612383	4896289
Medium	NE	M21	M_118	613878	4916265
Medium	NE	M16	M_120	618463	4901682
Medium	NW	M2	M_121	587209	4889616
Medium	NE	M15	M_122	618330	4899426
Medium	NW	M26	M_123	579951	4924419
Medium	NW	M2	M_124	590326	4890318
Medium	NE	M10	M_125	612764	4892836
Medium	NE	M22	M_126	593536	4893739
Medium	NE	M15	M_127	614198	4902680
Medium	NE	M12	M_129	614625	4894519
Medium	NW	M4	M_13	589244	4893840
Medium	NE	M7	M_131	610220	4888938
Medium	NW	M4	M_132	586278	4897660
Medium	NW	M26	M_133	580222	4922260
Medium	NE	M19	M_134	612383	4905721
Medium	NE	M3	M_135	598861	4887557
Medium	NW	M1	M_137	575888	4901028
Medium	NW	M1	M_138	582460	4895329
Medium	NE	M20	M_14	610635	4916403
Medium	NW	M26	M_140	579407	4916391
Medium	NE	M16	M_141	623543	4900459
Medium	NE	M14	M_144	609109	4901542
Medium	NW	M24	M_145	593335	4905924

Strata	Region	Route	Site	UTM_East	UTM_North
Medium	NE	M13	M_147	605057	4902936
Medium	NE	M21	M_148	614773	4915104
Medium	NE	M13	M_149	604276	4901092
Medium	NW	M30	M_15	596507	4899227
Medium	NW	M6	M_150	588419	4902974
Medium	NW	M28	M_151	592043	4914133
Medium	NE	M7	M_152	606326	4885067
Medium	NW	M5	M_153	580368	4904295
Medium	NW	M27	M_154	588321	4919729
Medium	NE	M7	M_156	608973	4885838
Medium	NW	M5	M_157	577239	4906145
Medium	NE	M18	M_16	616451	4912411
Medium	NW	M2	M_160	586237	4892292
Medium	NE	M12	M_161	622227	4895529
Medium	NW	M24	M_162	595305	4902627
Medium	NE	M31	M_164	629360	4896361
Medium	NE	M15	M_165	615720	4901704
Medium	NE	M11	M_166	622875	4892592
Medium	NE	M13	M_167	605799	4897484
Medium	NE	M19	M_168	608187	4909238
Medium	NW	M27	M_169	586331	4923454
Medium	NW	M26	M_17	580182	4920603
Medium	NW	M30	M_170	597331	4901836
Medium	NE	M9	M_171	597078	4896173
Medium	NW	M30	M_172	598661	4898180
Medium	NE	M19	M_173	608207	4904607
Medium	NE	M17	M_174	618863	4905700
Medium	NW	M27	M_175	584609	4922160
Medium	NW	M4	M_176	586013	4894410
Medium	NW	M29	M_178	599162	4916707
Medium	NW	M1	M_18	579847	4895157
Medium	NW	M25	M_180	581763	4921718
Medium	NE	M31	M_181	622622	4899009
Medium	NW	M4	M_182	585652	4896319
Medium	NE	M11	M_183	619020	4890662
Medium	NE	M11	M_184	625379	4890795
Medium	NE	M18	M_19	621416	4912500
Medium	NE	M9	M_21	603636	4895500
Medium	NE	M9	M_22	601438	4896895
Medium	NE	M19	M_23	606863	4907042
Medium	NW	M24	M_24	600595	4906240
Medium	NE	M12	M_25	618423	4892647
Medium	NE	M10	M_26	610624	4894553
Medium	NE	M17	M_28	615968	4907985
Medium	NE	M8	M_29	599764	4893472
Medium	NE	M21	M_3	611335	4910292
Medium	NW	M5	M_30	580162	4902159
Medium	NE	M13	M_31	601385	4903176
Medium	NW	M25	M_32	583716	4924280
Medium	NW	M25	M_33	581849	4916572

Strata	Region	Route	Site	UTM_East	UTM_North
Medium	NW	M24	M_34	597218	4903811
Medium	NW	M25	M_35	583900	4912927
Medium	NE	M21	M_36	612872	4910774
Medium	NE	M22	M_38	590474	4896347
Medium	NE	M13	M_39	601096	4899879
Medium	NE	M10	M_4	614661	4888902
Medium	NE	M7	M_41	608203	4883176
Medium	NW	M4	M_42	587509	4896420
Medium	NE	M9	M_43	599739	4896006
Medium	NE	M8	M_44	602544	4889012
Medium	NE	M31	M_45	627316	4896994
Medium	NW	M23	M_46	583772	4908124
Medium	NE	M7	M_48	607565	4890375
Medium	NW	M28	M_49	592303	4919916
Medium	NE	M8	M_5	601557	4890735
Medium	NE	M9	M_50	603264	4897642
Medium	NW	M6	M_51	589696	4901869
Medium	NE	M10	M_52	609147	4892585
Medium	NE	M3	M_53	599065	4890696
Medium	NW	M28	M_55	595909	4915487
Medium	NE	M3	M_56	600949	4886922
Medium	NE	M20	M_57	609657	4919675
Medium	NW	M26	M_58	579646	4918793
Medium	NW	M24	M_59	592737	4904320
Medium	NE	M19	M_6	606261	4904027
Medium	NW	M27	M_60	586589	4918753
Medium	NW	M23	M_61	587656	4904491
Medium	NW	M23	M_62	584655	4906328
Medium	NE	M3	M_64	593014	4889212
Medium	NE	M21	M_65	610290	4907296
Medium	NW	M2	M_66	584502	4892856
Medium	NE	M22	M_67	591840	4894878
Medium	NE	M13	M_68	603711	4903478
Medium	NE	M9	M_69	596123	4894577
Medium	NE	M15	M_7	615737	4899498
Medium	NE	M22	M_70	591977	4897408
Medium	NE	M7	M_71	609161	4887878
Medium	NE	M14	M_72	615590	4896450
Medium	NE	M10	M_73	610535	4892366
Medium	NE	M17	M_74	623105	4904901
Medium	NE	M17	M_77	621143	4907171
Medium	NE	M10	M_78	609277	4894746
Medium	NW	M29	M_79	602231	4920416
Medium	NW	M6	M_8	587298	4901343
Medium	NE	M14	M_80	613881	4899091
Medium	NE	M14	M_81	608410	4902487
Medium	NE	M11	M_82	621606	4890396
Medium	NE	M18	M_83	615888	4909457
Medium	NE	M12	M_85	616379	4893278
Medium	NW	M1	M_87	575562	4898049

Strata	Region	Route	Site	UTM_East	UTM_North
Medium	NW	M4	M_88	587558	4893512
Medium	NE	M7	M_89	603866	4888169
Medium	NE	M8	M_91	603957	4891564
Medium	NW	M24	M_92	599302	4905049
Medium	NW	M6	M_94	591292	4899643
Medium	NE	M20	M_95	610210	4913550
Medium	NE	M12	M_97	624906	4894096
Medium	NE	M11	M_98	622152	4887960

Appendix B. Data Sheet for Ruffed Grouse Surveys in the Black Hills National Forest

Season: ____________________ **Route Name:** ____________________

Site #: ____________________

Region: ____________________ **UTM:** __________ | __________

Survey #	Date	Time	Observer	Wind (mph)	Temp (F)
1					
2					
3					
4					

Survey #	Presence(1)/Absence(0)	Azimuth	Distance (<50, 50-150, >150m)	Weather Conditions
1				
2				
3				
4				

Survey #	Other Notable Observations
1	
2	
3	
4	

Appendix C. Instructions to Calculate Vegetation Areas for Ruffed Grouse Sample Sites in the Black Hills National Forest

To determine the area of vegetation types at each site, the user must first download the vegetation layer provided at the website: www.fs.fed.us/r2/blackhills/. Once at the website, select "Maps and Publications," then "Geospatial Maps and Data," then "Existing Vegetation (Shapefile)." After downloading, add this layer to a new project in ArcGIS. Next, the user must add the sites from Appendix A by copying and pasting the sites into Microsoft Excel, saving them as a Database IV file, and importing them into ArcGIS (the UTM coordinates should be projected onto the map using the NAD 1983 UTM Zone 13N coordinate system).

Next, the user will need to make a 550 m buffer around each point and clip the buffered region out of the vegetation layer (the buffer and clip tools are found in the Arc Toolbox under "Analysis Tools"). After clipping, the area of polygons ("Acres") must be recalculated within the clipped region; otherwise, polygon areas will be inaccurate. To recalculate polygon areas, the user can simply open the attribute table of the clipped layer, right click over the "acres" attribute, select "Calculate Geometry," select "Area," the coordinate system of the data source, and "Acres US."

Next, the user must add the site attributes such as ID, strata, and region to the clipped layer table. To do this, a spatial join should be completed by joining the buffered site layer (with all the site attribute info) to the clipped layer (with all the vegetation info). When completing this step, the user should select the option that allows each polygon to attain the attributes of the joined polygon it falls within. Now, the user is provided with a new layer that contains the correct vegetation attributes and site ID for each polygon in the clipped layer.

Note: This step can also be completed by using the "Intersect" tool also found in the "Analysis Tools." To do this, the user may select to intersect both the buffered site layer and the clipped layer. This will provide the user with another layer that contains both the vegetation data and site ID data in the attribute table.

Last, the user must sum the acres of each vegetation type within the 550 m radius surrounding each site. The easiest way to do this is to export the final joined table from the last step into Microsoft Excel and use the Pivot Table Wizard. When using the pivot table, the user should place the site ID in the row section, the "Cover Type" in the column section, and the "Acres" in the data section. This will provide a table with the acres of each vegetation type around each of the sites. The only vegetation types that are needed are aspen (TAA) and spruce (TWS).

Once the vegetation acres have been calculated around each site, all that is necessary is to copy and paste the values into the "Site Characteristics" worksheet (Figure 8). Currently, the vegetation area data for 2007 is entered in the worksheet. When vegetation layers for the BHNF are updated on the website described above, vegetation areas should be recalculated.

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