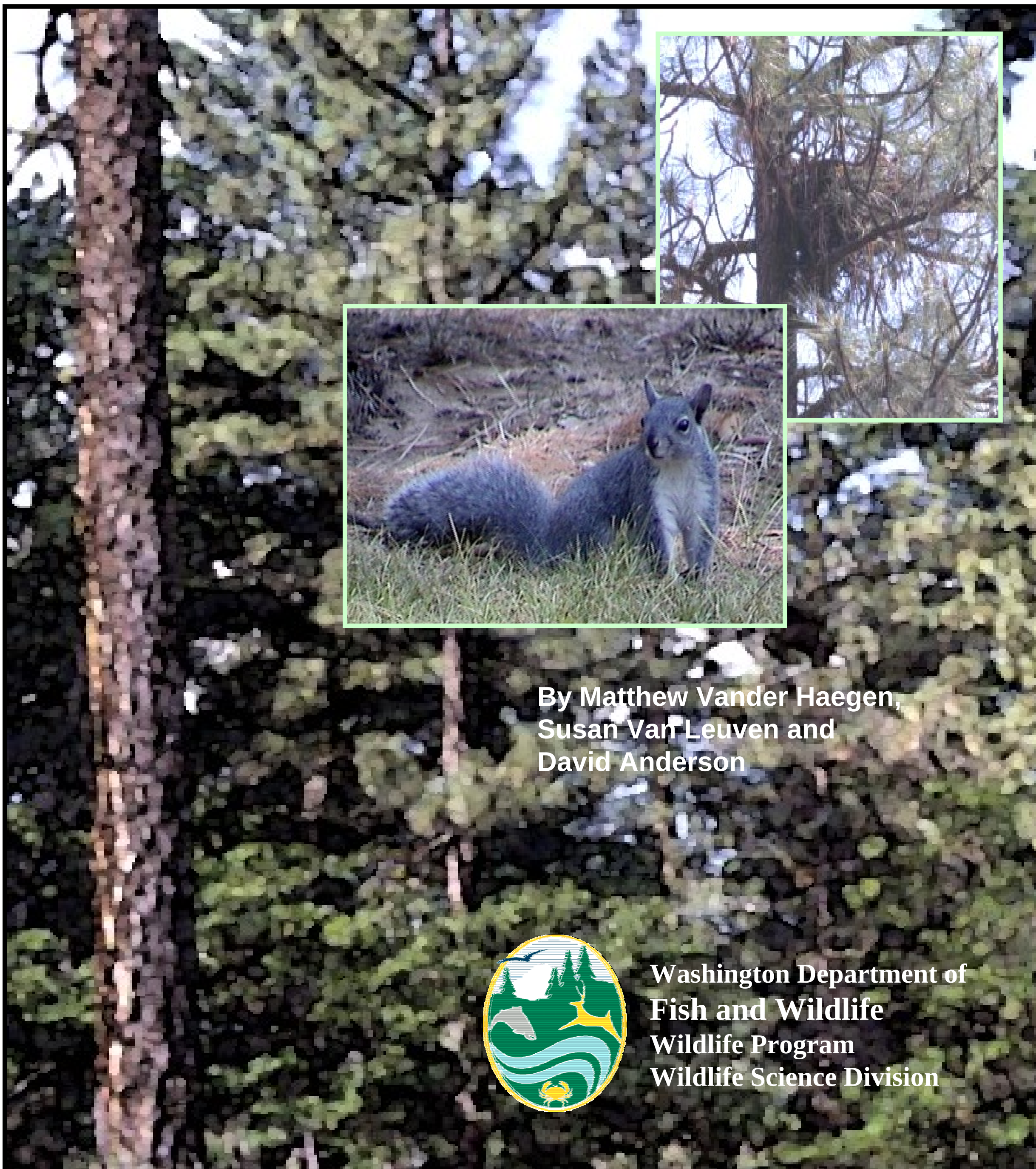
SURVEYS FOR WESTERN GRAY SQUIRREL NESTS ON SITES HARVESTED UNDER APPROVED FOREST PRACTICE GUIDELINES



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SURVEYS FOR WESTERN GRAY SQUIRREL NESTS ON SITES HARVESTED UNDER APPROVED FOREST PRACTICE GUIDELINES: ANALYSIS OF NEST USE AND OPERATOR COMPLIANCE

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EXECUTIVE SUMMARY

The western grey squirrel (*Sciurus griseus*) inhabits oak/conifer forests in California, Oregon, and Washington. In Washington, the western grey squirrel currently exists in only three locations (Puget Sound, Chelan and Okanogan Counties, and Klickitat County), its range severely reduced from historical times by loss of suitable habitat. This reduction in habitat combined with an uncertain future for the extant populations prompted the Washington Department of Fish and Wildlife to list the species as state-threatened in 1993.

Harvest of timber within the occupied range of the western grey squirrel has the potential to degrade habitat by removing mast-producing trees, destroying nests and potential nest sites, and decreasing the interconnected tree canopy that squirrels use to travel safely through their territories. Beginning in the mid-1980s, western gray squirrel habitat in south-central Washington has been logged at an accelerated rate due to a strong timber market and attempts to salvage beetle and drought-killed ponderosa pine (*Pinus ponderosa*). To address this threat, in 1996 the Washington Forest Practices Board established guidelines for commercial harvest within areas occupied by western grey squirrels. These guidelines were designed to protect existing nest trees and provide for retention of mast-producing trees and corridors to water sources within sites used by squirrels.

In spring of 1999 we began revisiting sites that had been harvested under approved forest practice applications for the purpose of documenting post-harvest nesting activity by western gray squirrels. Our objective was to address two questions of direct relevance to current nest protection guidelines: 1) does timber harvest affect nesting activity of western gray squirrels?, and 2) are operators complying with the current voluntary guidelines? Our approach was to resurvey sites that had been surveyed in prior years and document change in number of active nests. We resurveyed 10 sites that had been surveyed for western gray squirrels and subsequently harvested for timber, and 10 sites that had been surveyed but not harvested. All nest trees on post-harvest sites were evaluated for quality of protection according to nest protection guidelines. All sites were located within the Klickitat River drainage in south central Washington.

Examination of nests marked during pre-harvest surveys revealed that operators frequently were not complying with nest protection guidelines specified in individual forest practice permits. In some cases the violations appeared to represent disregard for the nest protection measures (e.g., removal of large pine trees in close proximity to nests), whereas in others the violations were less obvious. For example, fair or poor ratings for many of the nest trees on one site resulted from understory thinning of young trees within the 50-ft buffer. Situations such as this may have resulted from a misunderstanding on the part of the operator rather than a disregard for the guidelines. Regardless of cause, there obviously is much room for improvement in implementing current nest protection guidelines.

We found considerable change over time in the number of western gray squirrel nests on some sites, revealing the dynamic nature of nesting activity, and by association squirrel populations, on the landscape. The number of active nests changed substantially on some sites, but changes were not consistent in direction, either on the harvest or control sites. Resurveys were at least as

rigorous as original surveys, so decreases in nesting activity noted in this study likely reflect real changes. All sites except one had active nests during the resurvey, indicating that western gray squirrels continued to use most sites at some level. No active nests were found during the resurvey on one harvested site (Squirrel #4), indicating possible extirpation of that population.

At the level of individual nest trees, our data from marked nest trees suggest that timber harvest had a negative effect on their continued use by gray squirrels. Specifically, nest trees that were provided poor protection were less likely to have active nests than those provided good protection. This suggests that current nest protection guidelines, when followed, are working to maintain at least some level of suitability of existing nest trees. Multivariate models of nest activity indicated that excluding harvest activity from within 50 ft of the nest tree might be the most important component of the existing nest-protection guidelines.

This study has enabled an initial examination of conditions on sites harvested under western gray squirrel protection guidelines and the findings should be considered preliminary. This was largely an observational study, as we lacked experimental control, either over the placement of stands or when stands were harvested. Future research should focus on a controlled study measuring the demography of the populations on each site and how it changes as a function of harvest patterns, with detailed measurements of annual survival and productivity, as well as immigration and dispersal.

INTRODUCTION

The western grey squirrel (*Sciurus griseus*) inhabits oak/conifer forests in California, Oregon, and Washington. Relatively little is known about the ecology of the western gray squirrel and much of our existing knowledge comes from south in the species' range where habitat is very different from that in Washington and north-central Oregon. Studies in Oregon and California have been largely descriptive, with quantitative data based largely on small sample sizes (Ingles 1947, Cross 1969, Gilman 1986, Foster 1992). Most work in Washington has examined population distribution and has focused on locating nest sites, with little work on other aspects of western grey squirrel ecology (Bowles 1921, Barnum 1975, Rodrick 1986, 1999). Recent research on the Klickitat State Wildlife Recreation Area (KWRA) has provided new information on movements and habitat use by this species in Washington (Linders 2000). Findings from these studies and from ongoing research in Washington (WDFW unpublished data) have identified 5 components that appear critical to western gray squirrel habitat: 1) stands of large, mast-producing ponderosa pine (*Pinus ponderosa*), 2) clusters of mature conifer trees with interconnecting crowns for nesting, 3) mature Oregon white oaks (*Quercus garryana*) for acorns and for natal den sites (oak cavities), 4) hypogeous fungi, and 5) free-standing water.

Western gray squirrels depend on tree nests for protection from predators and for shelter from the elements. They typically use three types of nest: spherical stick nests (shelter nests), platform stick nests, and cavity nests. Stick nests are usually placed in large conifer trees and are created by weaving together terminal branches clipped from conifers (Grinnell and Storer 1924). Newly created nests, and nests that have had new material added to them recently, contain branches with green or red needles that distinguish them from older nests that contain only brown material. Platform nests are thought to be used for diurnal loafing, whereas shelter nests are used for shelter both day and night and are sometimes used by lactating females and their dependent young. Cavities in oaks or other hardwoods are used primarily as natal dens (Grinnell and Storer 1924, Linders 2000).

Figure 1. Western gray squirrel shelter nest in a ponderosa pine.

In Washington, the western gray squirrel currently exists in only three locations (Puget Sound, Chelan and Okanogan Counties, and Klickitat County), its range severely reduced from historical times by loss of suitable habitat (Rodrick 1993). This reduction in habitat combined with an uncertain future for the extant populations prompted the Washington Department of Fish and Wildlife (WDFW) to list the species as state-threatened in 1993. Current threats to western gray squirrel habitat in Washington include: harvest of mast-producing softwoods, conversion of ponderosa pine and oak woodlands to Douglas-fir *(Pseudotsuga menzeisii*) stands through silvicultural practices and fire suppression, clearing of ponderosa pine and oak woodlands for suburban and urban development, and habitat fragmentation. Biological threats to western gray squirrel populations include loss of mast-producing softwoods to pine beetle infestations, and mange epidemics such as those documented in the early and mid 1900s and more recently in Klickitat County in 1998 (Cornish et al. 2001).

Beginning in the mid-1980s, western gray squirrel habitat in south-central Washington has been logged at an accelerated rate due to a strong timber market and attempts to salvage beetle and drought-killed ponderosa pine (*Pinus ponderosa*). Harvest of timber within the occupied range of the western gray squirrel has the potential to degrade habitat by removing mast-producing trees, destroying nests and potential nest sites, and decreasing the interconnected tree canopy that squirrels use to travel safely through their territories. Timber harvest can decrease numbers of tree squirrels and is believed to be a factor in declining western gray squirrel populations in north-central Oregon (Foster 1992). In a controlled experiment in Arizona, Patton et al. (1985) found lower densities of Kaibab squirrels (*S. aberti kaibabensis*) in ponderosa pine stands harvested for timber compared to unharvested control stands, despite harvest restrictions that maintained a buffer around nest trees.

To address the threat that timber harvest might pose to western gray squirrels, the Washington Forest Practices Board established guidelines for commercial harvest within areas occupied by the species in Klickitat County (WDNR 1996). These guidelines were designed to protect existing nest trees and provide for retention of mast-producing trees and corridors to water sources within sites used by squirrels. These same guidelines currently provide the only protection for western gray squirrel habitat on timberlands in Washington. Pre-harvest surveys for arboreal stick nests are required for forest practice applications (FPAs) in Klickitat County. Surveys are conducted by WDFW biologists or by independent contractors or employees of the timber company who have undergone specific training. The area Habitat Biologist (WDFW) is responsible for entering language into the FPA that dictates how nests should be protected on the site. Generally, nest protection is considered in the harvest plan in accordance with a set of standard nest protection guidelines (Table 1). The Habitat Biologist has latitude when applying the standard guidelines and may choose to modify them after considering the nest survey results, condition of the forest stands, and the concerns of the landowner. For example, a dense cluster of nests in one stand might be put off limits to entry as a protected “set aside” in exchange for reduced canopy cover requirements in another part of the harvest unit that contains only scattered nests.

The protocol for nest surveys has changed slightly over the years, primarily in the quantity of data collected. Current protocol requires that both the condition and the color of each nest be recorded. These two characteristics yield insight as to the status of the nest. Nests in good condition suggest that they are currently in use, whereas nests that have lost some material or appear to be falling from the tree suggest an abandoned nest. Nests containing conifer branches with green or red needles indicate recent use, as this newly clipped material is added to the nest as part of new construction or maintenance. This information has been included in most surveys since 1997 but was provided only sporadically back to 1994, the year when organized survey efforts began. WDFW has also surveyed numerous sites in Klickitat County not associated with proposed timber harvests to document the extent of occupied habitat (Rodrick 1999). These surveys focused on areas deemed to have suitable habitat and were completed in a manner similar to pre-harvest surveys.

Although the nest protection guidelines have been in effect since 1996 and have influenced harvest prescriptions on numerous sites, their effectiveness in protecting nesting habitat for western gray squirrels has not been examined. In spring of 1999 we began revisiting sites that had been harvested under approved FPAs that included the nest protection guidelines to examine post-harvest nesting activity by western gray squirrels and document operator compliance. This effort was expanded later in 1999 and in 2000 to include a total of 20 sites.

Table 1. Standard guidelines for protecting western gray squirrel habitat in Washington (WDNR 1996).

1) protect all squirrel nests and nest trees
2) maintain a no-cut buffer within 50 feet of each nest tree
3) retain at least 50% canopy coverage within 400 feet of each nest tree
4) maintain arboreal “stringers” of trees between nests and other important resources (nearby water sources, foraging habitat, and other nest trees).
5) retain all oaks whenever possible
6) avoid logging, road building, or other noisy activities within 400 ft of all nest trees during the western gray squirrel breeding season (1 March – 30 September).

Research questions and study design

This study addressed two questions of direct relevance to current nest protection guidelines:

1) Does timber harvest affect nesting activity of western gray squirrels?

2) Are operators complying with the current voluntary guidelines?

We used two approaches in this study to examine if timber harvest affects nesting activity. Our first approach was to compare the number of nests from surveys conducted before and after timber harvest on sites where the nest protection guidelines were included as part of the forest practice permit. A significant decrease in the number of nests present on sites in the years following harvest might indicate a negative effect of timber harvest on nesting activity. Notably, compliance with the voluntary guidelines was likely to vary among sites; therefore, when comparing the number of nests before and after harvest, we were examining the effects of timber harvest *as it was practiced*—not the efficacy of the current guidelines. Thus, changes in nesting activity on harvested stands also may be related to non-compliance by operators, or inability of the operators to effectively implement the guidelines. Further, because timber harvest is only one of several potential factors influencing nesting activity, and to account for possible regional and temporal fluctuations in squirrel numbers, we duplicated the survey effort on a sample of sites that was not subjected to timber harvest. Differences in nest numbers on harvested sites that were not reflected in changes on unharvested (control) sites might then be more appropriately attributed to timber harvest.

Our second approach to examine the effects of timber harvest on nesting activity was at the scale of the individual nest (local variables) and focused on trees that were marked in pre-harvest surveys as containing western gray squirrel nests. We measured characteristics of these nest trees, including specific elements addressed in the current nest protection guidelines, and modeled the activity status of the nest trees as a function of these variables. The goal of this analysis was to examine what variables influence continued use of individual nest trees by western gray squirrels.

Determining nest status. — Because stick nests may remain visible in the tree canopy after being abandoned by squirrels, we needed some way to account for inactive nests. Active nests can best be identified by their condition (integrity) or by the presence of fresh plant material indicating recent maintenance. The current protocol for western gray squirrel nest surveys (Appendix A) requires that nest condition be recorded as either "A" (fully constructed nest or partially constructed nest that contains some fresh material [green or red conifer needles or oak leaves]), "B" (nest appears to have lost material and is beginning to fall out of tree), or "C" (most material is gone, but remaining nest material is of the size and type typically used by western gray squirrels). Similarly, nest color is recorded as "G" (green material visible in nest), "R" (red or "rusty" material [but no green] visible in nest), or "N" (neither green nor red material visible). In the current survey protocol, nests are considered active if they are in condition "A", ***or*** if they contain green or red material. Nest condition was not recorded in many of the earlier (pre-harvest) surveys, whereas presence of colored material was consistently noted. Therefore, we used the color of nests as the primary indicator of activity in both the original and resurveys, realizing that this would yield a conservative estimate of the number of active nests on a site.

METHODS

Site selection

We resurveyed 10 sites that had been surveyed for western gray squirrels and later harvested for timber, and 10 sites that had been surveyed for western gray squirrels but not harvested for timber (Appendix B). All sites were located within the Klickitat River drainage in south-central Washington (Figure 2).

We identified potential study sites by reviewing survey records on file with WDFW in Olympia and by consulting with the area habitat biologist. All sites were a mix of ponderosa pine and Douglas-fir, with patches of Oregon white oak. To be considered suitable, sites had to meet the following criteria:

1) $\geq$ 10 nests recorded on the initial survey, (we considered 10 nests the minimum number to indicate an active colony that would be likely to persist on the site),

2) between 80 and 300 acres in area,

3) survey records included a) a map showing the boundaries of the area surveyed and general locations of nests, b) documentation of the total number of nests, c) indication of how many nests contained green or red material, and d) dates the site was surveyed,

4) for post-harvest sites, a minimum of 1 year must have elapsed since harvest.

Sites meeting these criteria were visited to check if they had actually been harvested and to check for potential access problems. Too few sites met the above criteria, so we broadened the allowable size range to include sites less than 80 acres as long as they contained $\geq$ 10 nests in the original survey. Although surveys conducted prior to 1997 did not require recording of nest condition or color, some surveyors consistently recorded nest color making these earlier surveys suitable.

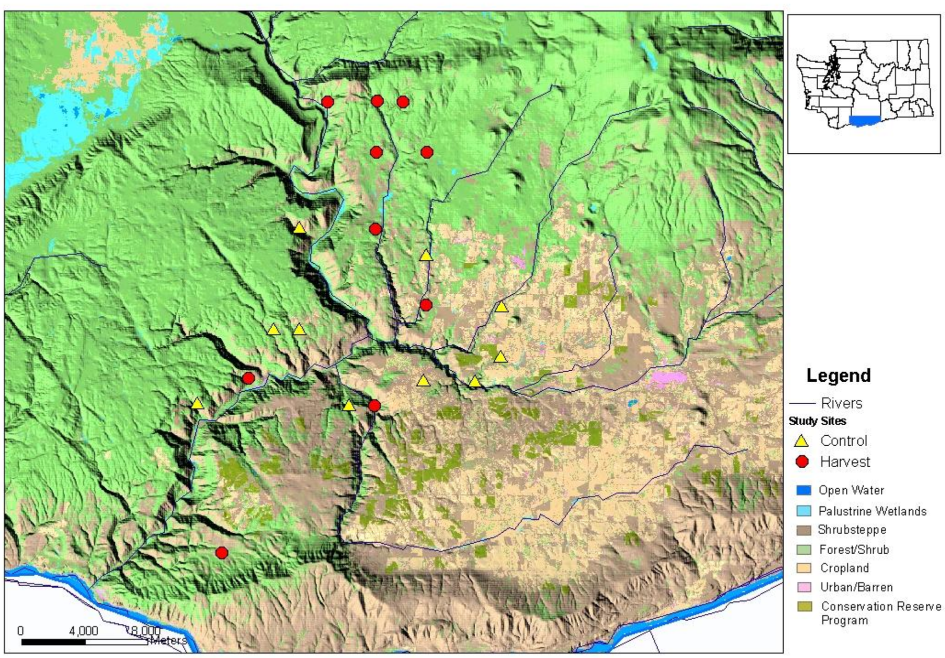

Figure 2. Study site locations in Klickitat County, Washington.

Surveys

We consulted the survey records for each site to determine the boundaries of the original nest survey. Coverage of our resurveys was similar to that on the original surveys, focusing on mature stands likely to contain nests and avoiding areas of young regeneration. In all but one case we contacted the original surveyor for additional information on the extent and intensity of the original surveys for specific sites. Two large sites were sub-sampled because of time constraints; only the nests within the sub-sampled area in both the original and resurvey were considered in our analyses. Sites were usually surveyed by walking along transects using a compass, but on steeper sites walking routes were along the contour of the slope. For each nest encountered on the survey we recorded type of nest (shelter or platform), condition of nest, color of material in nest, height of nest in tree, and diameter and species of the nest tree. Nest locations were marked on a map of the study site. We also noted direct observations of squirrels and other indicators of western gray squirrel activity such as foraging sign, as was done in the earlier surveys. One trained observer completed all 20 resurveys.

Nest trees located and recorded during earlier surveys were relocated during the follow-up survey using whatever means were available. On some post-harvest survey sites, nest trees were painted with numbers and bands around the trunk in a unique color; on other sites nests trees were marked with numbered or unnumbered flagging. Flagging on some trees was no longer visible, and on some control sites the nest trees had not been marked at all. On these, some trees were relocated using the original survey maps and description of the trees, but positive identification generally was not possible. Where previously marked nest trees could be positively identified, information was recorded for the tree using the same number assigned during the initial survey. Where identity of marked trees was not discernible, the nest trees were assigned new identification, but with a note on the survey sheet indicating that the trees were marked from an earlier survey.

Several characteristics of nests trees and their surroundings were recorded to aid in our evaluation of operator compliance. These were: canopy cover near the nest, presence of recent stumps near the nest, and damage to the nest tree.

A moosehorn coverscope with a 25-point grid was used to determine canopy coverage near nests in a few sample locations on each post-harvest survey site. After using the coverscope to establish a general range of values for the site, canopy coverage was estimated by visual observation, except where an especially compromised nest was found and an exact value for remaining canopy coverage seemed appropriate. To get a representative sampling of canopy coverage readings, canopy coverage was checked in eight locations (the four cardinal directions and four joint directions) 25 ft from the nest tree. These eight values were averaged and converted to a percentage. We estimated canopy coverage within 50 ft of the nest tree and in the general area surrounding the nest tree out to 400 ft.

We inspected the area within 50 ft of nest trees for stumps remaining from the most recent forest practice. Several of the post-harvest survey sites had been logged in the last 50 years and it was not unusual to find old stumps near nest trees. In some instances, the number of stumps near nests suggested a significant intrusion into the 50-ft buffers, but closer inspection showed that the stumps were all old, and no recent intrusion had actually occurred. Characteristics used to evaluate age of stumps were color of cut wood, looseness of bark, insect holes, decayed condition of interior wood, chainsaw marks and face cuts vs. rotary saw marks, stump height (indicating method of harvest), and presence of painted butt marks on sites where "take trees" were painted.

We examined nest trees for damage (broken limbs in the crown; missing bark on the trunk; removal of the entire nest tree) that could have resulted from harvesting trees too close to the nest tree (i.e., felling trees into the nest tree). When nest trees appeared to have sustained damage, we examined the face cuts on nearby stumps for indications of the direction trees were felled. Where nest tree damage was attributed to harvest activities, at least one stump was found showing evidence of felling close enough to have caused the damage.

Evaluation of nest protection

Nest protection on post-harvest survey sites was evaluated according to two sets of guidelines. One was the Standard Nest Protection Guidelines (Table 1), established in 1996 for application to all forest practices in Klickitat County that include sites occupied by western gray squirrels. The other was based on conditions for western gray squirrel protection detailed in the approved FPA for each site. These conditions are based on recommendations from a representative from WDFW. All nest trees were evaluated using both sets of guidelines. In five cases the two sets of protection measures were the same; in the remainder of cases, the conditions attached to the FPA varied from the standard set of guidelines.

Standard guidelines.—All nest trees on post-harvest sites were evaluated for quality of protection according to the Standard Nest Protection Guidelines. This provided a uniform set of criteria that could be applied to all nest trees, independent of the conditions placed on individual FPAs. The protection rating for each tree would then be used to evaluate its influence on the continued use of that tree for nesting by western gray squirrels. Evaluation of nest protection was weighted heavily on the condition of the nest tree and the condition of the 50-ft buffer.

A dichotomous key (Appendix C) provided a systematic approach for the surveyor to identify one of three levels of quality for nest tree protection based on the Standard Nest Protection Guidelines (Table 1). This assessment resulted in 8 possible outcomes (pathways through the key) to enable identifying one of the three levels of nest protection. Nest trees were rated as having a *Good* level of protection ***only if three conditions were satisfied***:

1) no damage to the nest tree,
2) canopy coverage within 50 ft of the nest >60%, and
3) a corridor of trees with interlocking branches maintained between the nest tree and other important resources (where this was present before harvest).

Nest trees could have a *Good* rating even if harvest-related alteration occurred within 50 ft of the nest tree as long as the aforementioned three conditions existed. Nest trees were rated as having a *Fair* level of protection if they failed ***only in one*** of either the corridor condition (3 above) or the canopy condition (2 above), as long as the canopy was still ≥40%. Nest trees were rated as having a *Poor* level of protection if they failed any other combination of these three conditions. Damage to the nest tree was pivotal as this condition alone resulted in a *Poor* level of protection rating.

Figure 3. Trees with interconnected canopies adjacent to nest trees provide squirrels an aerial pathway to and from their nests. Note shelter nest in center of photo.

Guidelines specified in FPA.—We considered only nest trees that were clearly marked when evaluating compliance with the conditions stipulated in the approved FPA. The assessment process closely paralleled that for the Standard Nest Protection Guidelines. Where the site prescription was essentially the same as the standard guidelines, the results of the two evaluation processes also were the same. Where the site prescription differed significantly from the standard guidelines, compliance with conditions of the FPA sometimes differed from the adherence to standard guidelines. Usually, variances allowed in individual FPAs effectively relaxed the requirements for protection, so on these sites, compliance ratings often were higher than nest protection ratings based on the standard guidelines.

We considered nest trees rated as "good" to be in compliance with the FPA, whereas nest trees rated as "fair" or "poor" were considered not to be in compliance. We assigned an overall compliance rating to each site based on the proportion of nest trees complying with the FPA. Sites where ≥90% of the nests trees complied earned a rating of "1"; those with 89-75% of nest trees in compliance earned a rating of "2"; and those with <75% of nest trees in compliance earned a rating of "3". This system for rating compliance held the operator to a high standard for protecting nests at the site level, while also allowing for a moderate degree of unintentional error in protection of individual nest trees.

In its FPA, the Kayser site was divided into three units, one of which was to be a "set aside" excluded from harvest activities. The two harvest units had different levels of nest protection defined in the FPA: nest trees in "management area B" were to be protected similar to the standard nest protection guidelines, whereas the "general harvest area" received less restrictive guidelines. Only nest trees in "management area B" were included in the analysis of change in number of total nests and active nests. We decided not to examine compliance on the Kayser site after it became apparent that confusion existed as to the boundaries of the 3 management units that remained unresolved before harvest began. We did rate protection of marked nest trees on the site with regard to the standard guidelines, and we used these ratings to derive a compliance rating for the site solely for use in the logistic regression models (see Data analysis).

All data were recorded on standard survey data sheets and nest locations were marked on a topographic map of the site (Appendix D). Survey sheets and nest maps for all sites are on file with WDFW in Olympia. Nest locations have been entered into WDFW's Natural Heritage Database.

Data analysis

Site-level analysis. — We used Wilcoxon's paired-sample test (Zar 1984) to test the null hypothesis of no change in the number of nests on sites over time. We performed this test on each of harvested and control sites, first using only active nests and then using all nests. Wilcoxon's paired-sample test evaluates the change in number of nests for each site using ranked scores (Zar 1984).

Nest-level analysis. — We used logistic regression to examine the effects of local variables on the continued use of marked trees for nesting after timber harvest. The analysis was limited to nest trees that had been clearly marked during pre-harvest surveys and remained identifiable during resurveys. Nests identified as "remnants" in the pre-harvest survey were excluded from this analysis. We began with univariate logistic regression analysis of all variables associated with marked nests (Table 2). Protection Class (equal to the protection rating arrived at from the dichotomous key) had possible values of *Good*, *Fair*, and *Poor*, and was converted to 2 design variables for analysis (Hosmer and Lemeshow 1989). The binary outcome variable was "nest status", with active nests = 1 and inactive or missing nests = 0. Significance of univariate tests was corrected for experimentwise error rate using Bonferroni adjustment (Zar 1984).

We used Akaike's Information Criterion (AIC_c) adjusted for small sample size (<40 observations/parameter in the largest model) to select from a suite of multivariate models. We used the Score procedure in Proc Logistic (SAS 1990) to identify likely models using best subsets selection, and generated AIC_c values and Akaike weights (Burnham and Anderson 2002) for the top 3 models in each group. The best-subsets selection included variables identified as significant ($P < 0.1$) in the univariate analyses plus those that we believed likely to have biological relevance (Hosmer and Lemeshow 1989). We used $P < 0.1$ as a decision threshold to decrease the odds of excluding meaningful variables. We dropped one variable from highly correlated pairs. We considered the model with the lowest AIC_c value to be the best approximating model for the data, and present alternate models that differed from the best model by ≤ 4 units in AIC_c values (Burnham and Anderson 2002).

Because this nest-level analysis used only recently-collected information on nest condition, we were able to use the current definition for active nests in assessing current use; that is, all nests that were in condition class "A" and/or contained red or green material were considered active. Nests that were in condition class "B" or "C" and that did not contain red or green material were considered inactive. Marked nest trees that no longer contained visible nests were considered abandoned. This broader definition of active nests that included "A" condition nests regardless of color was less likely to miss-classify an active nest as inactive.

Table 2. Variables associated with marked western gray squirrel nests and used in logistic regression models.

Variable name	Description
Protection Class	Protection rating of nest based on standard guidelines (Good, fair, poor)
Entry	Significant entry into the 50ft buffer surrounding the nest (yes, no)
CC50	Canopy closure within 50ft of the nest was >59% (yes, no)
CC400	Canopy closure within 400ft of the nest was >49% (yes, no)
Connect	Connectivity was maintained between the nest tree and other important resources (yes, no)
Site Rank	Compliance rating for the site overall (1 or 3)[a]
Yr_Harvest	Years elapsed between timber harvest and post-harvest survey
Mo_Survey	Months elapsed between pre- and post-harvest surveys
DBH	Diameter of nest tree
Height	Height of nest above ground
Species	Species of nest tree (fir or pine)

[a] Sites were classified as 1 (includes one site rate as 2) or 3 for this analysis.

RESULTS

Assessment of operator compliance

Overall compliance with nest protection guidelines stipulated in individual FPAs is presented in Table 3. Two sites scored a "1" rating; the Brickman site which was helicopter logged, and the Jackel site on which close spacing of most nests resulted in almost no harvest in that part of the site containing nests. On these two sites no 50-ft buffers were entered, or if they were, the nest tree remained intact and sufficient trees remained within the buffer to offer suitable canopy closure and protection of the nest tree. Six of the 9 sites earned a "3" rating, with an average compliance rate of 43% (range 14-67%). One site earned a "2" rating.

Most sites had at least 1 tree that received a poor rating and for four sites the proportion of nests rated as poor was substantial (> 30%). Only the Brickman site received good ratings for all marked nest trees. For 3 out of 9 of these sites the number of marked trees used to derive these figures was low (<6). Protection ratings for nest trees derived using Standard Nest Protection Guidelines are provided in Appendix E.

Table 3 . Compliance with western gray squirrel nest protection guidelines as described in forest practice application for each site, Klickitat County, Washington.

Site	Protection rating for marked nests			Nest trees in compliance (%)[a]	Damaged marked nest trees	Average rating for site[b]
	Good	Fair	Poor			
Soda Springs	27	15	9	53	2	3
Wide Sky	9	7	8	38	1	3
Squirrel #5	5	19	11	14	0	3
Brickman	15	0	0	100	0	1
Swale Canyon	30	16	22	44	6	3
Bowman Creek	2	2	1	40	0	3
Jackel	18	1	0	95	0	1
Squirrel #4	4	2	0	67	0	3
Squirrel #2	5	0	1	83	0	2

[a] Nest trees with a "good" protection rating.
[b] "1" = ≥90% of nest trees in compliance; "2" = 75-89%; "3" = <75%.

Change in number of nests

The total number of western gray squirrel nests counted on harvest and control sites increased between surveys by 47% and 46%, respectively. We counted a total of 449 nests on harvest sites during our post-harvest surveys, compared to 305 nests counted on the same sites before harvest. On control sites, we counted 340 nests during our resurvey, compared to 233 on the original survey. The increase in nest numbers on harvest sites was not significantly different from the increase in nest numbers on control sites ($\chi^2 = 0.0005$, df = 1, $P = 0.983$).

The direction and magnitude of change in number of nests varied greatly among individual sites, both for harvest (Table 4) and control (Table 5) sites. The range in number of nests (10-73) counted on the original surveys was similar on harvest and control sites, as were the median values for change in the number of nests counted between surveys (0.5 and 5.5, respectively). Results of the Wilcoxon's paired-sample test revealed no significant difference between number of nests counted in the original surveys compared to the number counted in resurveys for both the harvest ($T = 22.5$, n = 10, $P > 0.5$) and control ($T = 14$, n = 10, $P > 0.1$) sites. Clearly, the number of nests changed substantially on some sites, but the changes were not consistent in direction in either data set. All but one of the harvest sites had marked nest trees that no longer contained a nest (Table 4). For several sites this number was substantial, exceeding 25% of the trees originally marked. Similar figures are not available for control sites, because few nest trees were marked sufficiently well to be recognizable during the resurvey.

Change in number of active nests

We counted a total of 213 active nests on harvest sites during our post-harvest surveys, compared to 102 active nests counted on the same sites before harvest. On control sites, we counted 136 active nests during our resurvey, compared to 101 on the original survey. The increase in number

Table 4. Change in number of western gray squirrel nests counted on harvested sites over time.

	Number of nests				
Site Name	Pre-harvest survey	Post-harvest survey	Marked nest trees [a] without nests	Difference in number of nests	% change in number of nests
Soda Springs	61	51	19	-10	-16
Wide Sky FPA	46	23	13	-23	-50
Squirrel #5	33	32	5	-1	-3
Brickman FPA	15	36	0	21	140
Swale Canyon	73	76	23	3	4
Bowman Creek	16[b]	166	3	150	938
Jackel FPA	19	21	3	2	11
Squirrel #4	14[b]	13	1	-1	-7
Squirrel #2	10 [b]	8	4	-2	-20
Kayser FPA					
Set Aside Area	38	50	15	12	32
WGS Mgmt Area B	18	23	0	5	28
Gen. Harvest Area	16	16	0	0	0

[a] Marked trees that no longer have nests on post-harvest sites.
[b] Only nests plotted within the boundaries of the post-harvest survey were tallied for comparison purposes.

Table 5. Change in number of western gray squirrel nests counted on control sites over time.

	Number of nests				
Site Name	Original survey	Second survey	Marked nest trees [a] without nests	Difference in number of nests	% change in number of nests
Skookum Canyon	33	31	2[b]	-2	-6
KWRA	11	39	--[b]	28	255
Wahkiacus Canyon	18	22	--[b]	4	22
Mill Creek	15	13	--[b]	-2	-13
Schilling Ranch	12	70	--[b]	58	483
Blockhouse Creek	11	18	--[b]	7	64
Hilton Spring	23	17	--[b]	-6	-26
Beeks Canyon	10	20	--[b]	10	100
Little Klickitat South	30	16	--[b]	-14	-47
Chiles	70	94	--[b]	24	34

[a] Marked trees that no longer have nests.
[b] Previously marked trees could not be relocated in most cases on this site.

of active nests on harvest sites was significantly different from the increase in number of active nests on control sites ($\chi^2 = 5.66$, df = 1, $P = 0.017$). The ranges in number of nests counted on the original surveys were similar on harvest (4-22) and control (1-36) sites, as were the median values for change in the number of nests between surveys (-3 and 1, respectively).

Table 6. Change in number of active western gray squirrel nests on harvested sites over time.

	Number of active nests[a]		Difference in	% change
	Original	Post-harvest	number of	In number of
Site Name	survey	Survey	active nests	active nests
Soda Springs	22	10	-12	-55
Wide Sky	17	3	-14	-82
Squirrel #5	14 (2)[b]	7	-7	-50
Brickman	6 (1)	21	15	250
Swale Canyon	5	21	16	320
Bowman Creek	14[c]	114	100	714
Jackel	4 (1)	4	0	0
Squirrel #4	14[c]	0	-14	-100
Squirrel #2	6[c]	3	-3	-50
Kayser				
Set Aside Area	17 (8)	17	--[d]	--[d]
WGS Mgmt Area B	1 (5)	4	--[d]	--[d]
Gen. Harvest Area	7 (1)[c]	5 (1)	--[d]	--[d]

[a] Nests with green or red plant material
[b] Number in parenthesis is the number of nests for which color was either not recorded or could not be determined.
[c] Only nests plotted within the boundaries of the post-harvest survey were tallied for comparison purposes.
[d] Not suitable for analysis.

Similar to our findings for number of total nests, the direction and magnitude of change in number of active nests counted varied greatly among individual sites, both for harvest (Table 6) and control (Table 7) sites. Results of the Wilcoxon's paired-sample test revealed no significant difference between number of active nests counted in the original surveys compared to the number counted in resurveys for both harvest ($T = 20$, n = 10, $P > 0.5$) and control sites ($T = 21.5$, n = 10, $P > 0.5$). Clearly, the number of active nests changed substantially on some sites, but the changes were not consistent in direction in either data set.

A relationship appeared to exist between change in the number of active nests and overall compliance with the nest protection guidelines. Of the 5 sites where the number of active nests declined between surveys, four earned a compliance rating of "3" and the fifth earned a rating of "2". Two sites earning a compliance rating of "3" showed an increase in number of active nests. Both sites that earned a compliance rating of "1" showed no decline in number of active nests after harvest.

Table 7. Change in number of active western gray squirrel nests on control sites over time.

Site Name	Number of active nests[a] Original survey	Second survey	Difference in number of active nests	% change in number of active nests
Skookum Canyon	18	11	-7	-39
KWRA	5	27	22	440
Wahkiacus Canyon	9	9	0	0
Mill Creek	7	9	2	29
Schilling Ranch	1	21	20	2000
Blockhouse Creek	6	10	4	67
Hilton Spring	6	2	-4	-67
Beeks Canyon	2 (1)[b]	4	2	1
Little Klickitat South	11 (2)	8	-3	-27
Chiles	36 (3)	35	-1	-3

[a] Nests with green or red plant material
[b] Number in parenthesis is the number of nests for which color was either not recorded or could not be determined.

Nest status as a function of local variables

Of the 191 nests used in this analysis, 110 (58%) were classified as active, 29 (15%) as inactive, and 52 (27%) were missing. Univariate regression analyses revealed 3 variables that were related significantly to continued use of nests on post-harvest sites after Bonferroni adjustment: Protection Class, Connect, and Yr_Harvest (Table 8). Protection Class was related to continued use of nests, with nests afforded good protection more likely to have active nests than those afforded poor protection. One variable that helped determine protection class, Connect, also was significant, whereas the other 3 variables that comprise Protection Class, Entry, CC50 and CC400, were not significant. Yr_Harvest was related to continued use of nests, with nests less likely to be active with passing of time.

We included 7 independent variables in the best-subsets modeling procedure. Two of these variables were significant in univariate analyses (Connect and Yr_Harvest), and 5 were included because biological reasons exist that explain why they might influence continued nest use by western gray squirrels (Entry, CC50, CC400, Site Rank, and DBH). Protection Class was excluded because it was closely correlated with both Entry and Connect. Mo_Survey was similarly excluded for its close correlation with Yr_Harvest (both variables essentially measured passage of time). Height was excluded because it precluded use of trees that had lost their nests.

Best subsets model selection provided 16 models to compare using AIC_c. The best model contained only 2 variables: Entry and Yr_Harvest (Table 9). Both variables had a negative effect on continued nest use. Odds ratios (Hosmer and Lemeshow 1989) for Entry and Yr_harvest were 0.45 and 0.52, respectively, indicating that it was about half as likely that a nest would remain active when the 50-ft buffer was entered during harvest and with each passing year. The strength of evidence for this model as indicated by the Akaike weight (0.28) was not great, so we considered an additional 6 models that had AIC_c value within 4 units of the best model (Table 9)

Table 8. Univariate logistic regression analysis of variables measured at marked western gray squirrel nests on post-harvest sites.

Variable	Coefficient	SE	Wald X^2	*P*
Protection Class				
Good vs. Fair	-0.50	0.38	1.73	0.187
Good vs. Poor	1.28	0.34	13.92	<0.001[a]
Fair vs. Poor	0.78	0.39	4.00	0.045
Entry	-0.96	0.31	9.66	0.002
CC50	0.34	0.35	0.93	0.336
CC400	0.32	0.34	0.89	0.345
Connect	0.87	0.32	7.35	0.007 [a]
Site Rank	0.83	0.39	4.58	0.032
Yr_ Harvest	-0.66	0.19	11.68	<0.001[a]
Mo_Survey	-0.06	0.01	3.95	0.047
Height [b]	0.04	0.02	4.01	0.045
DBH	0.02	0.02	0.79	0.375
Tree Species	-0.01	0.33	0.01	0.976

[a] Significant at P<0.1 with Bonferroni adjustment for experimentwise error rate.
[b] Sample size for analysis of Height was reduced (n = 139) as nests that were missing from marked nest trees were not available for height measurement.

(Burnham and Anderson 2002). Models 2-4 differed from the best model by the addition of a single variable; the negligible change in –2 log likelihood with the addition of these single variables indicated that they contributed little to explaining nest status (Burnham and Anderson 2002). Similarly, Models 5-7 differed from either model 2 or model 3 by only one variable with a negligible change in –2 log likelihood. The Akaike weights of these 3 models also were low, indicating little evidence in their favor (Burnham and Anderson 2002). Each of the 6 top models included Entry and Yr_Harvest, suggesting elevated importance of these variables in influencing continued nest use. Nests apparently are less likely to remain active over time, and having Yr_Harvest in each model controlled for this effect. The variable Connect, although significant in the univariate analysis, was not significant in the multivariate analysis once Entry and Yr_Harvest were taken into account.

Table 9. Best multiple logistic regression models based on AIC_c and Akaike weight (w) that explained effects of nest site variables on continued use of nests by western gray squirrels.

Model	-2logL	AIC_c	ΔAIC_c	w
Entry Yr_Harvest	228.9	235.1	0	0.28
Entry Yr_Harvest Connect	227.9	236.2	1.1	0.16
Entry Yr_Harvest Siterank	228.3	236.6	1.5	0.13
Entry Yr_Harvest DBH	228.7	236.9	1.8	0.11
Entry Yr_Harvest Siterank Connect	227.4	237.8	2.7	0.07
Entry Yr_Harvest Connect DBH	227.7	238.1	3.0	0.06
Entry Yr_Harvest Connect CC50	227.9	238.3	3.2	0.06

DISCUSSION

Examination of nests marked during pre-harvest surveys revealed that operators frequently were not complying with nest protection guidelines specified in individual forest practice permits. In some cases, violations appeared to ignore nest protection measures (e.g., removal of large pine trees in close proximity to nests), whereas in others the violations were less obvious. For example, fair or poor ratings for many of the nest trees on one site resulted from understory thinning of young trees within the 50-ft buffer. Situations such as this may have resulted from a misunderstanding on the part of the operator rather than a disregard for the guidelines. Regardless of cause, there obviously is much room for improvement in implementing current nest protection guidelines. The most carefully crafted and scientifically sound forest practice guidelines will have little value to wildlife if they are not effectively implemented in the field.

We found considerable change in the number of western gray squirrel nests on some sites over time, which may reveal the dynamic nature of nesting activity, and by association squirrel populations, on the landscape. Substantial changes in local populations of western gray squirrels have been documented in California (Grinnell and Storer 1924, Asserson 1974) and in Oregon (Cross 1969, Foster 1992), with decreases attributed to clearcut logging, fire, and disease. Increased nesting activity on some sites in Washington may reflect an increase in squirrel numbers, whereas on other sites the apparent increase in nests may be due to increased search effort in the resurvey. Although we attempted to repeat the effort expended in the original survey, biologists surveying an impending forest practice sometimes are pressed for time and may not document all nests. Resurveys were at least as rigorous as original surveys, so decreases in nesting activity noted in this study likely reflect real changes on the site. All sites except one had active nests during the resurvey, suggesting that western gray squirrels continued to use the sites at some level. No active nests were found during the resurvey on one harvested site (Squirrel #4), indicating possible extirpation of that population.

Although changes in squirrel numbers may be influenced by timber harvest, other factors such as disease, predation, and movements associated with changing food availability also influence local populations (Foster 1992). Changes in the landscape adjacent to our survey sites also may have influenced nesting activity and contributed to observed increases or decreases. Harvest activity and modification of stand structure could result in squirrels leaving an area and "packing" into adjacent habitat, as has been suggested for forest birds in industrial forest landscapes (Hagan et al. 1996). Conversely, disturbance from extended harvest activity on nearby sites could force squirrels to leave an otherwise suitable area. Examination of harvest activities adjacent to our sites revealed no consistent pattern. Four harvested sites, Squirrel No. 2, Squirrel No. 4, Squirrel No. 5, and Kayser, all were within a large block of timberland that has been undergoing intense harvest; nesting activity on three of these sites dropped considerably between surveys while on the 4th it remained constant. However, nesting activity declined on two other harvested sites, Soda Springs and Wide Sky, and both were largely isolated from other forest practices. Harvest activity was limited beyond the boundaries of the Bowman Creek harvest site, yet nesting activity increased on this site dramatically, as it did on two control sites (KWRA and Schilling Ranch) that also had no forest practices nearby. Nesting activity decreased on a third control site, Skookum Canyon, which was buffered from timber harvest.

A major assumption of this study was that the number of nests found on a site is correlated with population density. This relationship has not been investigated for western gray squirrels; however, Dodd et al. (1998) found a significant correlation between number of total nests and density of the closely related Abert squirrel (*Sciurus aberti*) in ponderosa pine habitats in Arizona. Data derived from studies of radio-tagged western gray squirrels reveal that arboreal stick nests often are maintained from year to year (Vander Haegen, unpublished data). On one control site in the present study (Chiles), all 16 nest trees that were marked in the earlier survey and remained identifiable in the resurvey contained active nests after a period of 4 years. Because nest counts are currently used as an indicator of the importance of sites to western gray squirrels in Washington, it is critical that the relationship between nest numbers and squirrel numbers, as well as the general nesting ecology of western gray squirrels, be understood. Hence, investigation of the relationship of nest numbers and their significance in assessing western gray squirrel nesting ecology, especially in a forest practices context, is imperative.

At the level of individual nest trees, our findings indicate a negative effect of timber harvest on their continued use by western gray squirrels. Specifically, nest trees that were provided poor protection were less likely to have active nests than those provided good protection. This suggests that current nest protection guidelines, when followed, are working to maintain at least some level of suitability of existing nest trees. The multivariate analysis of nest status indicated that excluding harvest activity from within 50 ft of the nest tree might be the most important component of the existing guidelines. That nests, on average, should be less likely to remain active over time was not unexpected; however, this effect should occur independent from other variables examined in this study. Results of these regression analyses should be considered exploratory (Burnham and Anderson 1998) and findings should be treated as hypotheses to be tested with further research.

MANAGEMENT AND RESEARCH IMPLICATIONS

Compliance with nest protection guidelines dictated for individual FPAs was found to be poor on most sites in this study. Guidelines for protection of critical wildlife habitat, whether voluntary or mandatory, must be implemented effectively if they are to be of any value. Approaches and incentives to improve compliance by operators and refinements of methods to verify habitat protection in the field should be rigorously pursued.

Our findings indicate that the level of protection afforded individual nests during harvest activities influences whether those nests continue to be used by western gray squirrels. Nest provided "good" protection were more likely to see continued use, suggesting that the current guidelines are providing a level of protection for western gray squirrels. Avoiding entry into the 50-ft no-cut buffer surrounding each nest was most closely related to continued nest use; this component should be emphasized in future nest protection efforts.

This study has enabled an initial examination of conditions on sites harvested under western gray squirrel protection guidelines, so findings should be considered preliminary. This was largely an observational study, as we lacked experimental control, either over the placement of stands or when stands were harvested. Moreover, assessing the effects of timber harvest on western gray squirrels at the stand level will require more than simply counting the number of active nests. Nest counts may provide only an index to the number of squirrels and yield no information on the age or reproductive status of individuals inhabiting the site. Future research should focus on a controlled study measuring the demography of the populations on each site and how it changes as a function of harvest patterns, with detailed measurements of annual survival and productivity, as well as immigration and dispersal. A study of this type would provide a more complete picture of how timber harvest affects populations of western gray squirrels.

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Appendix A. Field protocol for surveying western gray squirrel nests.

Washington Department of Fish and Wildlife developed a protocol for surveying western gray squirrel nests in 1993 (Ryan et al. 1994). Over the years, this protocol has been modified and updated as we learned more about gray squirrel nesting ecology. The protocol that was used for the resurveys described in this report is presented below. It differed from the protocol used in the pre-harvest surveys mainly in requiring that nest condition and nest color be assessed and recorded. ***Anyone interested in conducting surveys for western gray squirrels should contact WDFW for the most up to date survey protocols.***

Materials

The following materials are required to effectively complete a survey:

1. Western Gray Squirrel Survey Cover Sheet, Western Gray Squirrel Survey Form, maps of the survey area.
2. Colored flagging and waterproof marker for marking nest trees for later identification
3. Binoculars, compass, and Global Positioning System (GPS) unit.

Survey Coverage

Surveys should be conducted by walking slowly and quietly through suitable habitat while visually searching the ground and trees for nests and squirrels. Transects may be used, but any method that results in careful and thorough coverage of appropriate habitat may be used. Because nests frequently are found in clusters, the search area should be enlarged and efforts intensified when nests or squirrels are observed. One squirrel uses many nests, but nests are not the exclusive property of any one individual. Home ranges overlap, so clusters of nests may indicate a breeding colony.

Identifying nest trees

Western gray squirrels typically construct stick nests by cutting the terminal 45cm from a live branch and weaving the stem and leaves (or needles) into the nest, forming a dense ball. Western gray squirrels often mix cuttings from conifer and broad-leaved tree species into their nests. Most nests are approximately 45-60cm in diameter and are tightly woven. Most stick nests are found in conifers, but nests have been found in many types of trees. A classic western gray squirrel nests is one constructed of pine boughs and placed about one-third of the way down from the top of a large tree, on a branch or a fork next to the bole; however, considerable variation does occur. Oak cavity nests are also used, but we currently have no methodology for accurately surveying and recording suitable cavities for nesting.

Nests of other species.—Because squirrels cut live branches, their nests can be distinguished from bird nests by the presence of bark on the twigs, and the density of leaves or needles worked into the nest, among other features. Douglas squirrel nests may appear similar to those of western gray squirrels, but are generally smaller in size ($\leq$30cm in diameter) and are typically made of Douglas-fir boughs. In addition, nests that appear to belong to Douglas squirrels often are solitary and widely scattered, lacking the clustering that is often found with western gray squirrel nests.

Documenting nest trees

Record all survey area boundaries, nests located, and squirrels observed on a copy of a USGS 7.5' topographical map. Before surveying, make 2 Xerox copies (enlarged to 200%) of relevant portions of USGS topographic maps to mark up in the field. Copies should include at least two (preferably 4) section corners as reference points. Save one copy for reporting results to Data Management and use the second copy for recording data in the field. Survey boundaries should delineate the extent of the area that could easily be viewed from the route walked by the surveyor. If areas of poor or unsuitable habitat were excluded from the survey, make sure this is clearly marked on the map. If possible, draw the basic walking route on the map, or indicate the survey technique (e.g. 30-m north-south transects) on the Survey Cover Sheet. WDFW tracks both positive and negative survey efforts for this species, so please fill out a Survey Cover Sheet for each survey.

When a western gray squirrel or nest is located fill out a Western Gray Squirrel Survey Form in addition to the Survey Cover Sheet with the information requested and locations clearly marked on an attached map. If possible, use a GPS unit to record the location of nests or squirrel sightings. Record locations in NAD27 datum and UTM coordinates if possible. If using another coordinate system, make sure to indicate the units and the datum in the comment line of the Western Gray Squirrel Survey Form. Feel free to write across several lines if needed, to describe any important or unusual aspects of the observation. If only a western gray squirrel is observed, map its location and indicate the details of the sighting on the Survey Form.

Documenting nest and nest tree characteristics

Nest Condition.—The appearance of western gray squirrels nests depends largely on whether the nest is currently in use. Abandoned nests that are not maintained will eventually disintegrate and fall from the tree. We use 3 "condition classes" to document the appearance of stick nests:

> A = fully constructed nest that appears intact and not deteriorating, *or* a partially constructed nest that contains some fresh material (green or red conifer needles or oak leaves)
> B = nest appears to have lost material and is beginning to fall out of tree (no green or red material present)
> C = most material is gone, but remaining nest material is of the size and type typically used by western gray squirrels (again, no green or red material present)

On the survey form, enter A, B, or C under Nest Condition.

Nest Color.—Newly created nests or nests that squirrels are maintaining will contain newly-cut branches with green needles or leaves, or somewhat less recently cut branches with red needles. We use 3 "color classes" to document the color of stick nests:

> G = green material visible in nest
> R = red or "rusty" material visible in nest
> N = neither green nor red material visible (all nest material is gray, brown, or black).

On the survey form, enter G, R, or N under Nest Color

Nest height.—estimate the height of the nest above the ground (unit = feet).

DBH of nest tree.—using a DBH tape, measure the diameter at breast height of the nest tree (unit = inches).

Tree species.—enter tree species as pine (P), fir (F), or oak (O).

Marking nest trees

Mark nest trees with high-visibility flagging (pink and black stripe is standard). Assign a number or letter to the tree, and mark "WGS (#)" on the solid colored side of the ribbon with a waterproof marker. Trees are marked to prevent accidental re-counting of the same tree and to make it possible to later revisit the tree. Record nest and tree data directly on a WGS Survey Form (including GPS location if possible), and plot tree location on field map. If there are multiple nests in a tree, fill out a separate line for each nest.

Appendix B. Harvest sites sampled for western gray squirrel nesting activity, Klickitat County, Washington.

Site Name	Legal Description	Acres Harvested	Acres Surveyed[a]	Date(s) of Survey[b] Pre-Harvest	Harvest Date	Date(s) of Survey[b] Post-Harvest
Soda Springs	T5N R14E S21 S1/2	240	170	14 Oct. - 14 Nov. 1996	1998	28 Apr. - 19 May 1999
Wide Sky	T3N R13E S28 & 29	70	70	27 Sept. - 1 Oct. 1996	1997	20 May - 8 Jun. 1999
Squirrel #5	T5N R14E S4, T6N R14E S33	570	570	2 Jul. 1997	1998	9 Jun. - 13 Jul. 1999
Brickman	T4N R13E S22	65	65	1 Apr. 1998	1998	27 Oct. - 3 Nov. 1999
Swale Canyon	T4N R14E S28 NW1/4	80	80	11 Jan. - 28 Mar. 1996	1996	9 Nov. - 19 Nov. 1999
Bowman Creek	T4N R14E S2 & 11	370	117	1 Nov. - 6 Nov. 1996	1996-97	9 Mar. - 21 Mar. 2000
Jackel	T6N R14E S30 NE1/4	23	12	19 Dec. 1997	1998	5 Apr. - 6 Apr. 2000
Squirrel #4	T6N R14E S27, 28, 33, & 34	906	206	8 May 1996	1997	24 May - 1 Jun. 2000
Squirrel #2	T5N R14E S2, 3, 10, & 11	333	333	16 Apr. - 31 May 1996	1998	8 Jun. - 16 Jun. 2000
Kayser				5 -14 Oct., Nov. & Dec. 1995	1998	20 Apr. - 23 Jun. 2000
Set Aside Area	T6N R14E S28 & 29	33	33			
WGS Mgmt Area B	T6N R14E S28 & 29	25	25			
Gen. harvest area	T6N R14E S21, 28, & 29	362	22			

[a] Post-harvest survey.

[b] Surveys occurred within theses date ranges, but not necessarily on all dates.

Appendix B (cont.) Control sites sampled for western gray squirrel nesting activity, Klickitat County, Washington.

Site Name	Legal Description	Acres Surveyed	Date(s) of Baseline Survey [a]	Date(s) of Follow-Up Survey [a]
Skookum Canyon	T4N R13E S11, 12, 13, & 14	195	15 Oct. -15 Nov. 1997	7 Dec. - 9 Dec. 1999
KWRA	T5N R14E S26, 27, 34,& 35	80	21 Oct. 1997	7 Jan. - 21 Jan. 2000
	T4N R14E S3 NE1/4			
Wahkiacus Canyon	T4N R13E S12	105	13 Nov. 1997	21 Dec.'99 - 26 Jan. '00
Mill Creek	T4N R15E S5, 7, & 8	40	12 Nov. 1995	22 Feb. - 24 Feb. 2000
Schilling Ranch	T4N R14E S29 & 30	50	21 Oct. 1995	29 Feb. - 3 Mar. 2000
Blockhouse Creek	T4N R15E S17,18, & 19	90	23 Oct. - 26 Oct. 1995	2 Mar. - 7 Mar. 2000
Hilton Spring	T4N R13E S29 & 30	34	3 Oct. 1996	23 Mar. 2000
Beeks Canyon	T5N R13E S24 & 25	50	1 Oct. 1996	11 Apr. - 12 Apr. 2000
Little Klickitat South	T4N R15E S19 & 30	58	27 Oct. 1995	19 Apr. 2000
Chiles	T4N R14E S23	97	6 Dec. 1995 - 3 Jan. 1996	4 May - 5 May 2000

[a] Surveys occurred within theses date ranges, but not necessarily on all dates.

Appendix C. Dichotomous key used to rate quality of protection provided for individual nest trees based on the Standard Nest Protection Guidelines.

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1. Has any harvest-related alteration occurred within 50 ft of the nest tree?
   No --------->Go to 5.
   Yes -------->Go to 2.

2. Is there damage to the nest tree?
   Yes -------->Poor Protection
   No -------->Go to 3.

3. Is remaining canopy coverage within 50 ft of the nest $\geq$ 60%?
   Yes -------->Go to 5.
   No --------->Go to 4.

4. Is remaining canopy coverage $\geq$ 40%?
   Yes -------->Go to 6.
   No --------->Poor Protection

5. Was a corridor of trees with interlocking branches maintained between the nest tree and other important habitat (where present before harvest)?
   Yes -------->Good Protection
   No --------->Fair Protection

6. Was any existing connection to other important habitat via a corridor of interlocking branches maintained?
   Yes ------->Fair Protection
   No -------->Poor Protection

Appendix D. Western gray squirrel survey form and survey map.

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WESTERN GRAY SQUIRREL SURVEY - DATA SHEET FOR NEST MAP

Attach data sheet to FPA or USGS map on which squirrel observations and nest locations have been mapped and numbered. If the survey covers more than one map, attach a SEPARATE data sheet to EACH map. See below for explanation of codes. A squirrel "observation" includes squirrels seen AND heard. If you observe a squirrel, mark the box with a LARGE X and use the comment field to indicate behavior, presence of young, etc. Also note if squirrel has mange or other physical problems.

DATE: 9 Mar.–21 Mar. 2000 **Location: T** 4N **R** 14E **S** 2

Write ONLY the township, range and sections that are shown on attached map

Surveyors: Susan Van Leuven–WDFW

(Names and affilitiations — WDFW, Boise- Cascade, etc.)

Contact Name Address & Phone

(to answer specific questions about this survey)

	Location Number on Attached Map	Sq. Obs. Here ?	Nest Type P/S/O	Nest Cond. A/B/C	Nest Color G/R/N	Nest Ht ft	Tree DBH In	Tree Spp P/F/O	Comments
F	FC		P	A	R	34	20	P	Conditions near this nest are the same as those at Nest FB.
F	FD		P	A	N	33	14	P	C.C. within 50ft. of the nest tree is 45%; otherwise, conditions are the same as for Nest FB.
F	FE		P	A	R	44	20	P	C.c. within 50ft of the nest tree is 45%; all other conditions are as for Nest FB.
F	FF		P	A	R	40	14	P	Several small pines have been cut within 50ft. of the nest tree. Connectivity is good; C.c. within 50ft. of the nest is 45%. C.c. 50–400ft. away is 35%.
P	FG		S	A	R	46	18	P	1 tree cut within a few inches of the base of the nest tree; a small pile of slash is nearby. C.c. near the nest is ~30%; c.c. 50–400 ft. away is 35–40%. Connectivity is good.
F	FH		P	A	N	22	11	P	Many saplings cut within 50ft.

IF THERE ARE MORE THAN 20 OBSERVATIONS OR NESTS PLOTTED ON THE MAP, ATTACH A SECOND COPY OF THIS SHEET!

NEST TYPE:
P = Platform; flat nest usually made of conifer boughs (can include other materials such as oak, lichen, grass, etc.).
S = Shelter; spherical nest usually made of conifer boughs (can include other materials).
O = Oak or "summer"; bulky mass of oak twigs & leaves.

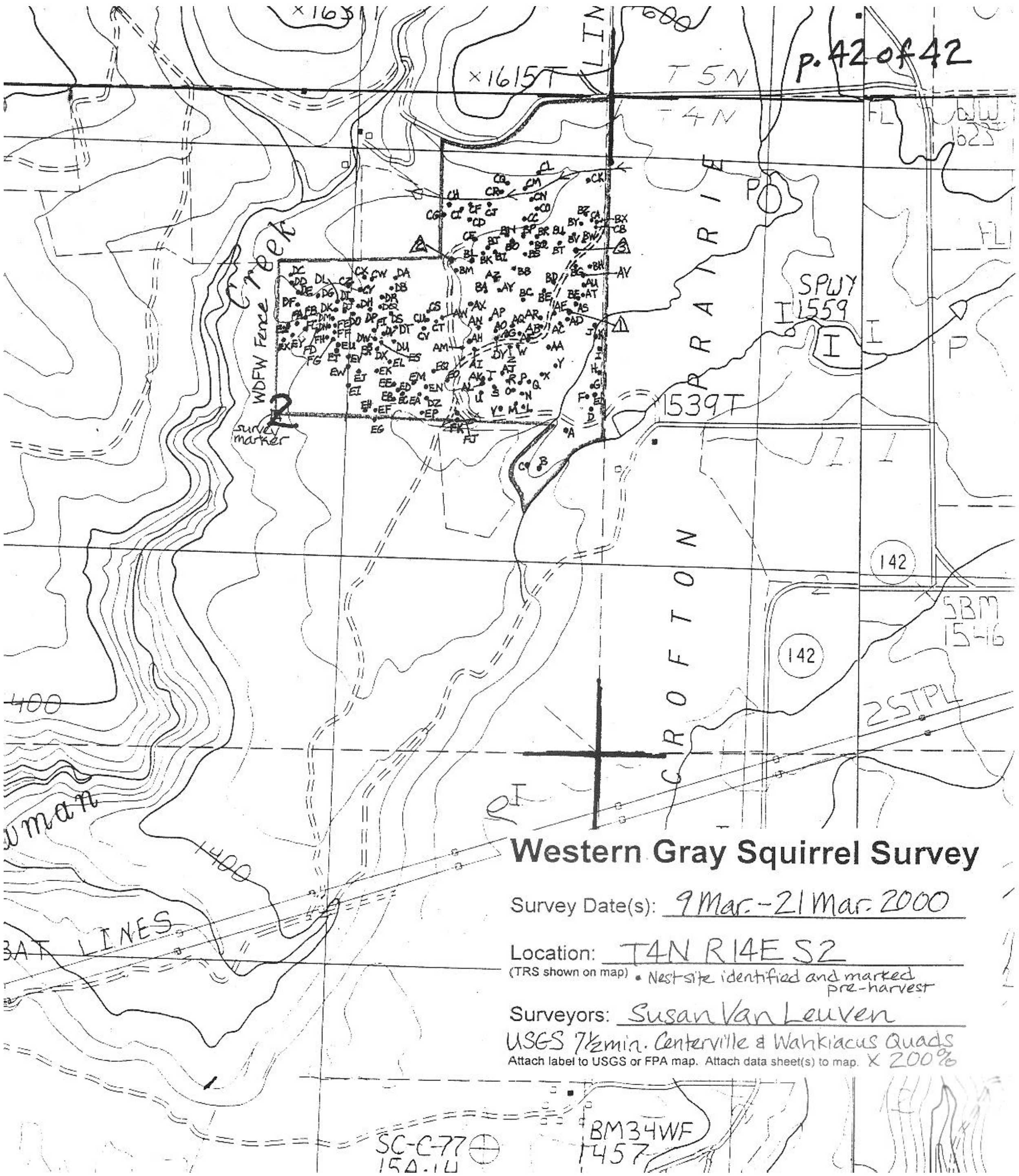
NEST CONDITION:
A = A fully constructed nest or a partially constructed nest that contains some fresh material
B = Nest apears to have lost material and is beginning to fall out of tree
C = Most material is gone, but material indicates western gray squirrel

NEST MATERIAL COLOR
G: Green (any amount)
R: Red or Rusty (any amount, but no green)
N: Neither (brown/black)

TREE SPP
P: Pine
F: Fir
O: Oak

Send survey package to: Julie Stofel, WDFW Wildlife Survey Data Management, 500 Capitol Way North, Olympia, WA 98501

Appendix D (cont.)



Appendix E. Protection ratings for western gray squirrel nest trees assessed using Standard Nest Protection Guidelines, Klickitat County, Washington.

	Marked nest trees			Unmarked nest trees		
Site	Good	Fair	Poor	Good	Fair	Poor
Soda Springs	7	24	23	5	8	2
Wide Sky	9	7	8	7	4	1
Squirrel #5	2	21	12	0	1	1
Brickman	15	0	0	7	8	3
Swale Canyon	17	12	39	14	5	11
Bowman Creek	2	2	1	24	71	66
Jackel[a]	18	1	0	4	1	0
Squirrel #4	4	2	0	3	2	2
Squirrel #2	4	1	1	3	0	3
Kayser						
Set Aside Area	25	5	6	24	2	3
WGS Mgmt Area B	2	1	1	9	3	4
Gen. Harvest Area	1	0	1	7	2	4

[a] Almost no harvest took place in unit containing squirrel nests because of close spacing of nests and overlap of 50-ft radius buffers.