USDA

United States
Department
of Agriculture

Forest Service

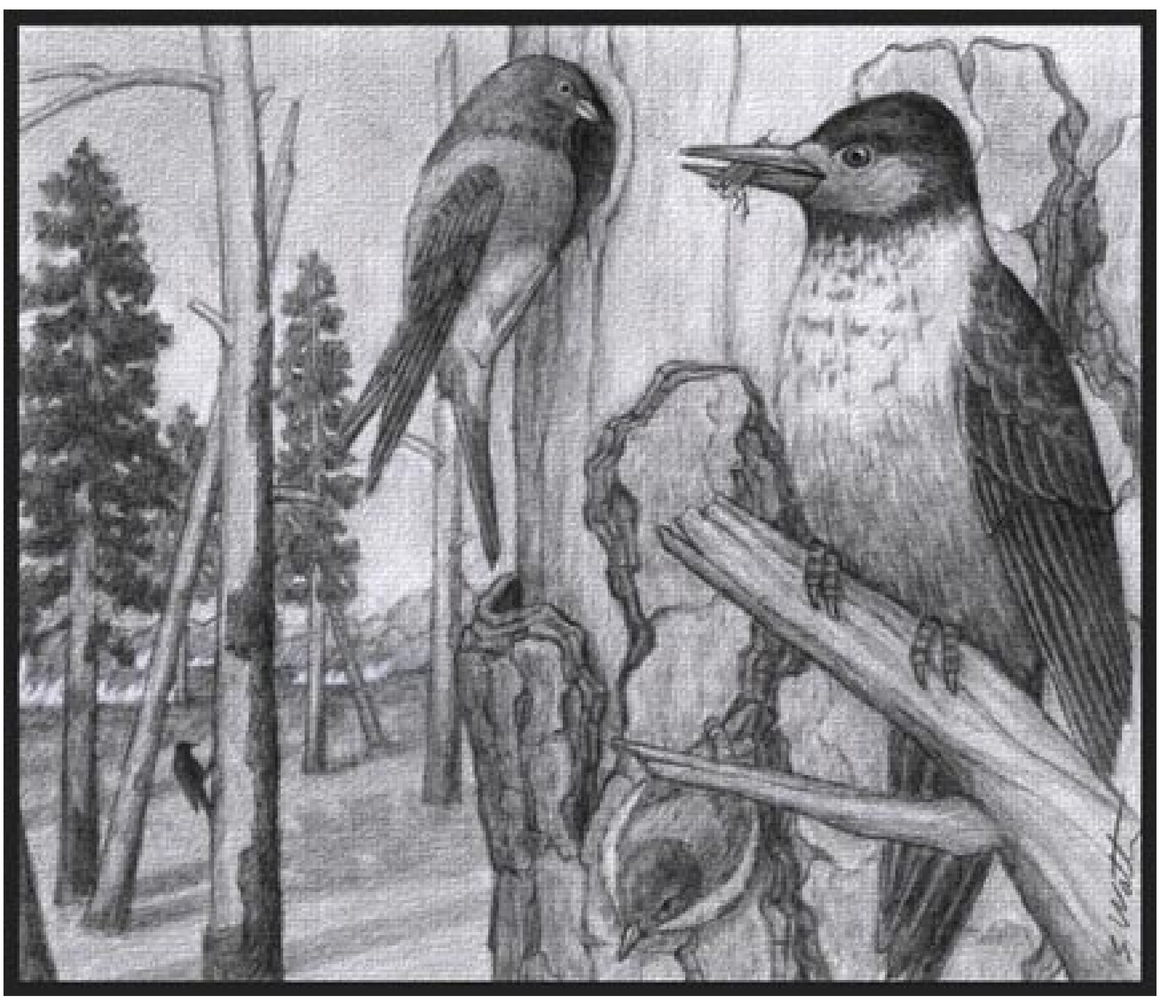
**Rocky Mountain**
**Research Station**

Research Paper
RMRS-RP-44

December 2003

# A Field Protocol to Monitor Cavity-Nesting Birds

**Jonathan Dudley and Victoria Saab**



Dudley, J. and Saab, V. 2003. **A field protocol to monitor cavity-nesting birds.** Res. Pap. RMRS-RP-44. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 16 p.

## Abstract

We developed a field protocol to monitor populations of cavity-nesting birds in burned and unburned coniferous forests of western North America. Standardized field methods are described for implementing long-term monitoring strategies and for conducting field research to evaluate the effects of habitat change on cavity-nesting birds. Key references (but not methodologies) for statistical analyses and habitat measurements are listed in our protocol. The protocol includes sections on study design, creation of field maps, conducting nest surveys, locating nest cavities by search image and bird behavior, recording data, nest monitoring, and data management.

***Keywords:*** cavity-nesting birds, field protocol, nest survey, nest monitoring, burned and unburned coniferous forests, long-term monitoring strategies

## The Authors

**Victoria Saab** is a research biologist with the Rocky Mountain Research Station's Ecology and Conservation of Terrestrial Wildlife and Habitats in the Interior West research work unit in Bozeman, Montana.

**Jonathan Dudley** is an ecologist with the same research work unit in Boise, Idaho.

*cover artwork by Shelley Watters*

This protocol could not have been developed without the support of the Boise National Forest, Mountain Home District (Larry Donohoo) and the Payette National Forest, Krassel District (Sam Hescock). We are grateful to these organizations and individuals.

You may order additional copies of this publication by sending your mailing information in label form through one of the following media. Please specify the publication title and series number.

**Fort Collins Service Center**

| | |
|---|---|
| **Telephone** | (970) 498-1392 |
| **FAX** | (970) 498-1396 |
| **E-mail** | rschneider@fs.fed.us |
| **Web site** | http://www.fs.fed.us/rm |
| **Mailing address** | Publications Distribution<br>Rocky Mountain Research Station<br>240 West Prospect Road<br>Fort Collins, CO 80526 |

Rocky Mountain Research Station
Natural Resources Research Center
2150 Centre Avenue, Building A
Fort Collins, CO 80526

# Contents

## Introduction

Many cavity-nesting birds depend on fire-prone landscapes for dispersal, movements, and other portions of their life history (Saab and Dudley 1998). Woodpeckers, in particular, are designated as sensitive species by federal and state agencies because they are responsive to fire and timber management activities. Recent wildfires and subsequent post-fire salvage logging have heightened concern about cavity-nesting birds (Dixon and Saab 2000, Kotliar et al. 2002, Saab et al. 2002). For these reasons, we began long-term studies in 1994 to address the effects of different fire conditions on populations and habitats of cavity-nesting birds in ponderosa pine (*Pinus ponderosa*) and mixed-coniferous forests in western North America (Saab and Dudley 1998, and see http://www.rmrs.nau.edu/birdsnburns/). Our purposes here are twofold: 1) provide field instructions for surveying and monitoring cavity-nesting birds during the breeding season; and 2) assist in developing long-term monitoring strategies for cavity-nesting birds. The guidelines describe standardized methods that can be used to evaluate the effects of habitat change on cavity-nesting birds. The instructions are based primarily on our work in habitats created by stand-replacement fire but apply to studies in unburned forests as well. Statistical methods and habitat measurements are not summarized in this document. Statistical concepts and modeling that can be applied to this work are reviewed in several publications, including these key references: Burnham and Anderson (1998), Thompson et al. (1998), Zar (1998), Morrison et al. (2001), Dinsmore et al. (2002), and Williams et al. (2002).

## Study Design and Field Maps

Study units must be large (250-400 ha) to obtain adequate samples of nesting birds for evaluating their responses to habitat change. Units on the smaller end of this range (250-300 ha) can be selected for burned forests where cavity-nesting birds are abundant (Saab and Dudley 1998), whereas larger units (>350 ha) are used for unburned forests where cavity nesters are relatively rare. A minimum of two replicate units is necessary for each treatment and control (e.g., salvage logged and unlogged) for assessing treatment effects.

The *BACI* (*before-after/control-impact*) design is used for impact assessments (Green 1979, Stewart-Oaten et al. 1986, Underwood 1994). Samples are taken before and after a disturbance or treatment, in each of the disturbed (impacted) units and undisturbed (control) units. If a treatment affects a population, it would appear as a statistical interaction between the difference in mean abundance of the sampled populations in the control and impacted units before the treatment and after the disturbance (for more detail on the BACI design see Ch. 5 in Morrison et al. 2001). For example, the *BACI* method can be used in a quasi-experimental design to evaluate the impacts of prescribed fire on cavity-nesting birds. Paired units are selected at random preferably, but in many cases the land manager has pre-selected (non-randomly) the units for treatment. In this case, strive to randomize which units will receive treatment. A unit (~ 250-400 ha) selected for prescribed fire (treated) is called the *impact unit*. A nearby unit that will not receive prescribed fire (untreated) serves as a *control unit*, where the vegetation, topography, and abundance of focal species are similar to the impact unit, and where the control unit is influenced in a similar way by natural disturbance (e.g., weather). These units would constitute one impact-control pair. This basic design would be extended to make inference to a larger group of impact areas by adding additional pairs of impact and control units (replication). The additional pairs need to be in similar areas with respect to the presence and habitat of the response variable of interest (e.g., a target population of cavity-nesting birds).

Once the study units are selected, an efficient tool to create field maps is a Geographic Information System (GIS). Generate a digital map from GIS at a scale of approximately 1:12,000 (figure 1). On the map, include topographic lines, elevations, streams, roads, belt transect lines, and the unit boundary. Establish belt transects that are 1-1.6 km long and positioned 200 m apart from which to survey cavity-nesting birds (see next section below). If you do not have access to GIS, then outline the study units on USGS 7.5 minute topographic maps and enlarge by photocopying. Draw 200 m-wide belt transects onto the topographic maps in a random orientation of north-south or east-west, covering each unit. If topography is steep, then sampling across the topographic gradient is recommended. Within this constraint, random selection of transect direction is encouraged. Letters are assigned to each belt transect to uniquely identify transects within each unit.

### *Field Personnel and Belt Transects*

The required number of field biologists will depend on the size, vegetation structure, topography, and abundance of nesting birds in the sampling unit. For each sampling unit (250-400 ha), one to three full-time field

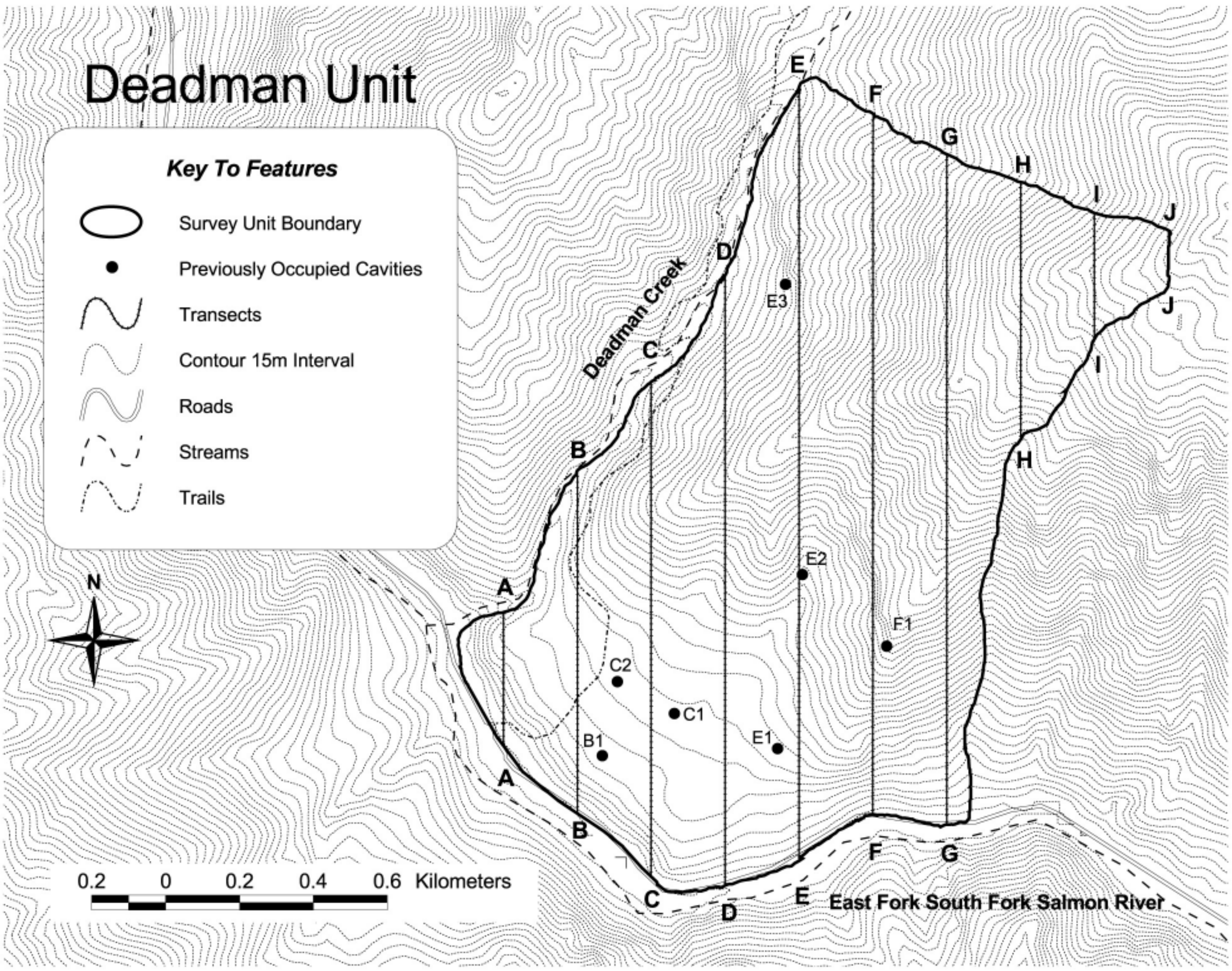



**Figure 1.** Example of field map generated using GIS

biologists will be sufficient to survey and monitor cavity-nesting birds throughout the breeding season. When possible, change or rotate observers between transects and units to minimize recurring bias in any segment of a survey (British Columbia Ministry of Environment, Lands & Parks 1999).

Field equipment carried by each biologist includes a field map of the unit, compass, Global Positioning System (GPS) unit, field notebook, blank nest cards, previous year's nest cards, flagging, binoculars, clinometer (optional), black permanent marker, pens, and pencils. Because woodpeckers are most active in the morning, nest surveys are conducted from a half hour after sunrise to 1200 each day from mid April to late June. Timing and length of the breeding season is species-specif c (see table 1) and varies with latitude and elevation. These differences must be considered for surveying during the breeding season. Surveys are terminated during periods of steady rain or high wind because birds are not easily detected, bird activity is reduced, and safety of the field crew is at risk due to falling trees or lightning activity. Air temperature, wind velocity, and cloud cover are estimated at the beginning of each survey period and updated periodically as conditions change.

Prior to conducting nest surveys, randomly select the order for surveying transects and for beginning surveys at transect endpoints. Nest surveys begin by assigning one transect to each field biologist. Navigate to transect endpoints by using a GPS unit. If a GPS unit is not available, interpret the field map to find the endpoint where the transect line meets the unit boundary. Find a nearby suitable tree or tall stump to act as a permanent transect center and end-point marker, called a "transect tree." The transect tree should be situated so it can be readily located for future reference. The tree should also be large in diameter so flagging is easily seen. For example, an ideal transect tree would be 50-100 cm in diameter with few, low obstructing branches that is located in a relatively open area of a lower slope or ridge. Once a transect tree is located, it is wrapped with three individual bands of flagging at approximately waist to

**Table 1.** Nesting chronology for cavity-nesting birds common in coniferous forests of Interior Western North America. Average median dates are based on data reported for western Idaho from 1994-2000 (Saab and Dudley, unpublished data). Number of days reported are from Ehrlich et al. (1988). See Appendix A for common and scientific names of each species' four-letter acronym.

| Species | Courtship | # Eggs[a] | Laying | Incubation | Nestling | Fledgling[b] |
|---|---|---|---|---|---|---|
| AMKE | < 17 May | (3-7) 4-5 | 17 May; 4.5 d<br>n = 59 | 21 May; 29-31 d | 20 Jun; 30-31 d | > 20 Jul; 65 d<br>n = 50 |
| FLOW | --- | (2-4) 3-4 | ---; 3.5 d | ---; 26 d | ---; ? | ---; ? |
| NSWO | --- | (4-7) 5-6 | ---; 5.5 d | ---; 26-28 d | ---; 27-34 d | ---; 63 d |
| LEWO | < 30 May | (4-9) 6-7 | 30 May; 6.5 d<br>n = 390 | 5 Jun; 13-14 d | 18 Jun; 28-34 d | > 20 Jul; 51 d<br>n = 323 |
| RNSA | < 29 May | (3-7) 4-5 | 29 May; 4.5 d<br>n = 1 | 2 Jun; 12-13 d | 14 Jun; 25-29 d | > 12 Jul; 44 d<br>n = 1 |
| WISA | --- | (3-7) 5-6 | ---; 5.5 d | ---; 12-14 d | ---; 21-28 d | ---; 43 d |
| DOWO | < 24 May | (3-6) 4-5 | 24 May; 4.5 d<br>n = 4 | 28 May; 12 d | 9 Jun; 20-25 d | > 2 Jul; 39 d<br>n = 4 |
| HAWO | < 8 May | (3-6) 4 | 8 May; 4 d<br>n = 141 | 11 May; 11-15 d | 24 May; 28-30 d | > 24 Jun; 46 d<br>n = 126 |
| WHWO | < 22 May | (3-7) 4-5 | 22 May; 4.5 d<br>n = 17 | 26 May; 14 d | 9 Jun; 26 d | > 7 Jul; 44.5 d<br>n = 15 |
| TTWO | --- | (2-6) 4 | ---; 4 d | ---; 11-(14?) d | ---; 22-26 d | ---; 40.5 d |
| BBWO | < 6 May | (2-6) 4 | 6 May; 4 d<br>n = 50 | 9 May; 12-14 d | 22 May; 25? d | > 15 Jun; 42 d<br>n = 46 |
| NOFL | < 19 May | (3-12) 5-8 | 19 May; 6.5 d<br>n = 134 | 25 May; 11-14 d | 6 Jun; 25-28 d | > 3 Jul; 45.5 d<br>n = 110 |
| PIWO | --- | (3-5) 4 | ---; 4 d | ---; 15-18 d | ---; 26-28 d | ---; 47.5 d |
| BCCH | --- | (5-10) 6-8 | ---; 7 d | ---; 11-13 d | ---; 14-18 d | ---; 35 d |
| MOCH | --- | (5-12) 5-9 | ---; 7 d | ---; 14 d | ---; 21 d | ---; 42 d |
| RBNU | --- | (4-7) 5-6 | ---; 5.5 d | ---; 12 d | ---; 14-21 d | ---; 35 d |
| WBNU | --- | (3-10) 5-8 | ---; 6.5 d | ---; 12 d | ---; 14 d | ---; 32.5 d |
| PYNU | --- | (4-9) 6-8 | ---; 7 d | ---; 15-16 d | ---; 20-22 d | ---; 43.5 d |
| HOWR | --- | (5-12) 6-8 | ---; 7 d | ---; 13 d | ---; 12-18 d | ---; 35 d |
| WEBL[c] | < 15 May | (3-8) 4-6 | 15 May; 5 d<br>n = 112 | 20 May; 14.5 d | 3 Jun; 17.5 d | > 25 Jun; 37 d<br>n = 89 |
| WEBL[d] | < 22 Jun | (3-8) 4-6 | 22 Jun; 5 d<br>n = 27 | 27 Jun; 14.5 d | 12 Jul; 17.5 d | > 29 Jul; 37 d<br>n = 17 |
| MOBL[c] | < 20 May | (4-8) 5-6 | 20 May; 5.5 d<br>n = 129 | 25 May; 13-14 d | 7 Jun; 22-23 d | > 27 Jun; 41.5 d<br>n = 87 |
| MOBL[d] | < 29 Jun | (4-8) 5-6 | 29 Jun; 5.5 d<br>n = 12 | 4 Jul; 13-14 d | 17 Jul; 22-23 d | > 1 Aug; 41.5 d<br>n = 7 |
| EUST | < 10 May | (4-8) 4-6 | 10 May; 5 d<br>n = 19 | 14 May; 12-14 d | 27 May; 18-21 d | > 12 Jun; 37.5 d<br>n = 19 |

[a] Range of clutch sizes in parentheses, followed by mode of clutch sizes (Ehrlich et al. 1988).
[b] Average median fledging date, followed by mean number of days in the nesting period.
[c] First clutch.
[d] Second clutch.

head height, and each band labeled with its assigned transect letter using a black permanent marker (e.g., "TRANS A"). Label each band in several places so it is easily read if approached from various directions. Labeling every band of flagging ensures that the transect will remain identified until the following year. In addition, flagging degrades from exposure to weather and should be replaced each year with new bands. Two trees per transect are marked with flagging, one at each end of the transect (figure 1).

Once the transect tree is flagged, determine on land the extent of your belt transect, which is 100 m, from each side of the centerline. This distance is best estimated with a GPS unit. Plotted locations of previously known nest cavity trees are helpful in determining your bearings while conducting surveys. Use a GPS unit, or a compass with the correct bearings for true north, in conjunction with the field map to follow the belt transect. View the topography within the belt transect, as outlined on the field map. This will provide a reference from which to survey, ensure adequate transect coverage, help with locating previously occupied nest cavities, and prevent one from straying off course. When you know the extent of your belt transect and location of previously occupied cavities that need to be revisited, begin surveying. Record the start time in your field notebook. Take note that when walking downhill at a naturally faster pace, nest cavities could be more easily overlooked. Periodically check the field map while conducting the survey. If straying does occur, backtrack to your transect and continue surveying. Proceed at a comfortable pace maintaining safety with respect to weather conditions, topography, vegetation, down wood, and bird activity. Often you will need to meander and focus attention on key habitat features within your belt transect. For example, high snag densities or snag clumps, bird activity, ridges, valleys, knobs, and inclement weather will require more meandering and increased focus to conduct an adequate survey. Conversely, an open slope with few trees and little bird activity can be surveyed with little or no meandering. When you come to the end of your transect, locate, flag, and label another transect tree, and record general weather conditions and ending time.

## Nest Cavity

### *Definition*

Nest cavities must have: (1) a large enough entrance for the species of interest (table 2); (2) cylindrical-shaped entrance walls, ("tunnel-shaped" as opposed to "funnel-shaped" entrance); and (3) vertical depth

**Table 2.** Descriptions of tree cavities used by cavity-nesting birds common to Interior Western North America. Data taken from *The Birds of North America* species accounts (see literature cited). Means are followed by ± SD. See Appendix A for common and scientific names of each species' four-letter acronym.

| Species | Entrance shape | Re-use cavity | Entrance height (cm) | Entrance width (cm) | 1° or 2° excavator |
|---|---|---|---|---|---|
| AMKE | Variable | Yes | Variable | Variable | 2° |
| FLOW[1] | Variable, often circular | Frequently | 5.64 ± 0.99 | 5.68 ± 1.06 | 2° |
| NSWO[2] | Variable, often circular | Yes | 6.0-7.0 | N/A | 2° |
| LEWO[3] | Variable, often circular | Frequently[3a] | 6.2 ± 0.2 | N/A | 1° & 2° |
| RNSA[4] | Oval | No | 4.0 ± 0.1 | 4.6 ± 0.1 | 1° |
| WISA[5] | Circular | Occasional | 4.17 ± 0.10 | N/A | 1° |
| HAWO[6] | Circular | Rare[6a] | 4.8 ± 0.2 | 4.5 ± 0.7 | 1° |
| DOWO[7] | Circular | Rare[7a] | | Diameter range 2.5-3.8 | 1° |
| WHWO[8] | Slightly oval | Occasional | 5.0 | 4.8 | 1° |
| TTWO[9] | Irregular--gourd/pear | No | 3.8-4.5 | N/A | 1° |
| BBWO[10] | Circular | Rare | 4.4 | N/A | 1° |
| NOFL[11] | Variable, often oval | Occasional | 7.5 ± 0.3 | 6.9 ± 0.5 | 1° |
| PIWO[12] | Oval | Only for roosting | 12.0 | 8.5 | 1° |
| BCCH[13] | Variable | Rare | Variable | Variable | 1° |
| MOCH[14] | Variable | In successive years | Variable | Variable | 2° |
| RBNU[15] | Oval | Occasional | 1.4 ± 0.09 | 4.0 ± 0.35 | 1° |
| WBNU[16] | Variable | Occasional | Variable | Variable | 1° & 2° |
| PYNU[17] | Oval | Frequently | 3.83 ± 0.63 | 3.43 ± 0.75 | 1° & 2° |
| HOWR[18] | Circular | Frequently | 5.5 ± 1.4 | N/A | 2° |
| WEBL[19] | Variable | Frequently | Variable | Variable | 2° |
| MOBL[20] | Variable | Frequently | Variable | Variable | 2° |
| EUST[21] | Variable, often slightly oval | Yes | 6.9 | 6.3 | 2° |

[1] McCallum 1994.
[2] Cannings 1993.
[3] Tobalske 1997; [3a] Saab et al. 2004.
[4] Walters et al. 2002.
[5] Dobbs et al. 1997.
[6] Jackson et al. 2002; [6a] Saab et al. 2004.
[7] Jackson and Ouellet 2002; [7a] Saab and Dudley, unpublished data.
[8] Garrett et al. 1996.
[9] Leonard 2001.
[10] Dixon and Saab 2000.
[11] Moore 1995.
[12] Bull and Jackson 1995.
[13] Smith 1993.
[14] McCallum et al. 1999.
[15] Ghalambor and Martin 1999.
[16] Pravosudor and Grubb 1993.
[17] Kingery and Ghalambor 2001.
[18] Johnson 1998.
[19] Guinan et al. 2000.
[20] Power and Lombardo 1996.
[21] Cabe 1993.

below the entrance. If nest cavities are not viewed easily from the ground level, use some type of cavity viewer (mirror or electronic) attached to an extension pole (e.g., TreeTop Peeper by Sandpiper Technologies, Inc., Manteca, CA, http://www.peeperpeople.com). Recent excavations with sufficient-sized entrances but funnel-shaped walls are flagged as "potential cavities." A partial excavation of this type may be completely excavated and used for nesting at a later date. Older snags, however, often contain deep foraging excavations that should not be misidentified as potential cavities.

## Locating by Search Image

Surveyors are instructed to develop "search images" for nest trees. A search image is a pictorial and verbal visualization or description of an object that biologists want to find in the field. For example, biologists want to look for broken-topped snags (i.e., the search image) because such snags are frequently used as nest trees by woodpeckers.

Key characteristics or search images of nest trees are well described by Bull et al. (1997) in unburned forests and by Saab and Dudley (1998) in burned forests. Live trees with dead tops (spike tops) are particularly important for nesting in unburned forests. During the first few years after fire, snags with broken or forked tops that pre-dated the wildfire are particularly important for cavity nesters (Saab and Dudley 1998). The sapwood of snags or live trees can be relatively hard and not easily excavated soon after disturbance (fire, disease, insects, or lightning). If the treetop is broken or forked, the 1–2 m section below the break or fork is often soft enough for cavity excavation. This section is most readily used for nesting.

To locate cavity entrances, examine the top couple of meters below major breaks or forks in snags or live trees, or in the dead tops of live coniferous trees. Binoculars are essential for this purpose and should be used continuously to examine potential cavity trees. Some species (e.g., hairy and black-backed woodpeckers), however, have strong excavator morphology and may create cavities in trees with relatively little decay compared to trees excavated by other cavity nesters (Dixon and Saab 2000). Because of this difference, their cavities may be found lower in the trunk of broken and forked-topped snags or in intact snags. As tree decay increases, trees become more suitable for excavation, and cavity placement becomes less related to tree top condition.

Older snags frequently break off to a shorter, relatively stable height. This leads to a second search image for large diameter, relatively short, broken-topped, and heavily decayed coniferous snags. These snags are primarily excavated by northern flickers and may contain several cavities and foraging excavations. Such snags are used for nesting by bluebirds, flickers, Lewis's woodpeckers, kestrels, and starlings.

Other important search images for nests are dead tops in live trees and aspen patches. Dead sections may contain many irregularly shaped cavities of various sizes, and are key for nesting in live-tree stands where snag densities are low. An emphasis should be placed on the importance of aspen patches to cavity nesters. When snags are rare and during the early years following fire, cavity nesters frequently use aspens for nesting. Aspen is often preferred for cavity excavation because it is susceptible to heartwood rot, which provides a soft substrate for excavation while retaining firm sapwood that creates stability and protection for the cavity (Conner et al. 1976, Harestad and Keisker 1989, Aitken et al. 2002). Flickers, sapsuckers, and hairy, Lewis's, downy, and white-headed woodpeckers will excavate aspen for nesting. In addition, fires will create natural cavities in aspen by burning down into the trunk through the top, a knot hole, or branch. Bluebirds, kestrels, and flickers will frequently use these for nesting. Extra time should be spent surveying these patches because they may contain many excavated, natural, or fire-created cavities.

In summary, knowledge of nest-site selection and nest placement is important during surveys. Developing search images for broken and forked-topped snags, relatively short, heavily decayed snags, and dead tops in live trees, and spending extra time in aspen patches will increase the likelihood of locating cavities. In addition, an abundance of wood chips found around the base of a tree usually indicates that a cavity is nearby.

## Locating by Bird Behavior and Call Playback

The easiest way to locate cavities is by observing bird behavior. During surveys, search for cavity-nesting birds that breed in your study area (e.g., Appendix A.). Note their behavior. Sit down and observe, concealing yourself if necessary. Patience is important. Using the species/nesting table (table 1), determine the likely stage of the nesting cycle for the species of interest. Try to decipher the reason for the observed behavior. For example, early in the nesting season (April-May), you might observe migrating individuals or courtship behavior, and the birds are not yet associated with a cavity. Record the observations in your field notebook and pencil-in the bird's location on a field map. Return to the area within two weeks to determine if the birds have occupied a nest cavity. Allow time to observe carefully during the nestling stage (June-July), when adults are carrying food to their nest cavity. This could be the only chance to find the nest if nestlings fledge before you revisit the area.

Call playbacks can be used in conjunction with observing bird behavior to locate nests. Playbacks are particularly effective for locating nests early in the nesting season, especially before the onset of incubation. We recommend this method for rare species, those that may be difficult to detect or occupy relatively large home ranges (e.g., black-backed, three-toed, and white-headed woodpeckers) (British Columbia Ministry of Environment, Lands & Parks 1999). Tape recordings of woodpecker drumming and calling are broadcast in areas of known or suspected activity. Play the tape in various directions in order to achieve good sound coverage (e.g., up and down drainages or toward opposing slopes of a ridge). If a response is elicited, woodpeckers often drum or fly into the area of the tape recording. From this point, the bird can be followed to its cavity. If sight of the bird is lost, try the broadcast again. For details on formal call playback surveys, see British Columbia Ministry of Environment, Lands & Parks (1999) http://srmwww.gov.bc.ca/risc/pubs/tebiodiv/woodpeckers/index.htm.

### Mapping and Flagging

When a nest cavity is found, determine its location on the field map. Place a dot on the map to indicate the location of the cavity tree. Use a GPS unit to record the digital location. Assign a unique alpha-numeric identification number to the cavity (letter from nearest transect followed by consecutive number, e.g., A1, A2, A3 for the first three cavities found on transect A). Label the dot on your field map with the assigned identification number. Each year for all transects, restart the numbering (e.g., A1, B1, C1 for the first three cavities found on transects A, B, and C). Secondly, select a nearby tree to flag for taking a compass bearing to the cavity tree; this tree is known as the bearing tree (Bt). The bearing tree should be located at least 5-10 m from the cavity tree, at least 30-40 cm in diameter, and with a view of the cavity entrance. Wrap the bearing tree with two bands of flagging and label them with the assigned cavity identification number using the black permanent marker.

## Nest Cards

Nest cards are used to record the nest location, physical characteristics of the cavity tree, and the status of a nest at each visit (every two to four days) (Appendix B). When an occupied cavity is found, record on the card the appropriate cavity number and unit identification, bird species, cavity location/description, tree species, and bird behavior (Martin et al. 1997; Appendix B). Additional information will be recorded on the card when vegetation characteristics are measured following the nesting season. If cavities are revisited in subsequent field seasons, information must be accurately transposed from the previous nest card to a new card for the current field season (only front side of card). Changes may occur between years and should be added to the new nest card as necessary (e.g., bird species is left blank because the cavity is unoccupied in subsequent survey, cavity is assigned a different id#, a new bearing tree is selected, the tree top has broken off above the cavity, or the location/cavity description [table 3] section needs clarification). If a nest cavity tree has fallen over, broken below the cavity entrance, or the cavity was destroyed in another way, record the changes in the "nest status" box (see Appendix C for codes). Record the "computer identification number" if one was previously assigned to the nest cavity.

### Nest Cavity Location/Description

Nest locations are geographically referenced using a GPS unit, which aids in relocating nests. However, a written site description is needed to ensure that a nest cavity can be visited by several observers and readily found in subsequent years. Descriptions should be recorded at macro- and micro-site levels (table 3). For the macro-site perspective, describe the landscape features surrounding the nest tree and the nest location in relation to the entire study unit. At the micro-site level, describe the area immediately surrounding the nest tree, characteristics of the nest tree, tree features around cavity entrance, and the cavity entrance. If a cavity is difficult to see, or is not excavated (e.g., a natural cavity in aspen), include a sketch with your description using arrows to point out its location.

### Cavity Age

Cavity age is determined as either old (O) or new (N). New cavities have light-colored wood (not gray) at the cavity entrance and have been excavated since the previous autumn. Clues to determine cavity age include observations of excavating behavior, wood chips scattered around the base of the cavity tree, woodpecker use at the cavity entrance, and weathering on the cavity walls. If excavating is not observed, search

**Table 3.** Site descriptions of cavity trees at different spatial scales.

| | |
|---|---|
| **A) MACRO-SITE** | 1.) Landscape Features (e.g., ridges, creeks, drainages, roads) |
| | 2.) Site Level (e.g., north end of transect, between transects E and F) |
| **B) MICRO-SITE** | 1.) Area Around Cavity Tree (e.g., S-facing slope, 25m up from the bottom, below G12 40m, across from rock outcrops) |
| | 2.) Cavity Tree (e.g., broken top, several cavities, heavily charred, small diameter, sloughing bark, many branches) |
| | 3.) Area Around Cavity Entrance (e.g.,cavity 20 cm under protruding branch, bark missing ½ m below and above entrance, cavity 1 m below forked top, upper of two cavities) |
| | 4.) Cavity Entrance (e.g., cavity entrance faces down slope, vertically oblong-shaped entrance, "bearded" entrance, natural [not excavated] entrance) |

near the base of the tree for wood chips that originated from the cavity. Newly excavated cavities will have light-colored wood chips lying on top rather than under the previous autumn's ground litter. Be careful not to disturb the area prior to determining if wood chips exist near the tree. Old cavities will be dull gray in color because of exposure to weather; the cavity walls and the bark surrounding the cavity entrance will be gray. New cavities generally show less wear on the bark below the entrance (some is expected during excavation) and have relatively brighter, lighter-colored walls than older cavities. With this information we can try to answer whether a species uses previously excavated cavities (O) or newly excavated cavities (N) each time it nests.

## Tree Species

To determine tree species of the nest cavity, you may need to consider more than one physical characteristic of the tree (Parks et al. 1997). Here, we provide only a few examples. For ponderosa pine, the bark is puzzle piece-shaped, hard to the touch, and may be yellowish-red. Branches are blunt-ended, with two to three long needles per bundle, and the trees can tolerate open, drier sites. For Douglas-fir (*Pseudotsuga menziesii*), after fire the bark is spongy to the touch. Branches are finely dissected to a point and often pointed downward, needle leaves are short and pointy, and trees tolerate wetter, colder, and north-facing units. For aspen (*Populus tremuloides*), the bark is thin and generally white in color. Aspen trees occur in clumps, are often associated with wet areas, and have many new, live suckers. For subalpine fir (*Abies lasiocarpa*), the bark is thin with horizontal "blistering." Trees are narrowly conical in shape, with curled under branches and short, blunt needle leaves, and occur at higher elevations. For black cottonwood (*Populus trichocarpa*), its bark and sapwood/heartwood resemble that of aspen, being thin and white, and relatively soft, respectively. These trees are usually large in diameter and tall, with spreading branches, and are usually found in small numbers associated with creeks and adjacent tributaries.

## Cavity Orientation

Orientation is recorded as the true compass bearing for the direction that the cavity entrance faces. We determine cavity orientation by standing 10-15 m from the cavity tree, facing the cavity to get a direction, then taking the back azimuth. This method is more accurate than standing below the unviewed cavity at the base of the tree because the cavity is viewed directly. Directions are recorded from 0 to 359°.

## Original Excavator

Original excavator is defined as the first species responsible for excavating the cavity for nesting. The excavator is most easily determined from direct observation, although direct observation is rare. More commonly, original excavator is determined from knowledge of cavity entrance shapes and sizes (table 2), and microhabitat used by individual species (see *The Birds of North America* species accounts listed in the literature cited). If you are uncertain of the original excavator, circle "unsure" on the nest card (Appendix B). Commonly, cavities are originally excavated by relatively small species (e.g., hairy, black-backed, and white-headed woodpeckers), and subsequently enlarged by larger species (e.g., northern flicker, Lewis's woodpecker). Early in the nesting season between nest visits, the original excavator may be displaced by another species. This can also occur between nesting seasons, creating a potential source of error when determining original excavator.

## *Tree Top Condition*

Tree top condition often indicates the suitability of a tree for nesting (e.g., Bull et al. 1997). Breaks in treetops allow colonization by insects and diseases, causing wood to decay. The decay causes saprot (in ponderosa and lodgepole pines) and heartrot, creating wood that is more easily excavated by primary cavity nesters. Tree top condition can be intact (I), forked (F), broken before fire (BB), broken after fire (BA), or dead top (DT). Intact trees have a single top without any breaks or forks. Forked trees include those with obvious multiple trunks that divide above breast height, and those with a branch or branches that have grown after the top broke, forming a new terminal leader (bayonet). Dead-topped trees have single or multiple dead sections in tops of live trees. Trees in burned forests with tops broken prior to the fire are critical for nesting habitat in the early post-fire years when other trees are not easily excavated (Saab and Dudley 1998). Treetops in burned forests that are broken before fire are blackened at the break, whereas tops broken after fire are lightly colored and unburned.

## *Previous Cavity ID#, Species, and Year*

Previous cavity id#, species, and year are designed for multi-year studies to follow the history of cavity occupancy. Pertinent data (Appendix B) from the previous year's nest card should be transferred to the current year's card. For example, in 2002 a flicker occupies a cavity on transect B. In 2001, a Lewis's woodpecker occupied the same cavity with a cavity id = B1. The 2002 nest card for the flicker would have a previous cavity id# = B1, species = LEWO, year = 2001. If the cavity was not occupied in the previous year, leave the box blank for previous nest species, and transfer the remaining data (previous cavity id# and year).

## *Multiple Cavity ID#, Species, and Year*

Multiple cavity id#, species, and year are designed to track the history of two or more occupied cavities in the same tree. Data are recorded similarly as previous cavity id#, species, and year except the data pertain only to the current year. For example, if a snag has a lower cavity occupied by a flicker (cavity id# = A1) and an upper cavity occupied by a western bluebird (cavity id# = A2), both nest cards for each will indicate that they are sharing the same tree. The nest card for A1 (NOFL) would have multiple cavity id# = A2, species = WEBL, year = 2002. The nest card for A2 (WEBL) would have a multiple cavity id# = A1, species = NOFL, year = 2002. In the next year, the flickers use the same cavity, but the bluebirds do not return and that cavity goes unoccupied. A1 could be reassigned as cavity id# = A5 and species = NOFL. A2 might be reassigned as cavity id# = A6 but species is left blank because the cavity is not occupied. The information recorded for multiple cavity id# for the flicker (A5) would be multiple cavity id# = A6, species = (blank), year = 2003. The nest card for A6 (blank) would have a multiple cavity id# = A5, species = NOFL, year = 2003.

# Nest Monitoring

## *Behavioral Observations*

We use BBIRD field protocol (Martin et al. 1997) with some modifications for nest monitoring. Nest monitoring can be conducted throughout the daylight hours. Bird behavior is recorded during each nest visit on the back of the nest card (see Appendix C for commonly used abbreviations). Each occupied nest is monitored every three to four days (e.g., every week on Monday/Thursday or Tuesday/Friday), but increases to daily as fledging dates approach. Each nest visit will last about 1 - 30 minutes, depending on the time it takes to determine the nesting stage (courtship, nest building, egg laying, incubation, nestling, fledgling). If you are unable to view inside the nest cavity, use bird behavior near the cavity to make inferences about the nesting stage (table 4). New observations are added with each return visit until the nest fails or until the young fledge successfully. From these data, nesting success is calculated using the Mayfield method (Mayfield 1961), with modifications to calculate variation in success (Johnson 1979). Detailed observations at each nest visit are necessary for determining the nesting stage. For example, recording aggression, drumming, excavating, copulating, carrying nesting material, percent of adult body entering cavity when feeding young, size of prey delivered to nestlings, fecal sac removal, begging young, or fledged young are all stronger indicators for determining nesting stages rather than only recording flying, calling, or foraging observations. Likewise, when determining nest fate, search for evidence of a failed (e.g., changes in cavity appearance, nest tree with claw marks, feathers or egg shells at the base of the tree) or successful nest (e.g., perched fledglings,

**Table 4.** Behaviors of cavity-nesting birds during various nesting stages. See Appendix A for common and scientific names of each species' four-letter acronym.

| Species | Courtship-laying stages | Incubating stage | Nestling stage | Fledgling stage |
|---|---|---|---|---|
| HAWO, BBWO, NOFL, LEWO, WHWO, DOWO, RNSA, PIWO | Wing displaying; copulating; reverse mounting (LEWO); head bobbing; drumming; chasing; excavating; calling | Adult looks out cavity entrance on approach or when tree tapped, may or may not flush; adult "nest guarding" (LEWO); drumming | Begging young heard or visible in cavity entrance; adult with frequent trips in/out of cavity; adult carrying food; tail shaking at cavity entrance (NOFL); food preparing then to cavity, food caching (LEWO); long flights to/from cavity tree; agitated calling; remove fecal sac; adult "nest guarding" (LEWO); Adult flushes, faint begging heard | Young perched quietly; awkward movements and flying; young "piggyback" adults; food begging; adults feed fledglings; cavity quiet, no activity |
| WEBL, MOBL, EUST | Pair investigating cavity (MOBL/WEBL); copulating; female carrying nesting material (MOBL/WEBL); 3 or more at cavity tree; chasing; calling | Adult looks out cavity entrance on approach or when tree tapped, may or may not flush; male perched quietly, female in cavity (MOBL/ WEBL); female exits cavity to forage, male follows, female returns without food and enters cavity (MOBL/WEBL); no begging heard | Adults with frequent trips to cavity; adults carrying food; remove fecal sac; agitated calling; bill popping (MOBL/WEBL); begging young heard or visible in cavity entrance; whitewash below cavity entrance (EUST) | Young perched together on nearby branch or loosely together on the ground, quiet (MOBL/WEBL); forage in family groups along riparian zone (EUST) or near cavity trees calling (MOBL/ WEBL); adults feed fledglings; cavity quiet or female exits (second clutch begun); whitewash below cavity entrance (EUST) |
| AMKE | Male swooping/dive display; copulating; calling | Male prey delivery to female; adult flushes on approach or when tree tapped, calling or silent; no response to tree tap | Male prey delivery to female then female carries food into cavity; adults with food into cavity; young begging heard or visible in cavity entrance | Young perched in adjacent trees, generally quiet, then begging when adults arrive with food; calling |

calling fledglings, or adults carrying food away from the nest area). These activities or characteristics at the nest tree are stronger evidence for determining nest fate than merely recording that no activity was observed.

## Nest Fate

Nest fate should be determined by the individual who conducted the last observation at the nest or by those with the most knowledge of the nest history (see Appendix B, No. 43). Detailed observations about why the nest fledged or failed need to be reported. This will help qualify the data when determining nest success. If nestlings are observed at 80% or more of their mean fledging age, we consider the nest successful because nestlings that reach this age have a high likelihood of fledging (Steenhof and Kochert 1982). For example, hairy woodpecker nestlings typically fledge at 28-30 days from the time of hatching. If hairy woodpecker nestlings were estimated to be 23 days old (82% of fledging age) on the last nest visit in which birds were in the cavity, then the nest would be reported successful unless evidence of failure was observed.

Nest failure may be caused by several factors. It may occur during nest building, cavity excavation, or the egg-laying stage. Early in a nesting attempt, when parental investment is relatively low, abandonment may occur. Abandonment can result from various disturbances such as storm related events, predation of an adult, or human interference at the nest cavity. Abandonment is difficult to determine in cavity nesters without a complete nest history accompanied by routine viewings into the cavity. Ectoparasites are another cause of nest failure. For example, adult flies may lay eggs on newly hatched nestlings that succumb to developing larvae. During this process, nestlings can appear lethargic. Like abandonment, failure due to ectoparasites is difficult to determine. A third cause of nest failure is depredation. It occurs when eggs, nestlings, and/or adults are killed or consumed by a "predator." For purposes here, a "predator" may be defined as mammal (bear, cat, weasel, squirrel, chipmunk), bird (corvid, accipiter, owl, other cavity nesters), or reptile (snake, lizard). Nest sites should be carefully searched for evidence of predators, including claw marks, hair, tracks, scat, torn open cavities, eggshells, feathers, etc. In some cases the nest contents (usually eggs or nestlings) are removed from the nest and the nest is usurped by an aggressive species. Nest usurpation is often exhibited by Lewis's woodpecker, and occasionally by hairy woodpecker and northern flicker. In our study areas, bluebirds, hairy woodpecker, and northern flicker have been the recipients, or "hosts" of nest usurpation, in which their nests were taken over by Lewis's woodpecker (Saab and Dudley, unpublished data).

Date fated is the date of fledging or failure. If the exact date is unknown, then record the median date between the last two visits. Several visits, however, may be required to determine if the nest is no longer active. In these cases, the median date should be calculated between the last visit with nest activity and the subsequent visit.

## Field Data Management

At the end of each day, nest cards are filed alphanumerically into study unit card files. During periods when surveys are not conducted, a second, pen-copy version of each nest card is completed. This pen-copy version remains in the field office as a backup copy and is periodically updated to include new nest monitoring observations. In addition, creating composite maps from survey results can be a useful reference for the field office. Maps of each unit are placed over bulletin board material with color-coded, flagged straight pins that signify the species, cavity id#, and location of each cavity tree.

After the nesting cycle is complete, vegetation measurements are recorded at nests and random locations to evaluate nest site and habitat selection. A GPS unit is used to record nest locations and vegetation plots for spatial analysis.

## Acknowledgments

We thank Lisa Bate, Bill Block, and Rudy King for insightful reviews of the manuscript. Scott Story assisted with developing the nest card information. Many field assistants helped with refining the field protocol and we are very thankful for their insights, especially those of Scott Story and Josh Schmidt.

## Literature Cited

Aitken, K.E. H., K.L. Wiebe, and K. Martin. 2002. Nest-site reuse patterns for a cavity-nesting bird community in interior British Columbia. Auk 119:391-402.

British Columbia Ministry of Environment, Lands & Parks. 1999. Inventory methods for woodpeckers. Standards for Components of British Columbia's Biodiversity No. 19. The Province of British Columbia, Published by the Resources Inventory Committee, Victoria, BC, Canada. http://srmwww.gov.bc.ca/risc/pubs/tebiodiv/woodpeckers/index.htm

Bull, E.L., and J.A. Jackson. 1995. Pileated woodpecker (*Dryocopus pileatus*). In: A. Poole and F. Gill, eds. The Birds of North America, No. 148. The Academy of Natural Sciences, Philadelphia, Pennsylvania and The American Ornithologists' Union, Washington, D.C.

Bull, E.L., C.G. Parks, and T.R. Torgersen. 1997. Trees and logs important to wildlife in the interior Columbia River Basin. USDA Forest Service, Pacific Northwest Research Station, Gen. Tech. Rep. PNW-GTR-391.

Burnham, K. P., and D. R. Anderson. 1998. Model selection and inference: a practical information-theoretic approach. Springer-Verlag, New York.

Cabe, P.R. 1993. European starling (*Sturnus vulgaris*). In: A. Poole and F. Gill, eds. The Birds of North America, No. 48. The Academy of Natural Sciences, Philadelphia, Pennsylvania and the American Ornithologists' Union, Washington, D.C.

Cannings, R.J. 1993. Northern saw-whet owl (*Aegolius acadicus*). In: A. Poole and F. Gill, eds. The Birds of North America, No. 42. The Academy of Natural Sciences, Philadelphia, Pennsylvania and The American Ornithologists' Union, Washington, D.C.

Conner, R.N., O.K. Miller, and C.S. Adkisson. 1976. Woodpecker dependence on trees infected by fungal heart rot. Wilson Bulletin 88:575-581.

Dinsmore, S.J., G.C. White, and F.L. Knopf. 2002. Advanced techniques for modeling avian nest survival. Ecology 83: 3476-3488.

Dixon, R.D., and V.A. Saab. 2000. Black-backed woodpecker (*Picoides arcticus*). The Birds of North America, No. 509. Poole, A. and F. Gill, eds. The Birds of North America, Inc. Philadelphia, PA.

Dobbs, R.C., T.E. Martin, and C.J. Conway. 1997. Williamson's sapsucker (*Sphyrapicus thyroideus*). In: A. Poole and F. Gill, eds. The Birds of North America, No. 285. The Academy of Natural Sciences, Philadelphia,

Pennsylvania and The American Ornithologists' Union, Washington, D.C.
Ehrlich, P.R., D.S. Dobkin, and D. Wheye. 1988. The birder's handbook: a field guide to the natural history of North American birds. Simon and Schuster Inc., New York.
Garrett, K.L, M.G. Raphael, R.D. Dixon. 1996. White-headed woodpecker (*Picoides albolarvatus*). In: A. Poole and F. Gill, eds. The birds of North America, No. 252. The Academy of Natural Sciences, Philadelphia, Pennsylvania and The American Ornithologists' Union, Washington, D.C.
Ghalambor, C.K., and T.E. Martin. 1999. Red-breasted nuthatch (*Sitta canadensis*). The Birds of North America, No. 459. Poole, A. and F. Gill, eds. The Birds of North America, Inc. Philadelphia, PA.
Green, R.H. 1979. Sampling design and statistical methods for environmental biologists. Wiley, New York.
Guinan, J.A., P.A. Gowaty, and E.K. Eltzroth. 2000. Western bluebird (*Sialia mexicana*). The Birds of North America, No. 510. Poole, V. and F. Gill, eds. The Birds of North America, Inc. Philadelphia, PA.
Harestad, A.S., and D.G. Keisker. 1989. Nest tree use by primary cavity-nesting birds in south central British Columbia. Canadian Journal of Zoology 67:1067-1073.
Jackson, J.A., and H.R. Ouellet. 2002. Downy woodpecker (*Picoides pubescens*). The Birds of North America. No. 613. Poole, A. and Gill, F. eds. The Birds of North America, Inc. Philadelphia, PA.
Jackson, J.A., H.R. Ouellet, and B.J.S. Jackson. 2002. Hairy woodpecker (*Picoides villosus*). The Birds of North America. No. 702. Poole, A. and Gill F. eds. The Birds of North America, Inc. Philadelphia, PA.
Johnson, D.H. 1979. Estimating nest success: the Mayfield method and an alternative. Auk 96:651-661.
Johnson, L.S. 1998. House wren (*Troglodytes aedon*). The Birds of North America, No. 380. Poole, A. and F. Gill, eds. The Birds of North America, Inc. Philadelphia, PA.
Kingery, H.E., and C.E. Ghalambor. 2001. Pygmy nuthatch (*Sitta pygmaea*). The Birds of North America. No. 567. Poole, A. and Gill, F. eds. The Birds of North America, Inc. Philadelphia, PA.
Kotliar, N.B., S. Hejl, R.L. Hutto, V.A. Saab, C.P. Melcher, and M.E. McFadzen. 2002. Effects of wildfire and post-fire salvage logging on avian communities in conifer-dominated forests of the Western United States. Studies in Avian Biology No. 25:49-64.
Leonard, D.L. 2001. Three-toed woodpecker (*Picoides tricdactylus*). The Birds of North America. No. 588. Poole, A. and Gill, F. eds. The Birds of North America, Inc. Philadelphia, PA.
Martin T.E., C. Paine, C.J. Conway, W.M. Hochachka, P. Allen, and W. Jenkins. 1997. BBIRD field protocol. Biological Resources Division, Montana Cooperative Wildlife Research Unit, University of Montana, Missoula, MT.
Mayfield, H.F. 1961. Nesting success calculated from exposure. Wilson Bulletin 73:255-261.
McCallum, D.A. 1994. Flammulated owl (*Otur flammeolus*). In: A. Poole and F. Gill eds. The Birds of North America, No. 93. The Academy of Natural Sciences, Philadelphia, Pennsylvania and The American Ornithologists' Union, Washington, D.C.
McCallum, D.A., R. Grundel, and D.L. Dahlsten. 1999. Mountain chickadee (*Poecile gambeli*). The Birds of North America, No. 453. Poole, A. and F. Gill, eds. The Birds of North America, Inc. Philadelphia, PA.
Moore, W.S. 1995. Northern flicker (*Colaptes auratus*). In: A. Poole and F. Gill, eds. The Birds of North America, No. 166. The Academy of Natural Sciences, Philadelphia, Pennsylvania and The American Ornithologists' Union, Washington, D.C.
Morrison, M.L., W.M. Block, M.D. Strickland, and W.L. Kendall. 2001. Wildlife study design. Springer-Verlag, New York.
Parks C.G., E.L. Bull, and T.R. Torgersen. 1997. Field guide for the snags and logs in the Interior Columbia River Basin. USDA, Forest Service, Pacific Northwest Research Station, General Technical Report PNW-GTR-390.
Power, H.W., and M.P. Lombardo. 1996. Mountain bluebird (*Sialia currucoides*). In: A. Poole and F. Gill, eds. The Birds of North America, No. 222. The Academy of Natural Sciences, Philadelphia, Pennsylvania and The American Ornithologists' Union, Washington, D.C.
Pravosudov, V.V., and T.C. Grubb Jr. 1993. White-breasted nuthatch (*Sitta carolinensis*). In: A. Poole and F. Gill, eds. The Birds of North America, No. 54. The Academy of Natural Sciences, Philadelphia, Pennsylvania and The American Ornithologists' Union, Washington, D.C.
Saab V.A., and J.G. Dudley. *Unpublished Data*. 1995. Nest usurpation and cavity use by Lewis's woodpecker. Unpublished report, USDA, Forest Service, Rocky Mountain Research Station, Boise, Idaho. 13 p.
Saab V.A., and J.G. Dudley. 1998. Responses of cavity-nesting birds to stand-replacement fire and salvage logging in ponderosa pine/Douglas-fir forests of southwestern Idaho. USDA, Forest Service, Rocky Mountain Research Station, Research Paper RMRS-RP-11.
Saab, V., J. Dudley, and W. Thompson. 2004. Factors influencing occupancy of nest cavities in recently burned forests. Condor 106, No. 1.
Saab, V., R. Brannon, J. Dudley, L. Donohoo, D. Vanderzanden, V. Johnson, and H. Lachowski. 2002. Selection of fire-created snags at two spatial scales by cavity-nesting birds. *In* Proceedings of The Symposium on The Ecology and Management of Dead Wood in Western Forests, Nov 2-4, 1999, Reno, Nevada, editors Shea, P. J.; W.F. Laudenslayer, Jr.; B. Valentine; C. P. Weatherspoon, and T. E. Lisle. USDA Forest Service, Pacific Southwest Research Station, Gen. Tech. Rep. PSW-GTR-181.
Smith, S.M. 1993. Black-capped chickadee (*Parus atricapillus*). In: A. Poole and F. Gill, eds. The Birds of North America, No. 39. The Academy of Natural Sciences, Philadelphia, Pennsylvania and The American Ornithologists' Union, Washington, D.C.
Stewart-Oaten, A., W.W. Murdoch, and K.R. Parker. 1986. Environmental impact assessment: "Pseudoreplication" in time? Ecology 67:929-940.
Thompson, W.L., G.C. White, and C. Gowan. 1998. Monitoring vertebrate populations. Academic Press, San Diego, CA.
Tobalske, B.W. 1997. Lewis' woodpecker (*Melanerpes lewis*). In: Poole, A. and Gill, F., eds. The Birds of North America. No. 284. The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington D.C.
Underwood, A.J. 1994. On beyond BACI: Sampling designs that might reliably detect environmental disturbances. Ecological Applications 4:3-15.

Walters, E.L., E.H. Miller, and P.E. Lowther. 2002. Red-breasted sapsucker (*Sphyrapics ruber*) and red-naped sapsucker (*Sphyrapicus nuchalis*). The Birds of North America. No. 663. Poole, A. and Gill, F. eds. The Birds of North America, Inc. Philadelphia, PA.

Williams, B.K., J.D. Nichols, and M.J. Conroy. 2002. Analysis and management of animal populations. Academic Press. San Diego, CA.

Zar, J.H. 1998. Biostatistical Analysis. Prentice-Hall, Inc., Englewood Cliffs, NJ.

# Appendix A. Common species of cavity-nesting birds in coniferous forests of Interior Western North America.

| Common name | Scientific name | AOU[1] acronym |
|---|---|---|
| American kestrel | *Falco sparverius* | AMKE |
| Flammulated owl | *Otus flammeolus* | FLOW |
| Northern saw-whet owl | *Aegolius acadicus* | NSWO |
| Lewis's woodpecker | *Melanerpes lewis* | LEWO |
| Red-naped sapsucker | *Sphyrapicus nuchalis* | RNSA |
| Williamson's sapsucker | *Sphyrapicus thyroideus* | WISA |
| Downy woodpecker | *Picoides pubescens* | DOWO |
| Hairy woodpecker | *Picoides villosus* | HAWO |
| White-headed woodpecker | *Picoides albolarvatus* | WHWO |
| Three-toed woodpecker | *Picoides tricdactylus* | TTWO |
| Black-backed woodpecker | *Picoides arcticus* | BBWO |
| Northern flicker | *Colaptes auratus* | NOFL |
| Pileated woodpecker | *Dryocopus pileatus* | PIWO |
| Black-capped chickadee | *Parus atricapillus* | BCCH |
| Mountain chickadee | *Poecile gambeli* | MOCH |
| Red-breasted nuthatch | *Sitta canadensis* | RBNU |
| White-breasted nuthatch | *Sitta carolinensis* | WBNU |
| Pygmy nuthatch | *Sitta pygmaea* | PYNU |
| House wren | *Troglodytes aedon* | HOWR |
| Western bluebird | *Sialia mexicana* | WEBL |
| Mountain bluebird | *Sialia currucoides* | MOBL |
| European starling | *Sturnus vulgaris* | EUST |

[1] American Ornithologists' Union.

# Appendix B. Example of a nest card.

**Appendix B.** Example of a Nest Card.

(Front)

| | | | | |
|---|---|---|---|---|
| Yr[1]: | Loc[2]: | Species[3]: | First Observer[4]: | Cavity ID#[5]: |
| Trt[6]: | Unit[7]: | Tasks Comp.[8]: GPS VEG FATE | Direction (º) BT-Nest[9]: | Distance (m) BT-Nest[10]: |

Cavity Location/ Description[11]:

| | |
|---|---|
| Nest Status[12]: | UTM (NAD27) |
| Find Method[13] (circle one): PB F SS NBC L PY YB | Northing[14]: Easting: |

| | | | |
|---|---|---|---|
| Computer ID#[15]: | Nest Ht (m) [16]: | Cavity Age[17]: | Decay Class[18]: |
| Tree Sp[19]: | Tree Ht (m) [20]: | DBH (cm) [21]: | Orient (º)[22]: |

| | | | | | |
|---|---|---|---|---|---|
| Original Exc[23]: | OE Cert[24]: SURE UNSURE | Tree Top Condition[25]: | Previous Cavity ID#[26]: | Previous Cavity Sp[27]: | Previous Cavity Yr[28]: |
| Aspect[29]: | Deg Slope[30]: | Position on Slope[31]: | Multiple Cavity ID#[32]: | Multiple Cavity Sp[33]: | Multiple Cavity Yr[34]: |

(Back)

| Visit Date[35] | | #Egg[36] | #Yng[37] | Beg-End Time[38] | Observations (parental behavior, nestling development, fate, etc) [39] | Cont.[40] | Stage[41] | Obs[42] |
|---|---|---|---|---|---|---|---|---|
| Day | Mo | | | | | | | |
| | | | | - | | | | |
| | | | | - | | | | |
| | | | | - | | | | |
| | | | | - | | | | |
| | | | | - | | | | |
| | | | | - | | | | |
| | | | | - | | | | |

Nest Fate[43]: 1-Successful Failed due to: 2-bear, 3-corvid, 4-squirrel, 5-chipmunk, 6-snake, 11-Fate unknown
(circle one) 7-weather, 8-cavity destroyed, 9-unknown, 10-other ___________

| | | |
|---|---|---|
| Initiation Date[45]: | | Success/Failure Notes[44]: Record detailed information used to determine nest fate |
| Date Fated[46]: | | |
| # Fledged[47]: | Fledge Conf.[48] SURE UNSURE | |

1- Yr: Four-digit year (e.g., 1998)
2- Loc: Location code - Combination of two letter location code + two state code (e.g., Payette National Forest, Idaho = PAID)
3- Species: AOU code (e.g., WEBL)
4- First Observer: Initials of surveyor who found nest, use middle initial as needed (e.g., VAS)
5- Cavity ID#: alpha-numeric combination of transect and sequential cavity # on transect (e.g., F12)
6- Trt: Treatment - an alphanumeric code indicating treatment type (e.g., BB= BEFORE BURN; AB=AFTER BURN; C=CONTROL)
7- Unit: two-letter unit code (e.g., BH = Buckhorn)
8- Tasks Comp: Tasks Completed: GPS VEG FATE (circle as completed for each nest)
9- Direction Bt-Nest: true compass direction (0-359°) from bearing tree to nest
10- Distance Bt-Nest: estimated distance from bearing tree to nest in meters
11- Cavity Location/Description: (see Tables 2, 3)
12- Nest Status: status of nest in current year (see Appendix C.)
13- Find Method: (circle one – see Appendix C.)
14- Northing, Easting: UTM Coordinates (NAD27)
15- Computer ID#: Computer number used to uniquely identify each nest
16- Nest Ht: Nest Height in meters
17- Cavity Age: (e.g., N=NEW, O=OLD, U=UNKNOWN)
18- Decay Class: Determined during vegetation surveys
19- Tree Sp: four-letter tree code (e.g., PIPO = Pinus ponderosa)
20- Tree Ht: Tree height in meters
21- DBH: Diameter at Breast Height (1.37 m) in centimeters, determined during vegetation surveys
22- Orient: true compass bearing (0-359°) of direction cavity faces
23- Original Excavator: (e.g., HAWO= Hairy Woodpecker)
24- OE Cert: Original Excavator Certainty (SURE of species that excavated the cavity or UNSURE, circle one)
25- Tree Top Condition: (I=Intact, BB=Broken Before Fire, BA=Broken After Fire, F=Forked, DT=Dead Top)
26- Previous Cavity ID#: Alpha-numeric number assigned to cavity during last survey/monitoring (transferred from box 5 of previous nest card) (e.g., F2)
27- Previous Cavity Sp: Occupant of cavity when last surveyed (e.g., HAWO or left blank if unoccupied)
28- Previous Cavity Yr: Year of last survey (e.g., 1997)
29- Aspect: True compass bearing (0-359°) of slope on which cavity tree resides, determined during vegetation surveys
30- Deg Slope: Degrees slope to nearest tenth, determined during vegetation surveys 31- Position on Slope: Position of cavity tree on slope (L=Lower, M=Middle, U=Upper)
31- Position on Slope: Position of cavity tree on slope (L=Lower, M=Middle, U=Upper)
32- Multiple Cavity ID#: Cavity ID# of any cavities occurring in same tree in same year (e.g., F13)
33- Multiple Cavity Sp: (e.g., NOFL)
34- Multiple Cavity Yr: (e.g., 1998)
35- Visit Date: Day and Month of visit (numeric)
36- #Egg: Enter # eggs in nest, circle value if certain count represents final number of eggs
37- #Yng: Enter # nestlings, circle value if certain count represents final number of nestlings
38- Beg-End Time: Beginning and ending time of observations in military time (e.g., 0742-0813)
39- Observations: Detailed notes of observation, see Appendix C.
40- Cont: Cavity contents (1=eggs, 2=nestlings, 3=eggs and nestlings, 4=nestlings and fledglings nearby)
41- Stage: Stage of nest- (E =Excavation/Nest Building, L= Laying, I=Incubation, N= Nestling, F=Fledgling)
42- Obs: Observer initials for each visit (e.g., VAS)
43- Nest Fate: Circle single best fate code -- 1-Successful, 2-10 Failed due to: 2-bear; 3-corvid; 4-squirrel; 5-chipmunk; 6-snake; 7-weather; 8-cavity destroyed (i.e., cavity tree fell or broke below cavity entrance); 9-unknown; 10-other (includes adult mortality, abandonment, ectoparasitism, predators not listed, human-caused failures). 11-Fate unknown (cannot determine from data)
44- Success or Failure Notes: Record detailed observations about why you think the nest was successful or failed
45- Init Date: Initiation Date, Record date (ddmm) first egg was laid if known, or calculate by backdating
46- Date Fated: Date (ddmm) on which nest fledged or failed, if known, otherwise enter median date between last two visits
47- # Fledged: Number of nestlings that fledged from the nest
48- Fledge Conf: Confidence that the number of fledglings reported in box 47 is the final total (circle SURE or UNSURE)

# Appendix C. Examples of commonly used abbreviations and nest status codes.

**Nest observations**

+ - and
@ - at
~, ≈ - approximately
∞ - many, numerous
≥ - greater than or equal to
♂ - male
♀ - female
ACA - agitated calling
Act - activity
AD, Ad, ad - adult
Adj - adjacent
AF - assume fledged
AFOR - aerial foraging
AG - agitated
Am - morning
CA - calling
CAV - cavity
CE - cavity entrance
COP - copulating
Ct - cavity tree
DR - drumming
E - egg
ENT - entered
FBY - feeding (fed) begging yng
FL - fledgling
FO - fly over
FOR - foraging
FS - fecal sac
INIT, init - initially
Juv - juvenile
LV - leave, leaving
Mins - minutes
NG - nest guarding
NM - nesting material
NR - no response (tapping, etc.)
nstling - nestling
OA - on approach
Obs - observed
Orig - originally
PE - perched
Pm - afternoon
PR - pair
Pred - depredated
rtn, rtns - return(s)
SI - singing
TT - tree tapped
w/ - with
w/o - without
w/in - within
WW - whitewash
X - times
Y, yng - young
YB - young begging

**Physical characteristics**

Bndry - boundary
Bt - bearing tree
BT - broken top
Dbh - diameter breast height
Dia - diameter
E - east
Elev - elevation
Ht - height
Hvly - heavily
Lrg - large
Med - medium
Mtn - mountain
N - north
NE - northeast
NW - northwest
Rd, rd - road
S - south
SE - southeast
Sm - small
SW - southwest
Trans - transect
W -west

**Nest status codes**

A - active
B - cavity tree broken below cavity
BC - cavity tree broken at cavity
DB - cavity destroyed by bear
DC - cavity destroyed by corvid
DF - cavity overgrown by fungus
DL - cavity destroyed by limb/branch
DO - cavity destroyed by other (be explicit)
F - fell over
I - inactive
NF - cavity not found
NS - transect not surveyed
U – unknown

**Find method**

PB - Parental Behavior
F - Flushed
SS -Systematic Search
NBC - Non-Behavioral Cue
L - Luck
PY - Previous Year's Nest
YB - Young Behavior

RMRS
ROCKY MOUNTAIN RESEARCH STATION

The Rocky Mountain Research Station develops scientific information and technology to improve management, protection, and use of the forests and rangelands. Research is designed to meet the needs of the National Forest managers, Federal and State agencies, public and private organizations, academic institutions, industry, and individuals.

Studies accelerate solutions to problems involving ecosystems, range, forests, water, recreation, fire, resource inventory, land reclamation, community sustainability, forest engineering technology, multiple use economics, wildlife and fish habitat, and forest insects and diseases. Studies are conducted cooperatively, and applications may be found worldwide.

**Research Locations**

| | |
|---|---|
| Flagstaff, Arizona | Reno, Nevada |
| Fort Collins, Colorado* | Albuquerque, New Mexico |
| Boise, Idaho | Rapid City, South Dakota |
| Moscow, Idaho | Logan, Utah |
| Bozeman, Montana | Ogden, Utah |
| Missoula, Montana | Provo, Utah |
| Lincoln, Nebraska | Laramie, Wyoming |

*Station Headquarters, Natural Resources Research Center, 2150 Centre Avenue, Building A, Fort Collins, CO 80526.