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Nest Site Characteristics and Breeding Biology of Flammmulated Owls in Missoula Valley

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NEST SITE CHARACTERISTICS AND BREEDING BIOLOGY OF FLAMMULATED OWLS (*Otus flammeolus*) IN MISSOULA VALLEY

By

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The Flammulated Owl is listed as a sensitive or species of concern with United States Forest Service, Bureau of Land Management, and Montana Fish, Wildlife and Parks. Despite these listings the Flammulated Owl is little studied in Montana. Although region-wide surveys have greatly increased our understanding of distribution and landscape level habitat associations of Flammulated Owls, information about breeding is lacking. In order to address this need for breeding information I searched for and quantified nest site characteristics and breeding biology of Flammulated Owls in Missoula Valley from 2008-2010. I located 17 Flammulated Owl territories, four nests, and banded 12 individuals. I also utilized radio telemetry to help gather information about roosting and foraging habitat. Although our sample size is limited, nest site characteristics and breeding parameters in my study were within the range of information published by other authors for Flammulated Owl nests. Much more information about Flammulated Owl breeding biology is needed to comprehensively assess the status of this owl species and build scientifically responsible models for managing habitat in Montana.

Contents

INTRODUCTION

In the western United States the Flammulated Owl (*Otus flammeolus = Psiloscops flammeolus)* is considered a Neotropical migrant and locally common breeder (AOU 1998). In Montana, the Flammulated Owl occurs in the western third of the state (Lenard and others 2003). Throughout its range, the Flammulated Owl primarily breeds in montane coniferous forests at moderate to high elevations, and shows a preference for mature- or old growth yellow pine forests (*Pinus ponderosa*, *Pinus jeffreyi*) mixed with other conifers, such as Douglas-fir (*Pseudotsuga menziesii*) and true firs (*Abies* spp.) (McCallum 1994a).

Flammulated Owls also breed in lower elevation yellow pine forest mixed with pinyon pine (*Pinus edulis*), juniper (*Juniperus* spp.), quaking aspen (*Populus tremuloides*), and cottonwood *(Populus* spp.) (Bent 1938, Marshall 1939, Johnson and Russell 1962, Reynolds and Linkhart 1987b, McCallum and Gehlbach 1988, Bull and others 1990, McCallum 1994a, Groves and others 1997, Arsenault 2004) and habitat without yellow pine such as, Douglas-fir forests (Powers and others 1996), quaking aspen stands (Marti 1997), white fir (*Abies concolor*), subalpine fir (*A. lasiocarpa*), limber pine (*Pinus flexilis*) (Dunham and others 1996), and possibly black oak forests (*Quercus* spp.) (Winter 1974, Marcot and Hill 1980). Howie and Ritcey (1987) and Christie and van Woudenberg (1997) reported Flammulated Owls to avoid pure ponderosa pine stands, opting instead for dry Douglas-fir forests with open aspect, including selectively logged forests. Flammulated Owls may also use small forest patches (Dunham and others 1996).

In Montana, Flammulated Owls were reported to occur in mature and old-growth xeric ponderosa pine/Douglas-fir stands (Holt and Hillis 1987), and in landscapes with higher proportions of ponderosa pine/Douglas-fir forest with low to moderate canopy closure (Wright and others 1997). Generally, the most common features that describe Flammulated Owl breeding habitat throughout its range in the western United States are: a cold temperate and semiarid climate, a high abundance or diversity of nocturnal arthropod (mostly insect) prey, open physiognomy, dense foliage for roosting, and trees providing nest cavities (McCallum 1994b).

Mature- to old-growth ponderosa pine/Douglas-fir forests have been heavily affected by wildfire suppression and logging practices. For nearly 100 years, removal of over-story ponderosa pine and wildfire suppression has changed pre-settlement forest physiognomy throughout the Intermountain West. These practices have led to replacement of most old-growth ponderosa pine forests by younger forest with a greater proportion of Douglas-fir, fewer large trees, and reduced open perennial grass/shrub understory (Habeck 1990). Indeed, across western United States, finding old ponderosa pine forests that have not been influenced by fire suppression, grazing, timber harvest, or other anthropogenic influences is uncommon (Morgan 1994). Ultimately, these influences could have affected habitat suitability for breeding Flammulated Owl populations.

As a result of these anthropogenic changes, lack of long-term monitoring and breeding season studies, and detailed habitat needs, the Flammulated Owl was listed as a sensitive species by the United States Forest Service Region 1 (USFS 2004). This listing provides special emphasis in planning and management activities to ensure its conservation (USFS 2004). Additionally, the United States Bureau of Land Management considers the Flammulated Owl sensitive, and imperiled in at least part of its range, including Montana (BLM 2001). In Montana, Flammulated Owls are listed as Tier 1 Species of Concern, in greatest need of conservation, and requiring adequate, systematic monitoring (MFWP 2005). Despite these mandates, few efforts have been undertaken to understand the breeding biology of Flammulated Owls at the northeastern edge of their breeding range in western Montana.

BREEDING STATUS OF FLAMMULATED OWLS IN MONTANA

To ascertain breeding status of Flammulated Owls in Montana, I examined and evaluated historical and current records. My intent was to: (1) provide a general overview of Flammulated Owl distribution in Montana; (2) review the current accepted breeding records for Montana and clarify criteria for what constitutes proof of breeding; and (3) underscore the need for long-term breeding research in Montana.

To evaluate breeding records and distribution, I compiled historical and current records of Flammulated Owls in Montana by reviewing scientific literature, Montana Natural Heritage Program (MTNHP) records, University of Montana Avian Science Center (UMASC) data, and Owl Research Institute (ORI) records. I based my decisions on my more than 10 years experience researching owls in Montana and current Montana breeding bird criteria (Lenard and others 2003).

Lenard and others (2003) listed the following as direct evidence of eggs or young: (1) an occupied nest (adults entering or leaving a nest site in circumstances indicating an occupied nest, includes high nests or nest holes, the contents of which cannot be seen) or adults incubating or brooding; (2) recently fledged young (of altricial species) incapable of sustained flight, or downy young (of precocial species) restricted to the area by dependence on adults or limited mobility; (3) adults attending young – adult carrying food or fecal sac for young, or feeding recently fledged young; (4) a used nest or eggshell found (identification must be convincing for such records to be accepted); and (5) a nest with egg(s) that can be clearly identified.

Lenard and others (2003) explicitly stated that breeding is not assumed by the presence of adults or from behavior. Although the five criteria – particularly number 1 – give some credence to circumstantial evidence, I accepted only records that indicated eggs or dependent young had been produced in accordance with the breeding phenology of Flammulated Owls. I did not consider Flammulated Owls singing, copulating, or flying in and out of cavities, as evidence of breeding. This falls under "indirect or circumstantial evidence" of breeding as outlined by Lenard and others (2003).

Historical Records

I defined historical records as any data prior to the UMASC's Flammulated Owl Monitoring Program initiated in 2005 (see Current Records below). Thus, I relied on Palmer D. Skaar's personal records on file with the ORI, Holt and others (1987), Wright (1996), and Wright and others (1997). I also cross-checked with the MTNHP database, and included what I believed were reliable observations from citizens.

Current Records

I defined current records as the beginning of UMASC's Flammulated Owl Monitoring Program initiated in 2005. I chose this definition because UMASC's program was a wide-spread project and included a citizen science component and because other state, federal, and private institutions were conducting surveys at this time. In 2008, the ORI initiated a breeding study of Flammulated Owls in the Missoula Valley and surrounding areas, which were also included.

Review of Historical Records

Apparently the first record of a Flammulated Owl in Montana was a road kill found in Glacier National Park in 1962 (Holt and others 1987). The first specimen record (UMZM 152310) was an owl found injured in 1971 near Darby, Montana and later died (Holt and others 1987). In 1975, an injured, recently fledged Flammulated Owl was found in downtown Missoula, Montana and later died in captivity. This was the first evidence of nesting in Montana (Holt and others 1987). In 1986, a snag containing 3 nestlings was felled by a logger near Blanchard Lookout in western Montana confirming the first nest in state (Holt and others 1987). Between 1962 and 1986 at least 11 records existed in the state (Holt and others 1987).

Between 1985 and 2004, periodic calling surveys and other observational records provided further evidence of breeding and widened the distribution of this species in Montana (Holt and Hillis 1987, Wright and others 1997, ORI unpubl. records). From 1994-1996 a study was conducted to determine the distribution and breeding season habitat associations of Flammulated Owls on the Bitterroot and Lolo National Forests in western Montana (Wright and others 1997). This study added 4 records of direct evidence of breeding, including one confirmed nest site, and a significant number of observations to the MNHP database.

Review of Current Records

UMASC's monitoring program is responsible for a huge increase in Flammulated Owl detections in Montana since 2005. Between 2005 and 2009 UMASC's Flammulated Owl Monitoring Program detected hundreds of calling Flammulated Owls. This study attempted to determine the statewide distribution and habitat associations of Flammulated Owls (Cilimburg 2006, Smucker and others 2008). Consequently, as of 2010, 646 records currently exist in MTNHP database.

ORI's Flammulated Owl Breeding Project, revisited areas of Missoula Valley where Denver Holt first detected Flammulated Owls in the mid-1980s (ORI, unpubl. data). Our study has verified occupancy and several nests in the same areas surveyed by DWH over 20 years ago and contributed additional records of Flammulated Owls in western Montana. Although our study is on-going more research is needed.

Direct Evidence of Breeding

I searched for nests near Missoula, Montana in 2008-present multiple times in areas where we detected Flammulated Owls during the breeding season (May-August). Although I observed Flammulated Owls copulate, and enter and exit cavities on multiple occasions, multiple inspections of over 100 cavities with a peeper camera and repeated nocturnal observations throughout 18 territories has resulted in only four confirmed nests since 2008.

Lenard and others (2003) considered adults entering or exiting cavities in circumstances indicating an occupied nest to be direct evidence of breeding. I understand that in cases where the cavity is too high or dangerous to access, observations of food-deliveries are the only realistic way of determining nesting. However, based on my experiences these observations must be made multiple times on multiple nights in order to verify an occupied nest.

Based on my evaluation of the direct evidence of breeding records in Montana, I accept 17 of 19; 8 nest sites, 7 family groups, and 2 fledglings without adults present (Appendix A). Given dates and locations at which fledglings were documented and in accordance with the breeding phenology of Flammulated Owls (Aug-early Sept.) it seems reasonable to accept that these young owls hatched in Montana. I did not accept two records because they did not meet the criteria established by Lenard and others (2003) and my own experiences (Appendix A). Of special note, a ground nest was discovered by Kristina Smucker in 2001, and may represent the only record of its kind for this species.

Flammulated Owl Distribution in Montana

The general distribution and breeding records of Flammulated Owls appears restricted to the western part of Montana (Figure 1). It appears that Flammulated Owls can be locally numerous in specific habitats during the breeding season, particularly xeric ponderosa pine/Douglas-fir forests. However, longitudinal surveys in other forest types have not been conducted. Although surveys have been conducted in the dry forest mountain ranges in eastern Montana, no Flammulated Owls have been detected (Cilimburg 2006).

Need for Long Term Breeding Research

The surveys conducted from 1994-1996 (Wright and others 1997) and in 2005 and 2008 (Cilimburg 2006, Smucker and others 2008) have done much to increase our understanding of distribution and landscape-level habitat associations of Flammulated Owls in Montana. In addition, a thorough and effective survey protocol has been developed (Cilimburg 2006, Smucker and others 2008). However, observations of vocalizing males may indicate breeding, but may also simply indicate transitory presence. It is well known that many species of migratory birds, including owls, will vocalize during migration, and may be there one day and not the next. Indeed, Flammulated Owls vocalize and defend territories even when apparently not breeding (Reynolds and Linkhart 1987b) – a suggestion that singing does not always indicate nesting. Thus it is important to extend efforts throughout the nesting period (May-Sept) to include; detection surveys, nest searches and nest monitoring.

The limited direct evidence of breeding to date in Montana underscores the need for rigorous long-term breeding season research. This research is urgently needed in order to develop complete, scientifically robust habitat and population models for Flammulated Owls. Federal and state agencies need to provide such models for management, and consequently conservation of listed species. To address the need for information about nest site characteristics and breeding habitat I attempted to locate Flammulated Owl nests in the Missoula Valley from 2008-2010. My project goals were to (1) locate FLOW nests; (2) quantify nest site characteristics, and (3) describe breeding habitat around nest trees.

METHODS

STUDY AREAS

My study was located in the Lolo National Forest, within a 30-mile radius of Missoula, Montana (Figure 2). Survey areas are characterized by steep, mountainous ridges containing habitat ideal for Flammulated Owls (hereafter FLOWs): open stands of ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*), and mixed shrub understory. I did not randomly select survey areas. Instead, I focused on areas of previous FLOW detection, including 4 survey routes established by University of Montana Avian Science Center in 2005 and areas where FLOWs were detected by the Owl Research Institute in the 1980s, particularly in the Marshall Canyon watershed. These areas included Crazy Canyon in Pattee Canyon Recreation Area, parts of Rattlesnake National Recreation Area, Blue Mountain, Woods Gulch, and Marshall Canyon. Forest type in all these areas is dominated by xeric ponderosa pine/Douglas-fir forests. I did not survey in other forest types.

FIELD SEASON 2009

May to mid-June 2009. The first 6 weeks of my field season entailed surveys to detect FLOWs. Surveys were conducted using methods described by Takats and others (2001) for nocturnal owls with the following modifications. Survey routes usually consisted of 10 survey points spaced 400 m apart. Starting points for routes already established were predetermined. I determined starting points for new survey routes arbitarily. Usually, I began surveys no less than 400 m but sometimes up to 1600m from trailheads depending on habitat. For example, if 400 m from a trailhead was located in a meadow I opted to start the survey at the interface of the meadow and trees. I alternated the direction that I conducted surveys along routes. If I conducted surveys at points 1-10 one night, I then surveyed points 10-1 the next time I surveyed the route. Surveys began at the end of civil twilight and typically continued to 1 a.m. Surveys points consisted of listening (Takats and others 2001) and audio broadcast of FLOW vocalizations (Barnes and Belthoff 2008, Cilumburg 2006). Each survey point lasted 8 minutes: 3 min listening, 1 min playback, 2 min listening, 1 min playback, and 1 min listening. Because we did not want to draw owls away from song trees we did not use audio broadcast if owls were detected during the first 3 min listening period or after the first 1 min broadcast period.

If I did not detect FLOWs on a survey, I replicated the route at least 3 but no more than 5 days later. If I did detect FLOWs, I returned to the route within 2 days, but only re-surveyed at points of detection (not the entire route). At these points, if FLOWs were once again detected, I marked the song tree with a GPS.

June 2009. In daytime, I returned to song trees to search for nest sites. Starting at the song tree, I covered a circle of habitat (≈ 450-m radius) by walking a spiral expanding 50 m each revolution around the song tree. For each snag that I encountered I walked a circle around and inspected for cavities. I defined this 450 m area as the owl "territory." I marked all cavity-bearing trees within territories with a GPS, assigning each tree a unique identifier. For each tree, I collected the data for the variables identified in Table 1:

Table 1. Variables Collected for Cavity Bearing Trees and Cavities

Tree	**Cavity**
Species	Height
Condition (live or dead)	Orientation (bearing) on tree
Configuration (crowned, spike- or broken-top)	*Ability to be used (bottom not rotted out, cavity large enough to fit FLOWs)
Height and dbh	+*Excavated or natural
Position (slope, ridge, draw)	
Number of cavities	

*Cavities must have met six 'minimally acceptable' criteria to be considered available, unused cavities that potentially could have been used by the nesting owls. These six criteria were (1) vertical and horizontal size of entrance ≥ 5 cm, (2) the cavity is available (e.g. not occupied by any other breeding animal species), (3) a cavity floor is present, (4) the cavity floor is not rotten or decayed, (5) cavity depth ≥ 15 cm, and (6) internal diameter ≥ 10 cm. I defined these criteria by drawing from minimum dimensions reported for FLOW nests in the literature

(McCallum and Gehlbach 1988, Bull and others 1990, Arsenault 2004, Powers and others 1996) and similarity to criteria used by Reynolds and Linkhart (1987a).

+*Pileated Woodpeckers (*Dryocopus pileatus*) and Northern Flickers (*Colaptes auratus*) are the two primary cavity excavators occuring in our study area. Other excavator species include Three-toed (*Picoides dorsalis*) and Hairy (*Picoides villosus*) Woodpeckers. However, I observed few flickers, Three-toed, or Hairy Woodpeckers in our study area and have found several Pileated Woodpecker nests within Flammulated Owl territories. I determined which woodpecker species excavated Flammulated Owl nest cavities based of the aforementioned observations and information about dimensions of nest cavities for Pileated Woodpeckers (Bull 1987, Bonar 2000) and Northern Flickers (Erskine and McLaren 1972, Arsenault 1999). Natural cavities were those formed by broken off limbs and rotted out knot-holes. I only collected this data for nest cavities.

June-July 2009. I returned to song tree areas at least 3 times. (Sites containing FLOW pairs were visited 5-10 times.) During visits, I checked all marked cavities for evidence of nesting (incubating or brooding female and/or eggs, nestlings).

If cavities were at a height of less than 15 m (50 ft), I checked them with a peeper camera. Beyond 15 m, cavities were too high to access. I checked these cavities via nocturnal surveys, which began least a half an hour after sunset. During these ≈ 35-45 min observations, I monitored cavities for FLOW courtship behavior: males singing from cavities, pairs entering and exiting cavities, pairs copulating, and females soliciting food with "mewing" calls.

Late July-August. I attempted to trap and band FLOW adults. My objectives were to (1) check for evidence of nesting (evidence of brood patches), and (2) lay the groundwork for assessing site fidelity in subsequent seasons. My technique was to place mist nets and an audio lure (FLOW primary song) at song tree sites (Barnes and Belthoff 2008).

August. I continued to search for evidence of breeding by conducting food begging surveys to search for FLOW nestlings. I began the surveys one half hour prior to end of civil twilight and ended by 2300 hrs. Surveys consisted of walking 200-300 m grids, stopping every 20-30 m to listen for food begging calls of dependent young. Sites were proximal to song trees or snags where pairs had been observed.

Table 2. Study Chronology, May-August 2009

Month	**May**	**June**	**July**	**August**
Activity #1	Surveys to detect FLOWs			
Activity #2		Searches for potential nest cavities		
Activity #3		Checks of cavities for evidence of nesting		
Activity #4			Attempts to trap and band FLOW adults	
Activity #5				Surveys for FLOW young

FIELD SEASON 2010
In 2010, I increased the number of minutes at survey points from 8 to 10 minutes to allow more time for listening and to be consistent with protocol established by Cilimburg and Hahn (2008). As a result survey points lasted 10 minutes: 3 min listening, 1 min playback, 2 min listening, 1 min playback, and 3 min listening.

May to mid-June 2010. I systematically surveyed in May. I surveyed 6 routes, each containing 10 survey points, spaced 400 m apart. Surveys began at the end of civil twilight and typically continued to 1 a.m.

If I did not hear FLOWs on a survey, I replicated the route several days later. If I did hear FLOWs, I returned to the route within 2 days, but only re-surveyed at points of detection (not the entire route). At these points, if FLOWs were once again detected, I marked the song tree with a GPS.

On 4 nights of the survey period, we conducted a preliminary study of survey techniques (passive listening versus playback). In order to investigate differences in timing of detection using passive listening versus listening/playback survey methods, we surveyed 2 routes simultaneously, employing only passive listening on 1 route, and on the other, both passive listening and playback.

June 2010. I attempted to trap, band, and place radio transmitters on FLOWs adults. These tools enabled me to (1) check for evidence of nesting (i.e. brood patches), (2) lay the groundwork for assessing site fidelity in subsequent seasons, (3) gather information about FLOW foraging habitat in Montana, and (4) inform a USFS forest management plan being developed for our study area.

To trap FLOWs, I placed mist nets in a "V" formation, with the bottom of the net 6-8 ft above ground. I also put an audio lure either low in a tree or on the ground in the middle of the V-formation. To attach Advanced Telemetry Systems A1055 radio transmitters to owls, I used a glue-on technique from Kenward (2001).

June-July 2010. In daytime, I returned to song trees to search for nest sites. Starting at the song tree, I covered a circle of habitat (≈ 450-m radius). I marked all cavity-bearing trees with a GPS, assigning each tree a unique identifier. For each cavity bearing tree, I collected the same variables as in 2009 (Table 1).

I returned to song tree areas at least 3 times, prioritizing sites with FLOW pairs (5-10 visits). During visits, I checked all marked cavities for evidence of nesting (incubating or brooding female and/or eggs, or nestlings). If cavities were at a height of less than 15 m (50 ft), I checked them with a peeper camera. Beyond 15 m, cavities were too high to access.

Late July-August. I continued efforts to capture adult FLOWs and search for nests. I also conducted nocturnal surveys to search for FLOW nestlings. These surveys consisted of walking 200-300-m grids around potential nest trees, stopping every 20-30 m to listen for food begging calls of dependent young. Sites were proximal to song trees or snags where pairs had been observed.

Table 3. Study chronology, May-August 2010

<table>
<tr><th>May</th><th>June</th><th>July</th><th>August</th></tr>
<tr><td colspan="2">Surveys to detect FLOWs</td><td></td><td></td></tr>
<tr><td></td><td>Attempts to trap adults</td><td></td><td></td></tr>
<tr><td></td><td colspan="2">Checks of cavities for evidence of nesting; radio tracking adults</td><td></td></tr>
<tr><td></td><td></td><td colspan="2">Attempts to trap adults and young</td></tr>
</table>

RESULTS

I surveyed 10 different routes for FLOWs in our study area. My survey coverage was more extensive in 2009, comprising parts of Blue Mountain Recreation Area, Clinton (Schwartz Creek), Marshall Canyon, Ninemile (Butler Creek), Missoula Valley, Pattee Canyon Recreation Area (Crazy Canyon), and Rattlesnake Recreation Area (Woods and Sawmill Gulch) (Figure 3). In 2010, I concentrated surveys in the Marshall Canyon/Woods Gulch complex and Crazy Canyon for two reasons: (1) I detected numerous FLOWs in these areas in 2009 and (2) I wanted to gather as much information as possible about FLOWs in the Marshall Canyon area to inform the USFS Marshall Woods project (Figure 4). I did not collect information regarding breeding habitat around the nest tree. Instead, I consulted with USFS biologists and silviculturalists about nest locations as the agency conducted analysis to prepare the Marshall Woods forest management action (e.g. burning, thinning). The pilot year of the project (2008) differed in effort and methodology from those in 2009 and 2010. In particular, I used radio marking methods to help locate nests and gather geospatial information about roosting and foraging habitat in 2010. Narrative summaries of the 2009 and 2010 field seasons are included in Appendix B.

NEST SITE CHARACTERISTICS

I located 4 FLOW nests from 2008-2010 (Figure 5). I located one nest in 2008, none in 2009, and 3 in 2010. All of these nests were located along a ridge in the Marshall Canyon watershed. I did not find nests in other areas I surveyed in my study area. Of special note, the nest I located in 2008 was the same tree and cavity as one of the three nests I located in 2010.

GPS Locations, Phenology, Reproductive Parameters, and FLOWs Banded at Nests 2008-2010

	Lat./Long. (WGS 84)	**Clutch Size**	**Laying Date**	**Hatching Date**	**Brood Size**	**Owls Banded**
***Nest #1**	N 46.91495°, W 113.92606°	2	15 June 2008 – 18 June 2008	07 July 2008 – 10 July 2008	2	None
***Nest #2**	N 46.91495°, W 113.92606°	3	03 June 2010 – 05 June 2010	26 June 2010 – 29 June 2010	3	2 adults, 3 young
Nest #3	N 46.91932°, W 113.91233°	2	07 June 2010 – 09 June 2010	29 June 2010 – 01 July 2010	2	2 adults, 2 young
Nest #4	N 46.91676°, W 113.92077°	2	02 July 2010 – 05 July 2010	25 July 2010 – 27 July 2010	1	2 adults, 1 young

*Same tree and cavity; hereafter referred to as Nest #1 and #2

All four of the nests that I located were excavated cavities in dead trees located on steep slopes with east to south-east aspects. Nest #1 and #2 were in a massive 93.9 cm DBH spike-top ponderosa pine snag with many branches. Bark covered most of the trunk. Interestingly, Nest #1 and #2 tree contained a large, active honey bee colony approximately 3 m below the nest cavity. Nest tree #3 was a small 27.9 cm DBH, broken-top Douglas-fir snag growing out of a rock outcropping. This tree had bark covering most of the trunk and many branches covered with *Letharia* spp. lichen. Nest #4 had no bark and was a large 69.9 cm DBH, broken-top ponderosa pine snag.

It should be noted that although I found 4 nests total, Nest #1 and #2 were in the same tree and cavity resulting in a sample size of n = 3. Nest tree heights were 6.7, 9.7, and 37.4 (range = 30.7 m). DBH of nest trees were 27.9, 69.9, and 93.9 cm (range = 66 cm). Height of nest cavities were 3.9, 8.2, and 11.6 m (range = 7.7 m). Length and width of nest cavity entrances were 8.3, 9.5, and 9.8 cm (range = 1.5 cm) and 8.3, 11.4, and 12.1 cm (range = 3.8 cm), respectively. Depth of nest cavities were 28.3, 28.6, and 45.7 cm (range = 17.4 cm). Internal diameter of nest cavities were 13.9, 22.7, and 23.5 cm (range = 9.6 cm). Pileated Woodpeckers were the likely primary excavators of all the nest cavities that I located.

Table 4. Summary of Nest Tree and Cavity Variables

TREES							
	Species	**Live or Dead**	**Tree Height (m)**	**DBH (cm)**	**Position**	**Aspect**	**Configuration**
Tree #1	PIPO	Dead	37.4	93.9	Slope	E(SE)	Spike-top
Tree #2	*	*	*	*	*	*	*
Tree #3	PSME	Dead	6.7	27.9	Slope	E(SE)	Broken-top
Tree #4	PIPO	Dead	9.7	69.9	Slope	SE	Broken-top

CAVITIES						
	Entrance Length (cm)	**Entrance Width (cm)**	**Depth (cm)**	**Internal Diameter (cm)**	**Cavity Height (m)**	**Orientation**
Cavity #1	9.8	11.4	28.3	23.5	11.6	S
Cavity #2	*	*	*	*	*	*
Cavity #3	8.3	8.3	45.7	13.9	3.9	NE
Cavity #4	9.5	12.1	28.6	22.7	8.2	SE

*Same as Nest #1

Characteristics of Cavity Bearing Tree in Breeding Territories. I located and measured characteristics of 6 cavity bearing trees containing 14 cavities in Nest #1 and #2 and Nest #4 breeding territories. A detailed comparison of nest sites and cavity bearing trees within these two breeding territories are presented in Appendix C.

TRAPPING, BANDING, AND SITE FIDELITY

FLOWs are known to exhibit strong site fidelity (Reynolds and Linkhart 1987a, Linkhart and Reynolds 2007). Indeed, of the 17 territories that I have detected since 2008, 11 appear to demonstrate site fidelity: 3 territories have been occupied 3 years, and 8 have been occupied at least 2 years. Five were new sites for 2010. One territory occupied in 2009 was unoccupied in

2010 (Figure 6). Unfortunately, I did not band FLOWs prior to 2010. However, I was able to band all the breeding adults and their young at the three nests we located in 2010 (n = 12). At two nests, radio marking the owls allowed me to easily locate the nest sites. In total I banded 6 adults and 6 young in 2010. Banding in subsequent seasons will help provide insights into site fidelity, and possibly survival, of Flammulated Owls in my study area.

ROOSTING AND FORAGING LOCATIONS

At Nest #3 I captured and attached a radio transmitter to the male, and it remained attached for almost 6 weeks (6/11/2010 – 7/19/2010). During this period, I radio tracked the male every third night and was able to obtain good information about roosting and foraging locations (Figure 7). At Nest #4 I attached a radio transmitter to the male but he plucked it off before egg-laying. However, I did obtain several roosting locations (Figure 8).

CHARACTERISTICS OF CAVITY BEARING TREES IN TERRITORIES

In 2009 and 2010 I located and measured characteristics of 51 cavity bearing trees containing 117 cavities in 11 Flammulated Owl territories within which I did not locate nests but where FLOWs were present throughout the breeding season. I located a total of 57 cavity bearing trees containing 131 cavities in 13 territories. Ponderosa pine was the most numerous species of cavity bearing trees that I located, comprising 41 (72%) of my sample. Douglas-fir and Western Larch were the other two cavity bearing tree species respresented in my sample comprising 15 (26%) and 1 (2%), respectively. I located 53 (93%) dead cavity bearing trees. Most often the cavity bearing trees I located were broken-top trees found on slopes with W-E aspect.

The distribution of height of cavity bearing trees appears skewed right (Figure 9). Cavity bearing trees in the 6-10 m and 11-15 m height classes comprised a combined 66% of our sample. Modal interval was the 6-10 m height class. Sample median height was 12.5 m and range 29.9 m (36 – 6.1 m). Grouped median height was 12.375 m.

The distribution of DBH of cavity bearing trees appears rather symmetric (Figure 10). The modal interval was the 36-45 cm DBH class. Twenty five (45%) of the cavity bearing trees we located were in the 36-55 cm DBH classes. Sample median DBH was 54.6 cm and range 92.7 cm (116.8 – 24.1 cm). Grouped median DBH was 53.0 cm.

CAVITY CHARACTERISTICS IN TERRITORIES

A narrow majority (52%) of the 131 cavities that I located were usable for FLOWs. Forty percent (61 of 115) of the cavities that I located were bearing S-E on trees. The distribution of height of cavities appears skewed right with an outlier in the 26-30 m height class (Figure 11). The modal interval was the 6-10 m height class, comprising over half (55%) of the cavities we located. Sample median was 8.45 m and range 22 m (26.3 – 4.3 m). Grouped median was 9.09 m. Sample median of height of nest cavities was 8.2 m and range 7.7 m (n = 3).

DISCUSSION

OVERVIEW OF FLAMMULATED OWL BREEDING RESEARCH

The breeding biology of Flammulated Owls has been rather well studied at the core of their range in New Mexico, Colorado, Utah, Oregon, and Idaho. Most of the studies have demonstrated an affinity to xeric ponderosa pine/Douglas-fir forests containing large diameter snags for breeding, although several studies have indicated that Flammulated Owls breed in other forest types such as Douglas-fir forests and aspen stands (Reynolds and Linkhart 1987b, Powers and others 1996, Marti 1997).

Several studies have investigated nest site preferences of Flammulated Owls and collected data comparable to our preliminary data. In New Mexico, McCallum and Gehlbach (1988) reported mean and standard deviation of nest tree DBH was 46.2 ± 10.7 cm (n = 17). Mean and standard deviation of cavity height, entrance diameter, depth, and internal diameter at nest sites was 4.9 ± 1.6 m, 5.9 ± 0.9 cm, 21.2 ± 5.2 cm, and 13.5 ± 2.8 cm, respectively. Arsenault (2004) reported mean and standard deviation of entrance length and width, cavity depth, and internal diameter 5.64 ± 0.9 and 5.68 ± 1.1 cm, 25.21 ± 9.2 cm, and 14.6 ± 4.1 cm, respectively in New Mexico (n = 34). Both of these studies reported cavity dimensions smaller than cavity dimensions in our study. Arsenault (2004) did not report height of nest cavities but did report a majority (18) of nests in live trees, mainly Gambel oak. Also, Arsenault (2004) concluded that Flammulated Owls nested in more Northern Flicker cavities than expected based on availability. However, Arsenault (2004) reported that most Acorn Woodpecker (*Melanerpes formicivorus*) nests were in live trees and Northern Flicker nests most often in dead trees. Given the fact that Arsenault (2004) found 18 Flammulated Owl nests in live trees may indicate that these owls largely depend on cavities excavated by Acorn Woodpeckers for nesting in New Mexico.

The assemblage of primary excavator species may differ throughout the range of Flammulated Owls. Depending on the assemblage this may result in a large variation in the dimensions of available cavities used for nesting by these owls. For example, Bull and others (1990) reported mean and standard deviation of nest tree DBH 72 ± 14.4 cm and nest cavity height 12 ± 4.7 m for Flammulated Owl nests in Oregon (n = 33), seventy percent of which were in ponderosa pine trees. No information about nest cavity dimensions was reported by Bull and others (1990). However, they did report most Flammulated Owl nests in cavities excavated by Pileated Woodpeckers in dead trees. Nest sites were located at sites dominated by ponderosa pine as the overstory tree species, similar to breeding habitat associations reported for Flammulated Owls in Colorado (Reynolds and Linkhart 1992). Bull and others (1990) concluded that relative to availability, Flammulated Owls used a higher percentage of Pileated Woodpecker cavities than expected.

In Idaho, Powers and others (1996) studied 24 Flammulated Owl nests in habitat without ponderosa pine but largely dominated by Douglas-fir with isolated pockets of trembling aspen. They reported mean and standard deviation for nest tree DBH, nest cavity height, and entrance diameter 49.9 ± 18.9 cm, 5.1 ±0.6 m, and 6.8 ± 1.3 cm, respectively (n = 13). They also reported most (20) of the nests were in dead trees of which 13 (54%) were broken-top Douglas-fir snags. In my study I found one nest in a 28 cm DBH dead, broken-top Douglas-fir snag. Eleven of the nests Powers and others (1996) found were in trembling aspen, seven in dead trees and four in live trees. Flammulated Owls are also known to nest in aspen in Colorado (Reynolds and Linkhart 1987b). Although our sample size (n = 3) is very limited our median nest tree DBH, nest cavity height and internal dimensions were within the range reported by other Flammulated Owl investigators. Bull et al. (1990) reported similar although slightly larger dimensions in ponderosa pine tree nests, while other studies (McCallum and Gehlbach 1988, Powers 1996, Arsenault 2004) have reported smaller values for these dimensions in Gambel oak and Douglas-fir tree nests.

The New Mexico and Idaho studies were in areas where primary cavity excavators were Northern Flickers. In Oregon, Pileated Woodpeckers were the primary excavators, similar to our study area. Both species are present in our study area and differentiating Pileated Woodpecker and Northern Flicker nest cavities can be difficult (Arsenault 1999). The mean entrance diameter of the nest cavities reported from Powers and others (1996) study (6.8 cm, SD = 1.3 cm) is similar to the mean length and width entrance dimensions for Flammulated Owl nests in Northern Flicker cavities reprorted by McCallum and Gehlbach (1988) and Arsenault (2004) from New Mexico. This may indicate that the dimensions of Northern Flicker nest cavities used by Flammulated Owls are similar throughout the owls' range in the intermountain western United States. However, it should be noted that Powers and others (1996) did not identify primary excavator species but only stated which primary excavator species were present in their study area.

Although my study does not provide a quantitative method for differentiating the nest sites of primary excavator species we observed few Northern Flickers and found several Pileated Woodpecker nests in our study area. Intuitively this leads to thinking that Pileated Woodpeckers were the most likely primary excavators of Flammulated Owl nest cavities that I found. The dimensions of the nest cavities in my study are much larger than the dimensions of Northern Flicker nest cavities used by Flammulated Owls reported by McCallum and Gehlbach (1988), Powers and other (1996), and Arsenault (2004), but similar to Bull and others (1990) in Pileated Woodpecker excavated cavities. However, a much larger sample size is needed before inferences can be made about Flammulated Owl nest characteristics in Montana. Further, the interaction between excavator species and nest tree species complicates the identification of common Flammulated Owl nest cavity physical characteristics throughout its entire range. Median clutch (2 eggs) and brood sizes (2 young) in my study are similar to sizes reported by other investigators (Reynolds and Linkhart 1987b, Powers and others 1996, Linkhart and Reynolds 2006).

Interestingly, Nest #4 that I located may be the latest occurrence of FLOW egg laying ever reported. Egg laying at this nest occurred between 02 – 05 July. To our knowledge, the closest report is that of a 29 June egg laying at a nest in Idaho (Barnes and Belthoff 2008), some 200 miles and nearly 2 degrees latidute farther south than my study area. A review of the literature indicates that FLOWs initiate breeding earlier in the southwestern U.S. (New Mexico), later in Colorado, and still later in Idaho. This variance in phenology makes intuitive sense, with colder, wetter conditions persisting longer at more northern latitudes of the FLOW's breeding range. Further seasons of research will clarify how common a July egg-laying date is, and whether mean egg-laying dates in Montana follow this phenological gradient.

In a review of Flammulated Owl biology, management, and conservation McCallum (1994b) provided good discussions of habitat preference, fitness functions, and the concept of source and sink populations. However, Holt (1995) concluded that given the scarcity of information identified in McCallum (1994b) not enough demographic data were available to build source and sink models for Flammulated Owls. Since that time, only the long-term study (23 years) by Linkhart and Reynolds (2006, 2007) provide enough demographic data to model Flammulated Owls in Colorado.

Occupancy studies have increased our knowledge of Flammulated Owl distribution and landscape level habitat associations in Montana. However, if occupancy does not imply breeding, then inferring breeding habitat associations with occupancy surveys may be limited because actual breeding is not taking place in the habitat occupied. Further, survey protocols using playback methods may draw owls away from core territories and habitat recorded around the point of detection may be important to predict occupancy but not necessarily breeding. For example, we captured and attached a radio-transmitter to a breeding female over 300 m from her nest site. Thus, it is important to continue efforts throughout the nesting period (May to Sept) to include detection surveys, nest searches and nest monitoring.

Montana remains one of 4 states (Montana, Wyoming, Washington, and California) within the 11 western states with no detailed breeding study of Flammulated Owls. In order to create scientifically accurate and responsible models researchers must include information about nest tree characteristics, foraging habitat, and productivity that is drawn from a large sample.

STUDY LIMITATIONS

Although we cannot rule out the possibility that we failed to detect nest sites, we are confident that our investigation has been rigorous and thorough. We intensively searched for potential cavities within territories, repeatedly checked cavities, and conducted further survey in accordance with the breeding phenology of Flammulated Owls (May-August), including food-begging surveys for dependent young given the resources available. Also, we have observed that breeding pairs are very active and visible at nest sites. When we knocked on nest trees, or simply approached the nest tree closely, incubating and/or brooding females regularly stuck their heads out of cavities. In addition, males made frequent food deliveries to the cavity after eggs hatched. At almost all cavities, regularly checked with a peeper camera or monitored via nocturnal observations, we did not observe owls or the aforementioned behaviors, even at most territories with paired owls. This lends itself to concluding that those cavities were not occupied or that the pair was not breeding. However, it is nearly impossible to find every cavity in a particular area of forest. It requires much effort to find nests because the terrain occupied by Flammulated Owls and their nocturnal habits make it difficult. No doubt, greater survey effort with more research staff would be needed to acquire a larger sample size.

RECOMMENDATIONS

No doubt the approach of radio marking the owls has helped tremendously in locating nests, and we will use this technique in future years. For the purposes of locating nests the glue-on technique we used worked well. Because the tags were easily shed off from owls entering and exiting cavities and the fact that one male plucked his tag off, glue-on techniques are not well suited for gathering foraging information. Instead, a backpack harness technique should be used.

Using a peeper camera is very effective for determining egg laying/clutch size and monitoring development of FLOW young. We recommend the use of such an instrument for any project conducting breeding research on FLOWs. It is also very useful for determining whether cavities are useable or not.

Using mist nest and audio lures to capture FLOWs seems to be effective and has been the most commonly used technique reported in the literature. However, most authors do not report the height at which nets should be placed. In my trapping attempts I observed that most often FLOWs tend to perch and fly 15 feet or more above the ground. As a result, I modified my trapping set to allow nets be raised so that the top of nets were at 15 feet. I suggest that researchers attempting to capture FLOWs place nets as high as possible to increase chances of success.

Our research attempted to address the need for breeding information about Flammulated Owls in Montana but much more needs to be done. Below we offer suggestions for future research and management.

SUGGESTIONS FOR FUTURE RESEARCH AND MANAGEMENT

Research

We strongly recommend that Flammulated Owl research extend beyond detection and occurrence to continue from detection through nesting and fledging (May-Sept.). We realize that replication of routes and repeated observations can lend strong inference towards which habitats singing males are using. However, as mentioned previously – singing does not always indicate nesting. Indeed, in three years of research in our study area we did not find nests one year. Whether this resulted from our failure to find them or the owls we monitored did not breed is not known, but may indicate that breeding of Flammulated Owls in local areas in Montana is not consistent from year to year. Essentially, we have no idea if Flammulated Owls are breeding in a way to sustain viable populations in Montana, important information that may affect management strategies if a sink population exists. Further, the outcomes of demographic modeling may be misleading if no annual variation in productivity is assumed. No doubt substantial commitment is needed to comprehensively assess breeding status, nest site selection, habitat requirements, and general breeding biology in Montana. This will require much in terms of money, resources, and personnel. However, as much as possible within these constraints managers should emphasize demographic variables if concerned with habitat quality (Johnson 2007).

Presence-absence data are useful for managing wildlife in many contexts, including identifying habitats that are of high value to specific species of conservation concern (MacKenzie 2005). For example, occupancy studies conducted by researchers in the mid-1990s and Avian Science Center at the University of Montana have provided a solid understanding of distribution and landscape level habitat associations in Montana. These studies have also demonstrated that singing Flammulated Owls can be quite numerous in local areas during the breeding season and occupying specific habitat (i.e. dry montane forests, open canopy and understory). In a review of density as an indicator of habitat quality and breeding Bock and Jones (2004) concluded that of 109 published cases on 67 species across North America and Europe that, in most cases, density will be a reliable indicator of breeding habitat quality. Intuitively, this implies that areas where there is lots of singing there is lots of breeding. However, it is known that Flammulated Owls will sing and defend territories if not breeding. Interestingly, Bock and Jones (2004) also reported a negative association between density and per capita reproduction in highly territorial species. However, it should be noted that most of the studies reviewed by Bock and Jones (2004) were conducted on non-strigiform species, mainly passerine birds. Nonetheless, in the end habitat characteristics associated with breeding must form the basis of modeling habitat for Flammulated Owls (van Woudenberg and Christie 2000). If it cannot we offer the following suggestions.

Researchers may be able to obtain data about breeding habitat by conducting properly designed presence-absence surveys, collecting habitat information, and then inferring that density of singing males indicates successful breeding if they had the evidence. A well designed long term presence-absence study coupled with efforts to locate nesting individuals at points of repeated observations may provide such evidence.

Future research should also examine Flammulated Owl habitat use in other forest types. Flammulated Owls are known to nest in forest types other than ponderosa pine (Christie and van Woudenberg 1997, Dunham and others 1996, Howie and Ritcey 1987, Marti 1997, Powers and others 1996) and this could have important conservation implications if determined to be the case in Montana. It also presents an opportunity to compare productivity between different habitat types.

Management

If models with little supporting demographic data are used to manage habitat for Flammulated Owls, a significant commitment to monitoring is required to determine the viability of this approach. Models based on short-term studies may capture relationships between animals and habitat during the course of investigation but may be ineffective in accurately predicting these relationships over time (see Rotenberry and Wiens 2009). Researchers and wildlife managers must have longitudinal data that includes breeding data to make strong inferences that decipher these changes. Further, models without these data could be honestly challenged in court if agency actions concerning forest management and Flammulated Owls in Montana are litigated. For example, will ground-truthing and monitoring be conducted to determine if habitat models are biologically relevant? Federal and state agencies should provide contingency plans to assess models. Models should also allow for catastrophic events. Indeed, wildfire is an annual occurrence in forests of the western United States. Fire should be a model parameter as should potential effects of global warming on Flammulated Owl breeding ecology.

Snag Management—Flammulated Owls are obligate secondary cavity nesters and the presence of suitable cavities is a prerequisite for successful nesting. A large majority of Flammulated Owl nests have been reported in large, dead trees (dbh > 40 cm), especially cavities excavated by Northern Flickers (*Colaptes auratus*), and Pileated Woodpeckers (*Dryocopus pileatus*) (McCallum 1994a). We have yet to adequately describe characteristics of nest trees (snags) used by Flammulated Owls in Montana. Not all snags are created equally. They vary in height, dbh, age, and many other variables. For example, studies by D. Holt (unpubl.data) have shown Northern Saw-whet and Northern Pygmy-owls have different requirements for nest trees, and that leaving the "classic" old snag with woodpecker holes may not provide nests for both species. Additionally, the interior of all cavities are also not created equally. Evaluation of the interior of snags revealed that although the entrance hole looked appealing, the interior can vary from structurally sound to unusable (D. Holt, unpubl. data). Thus, snag retention policies for secondary obligate cavity nesters may need revaluation.

Long-term, rigorous study of breeding biology and habitat is urgently needed in order to develop scientifically robust and reliable population models for Flammulated Owls. This will require surveying to locate owls and intensive nest searching and monitoring. A well thought out presence-absence survey coupled with nest searches at points of repeated observations may lend an important protocol for wildlife managers concerned with habitat quality for Flammulated Owls, particularly habitat features associated with breeding.

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FIGURES

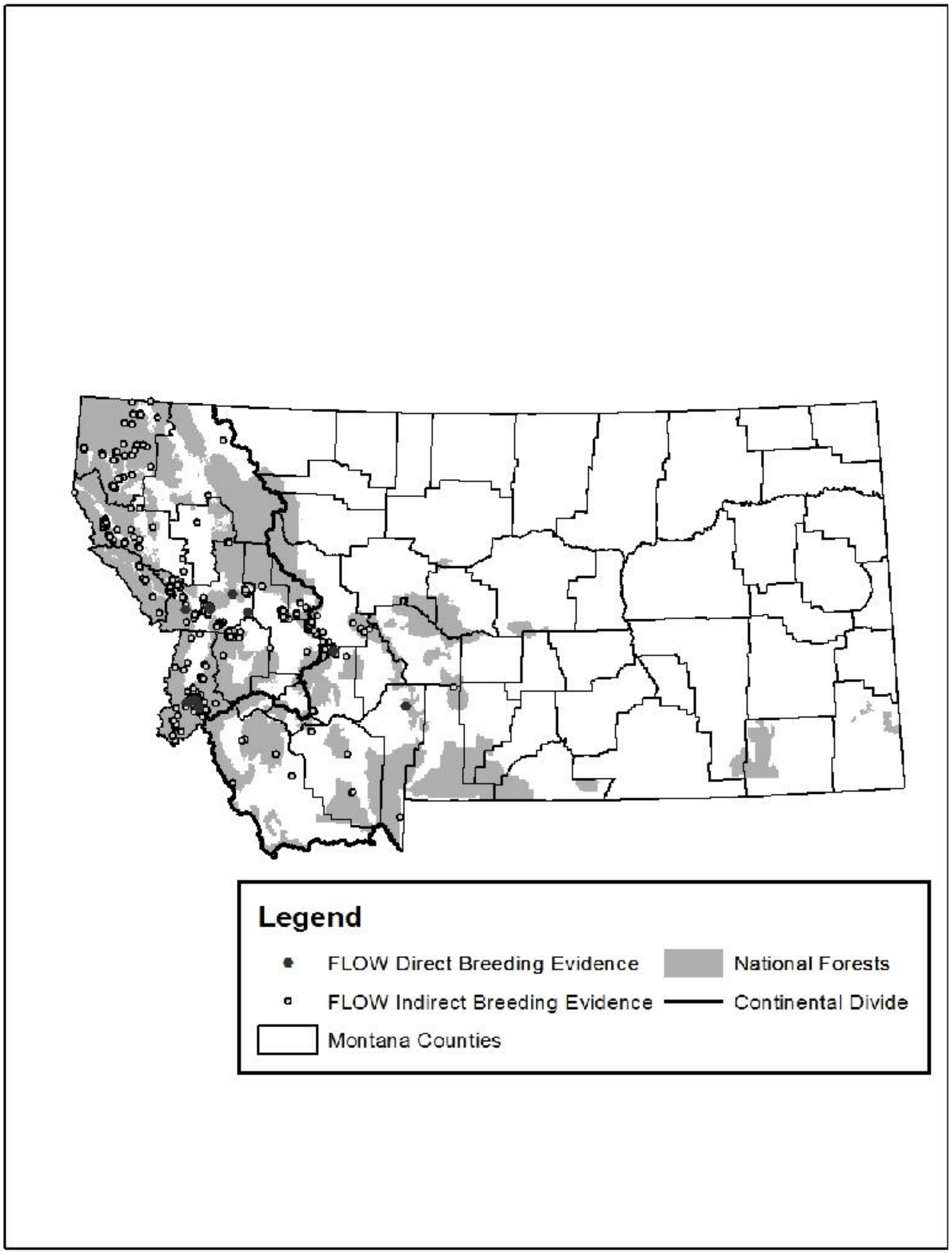


Figure 1. Flammulated Owl records from Montana

Figure 2. Study Area

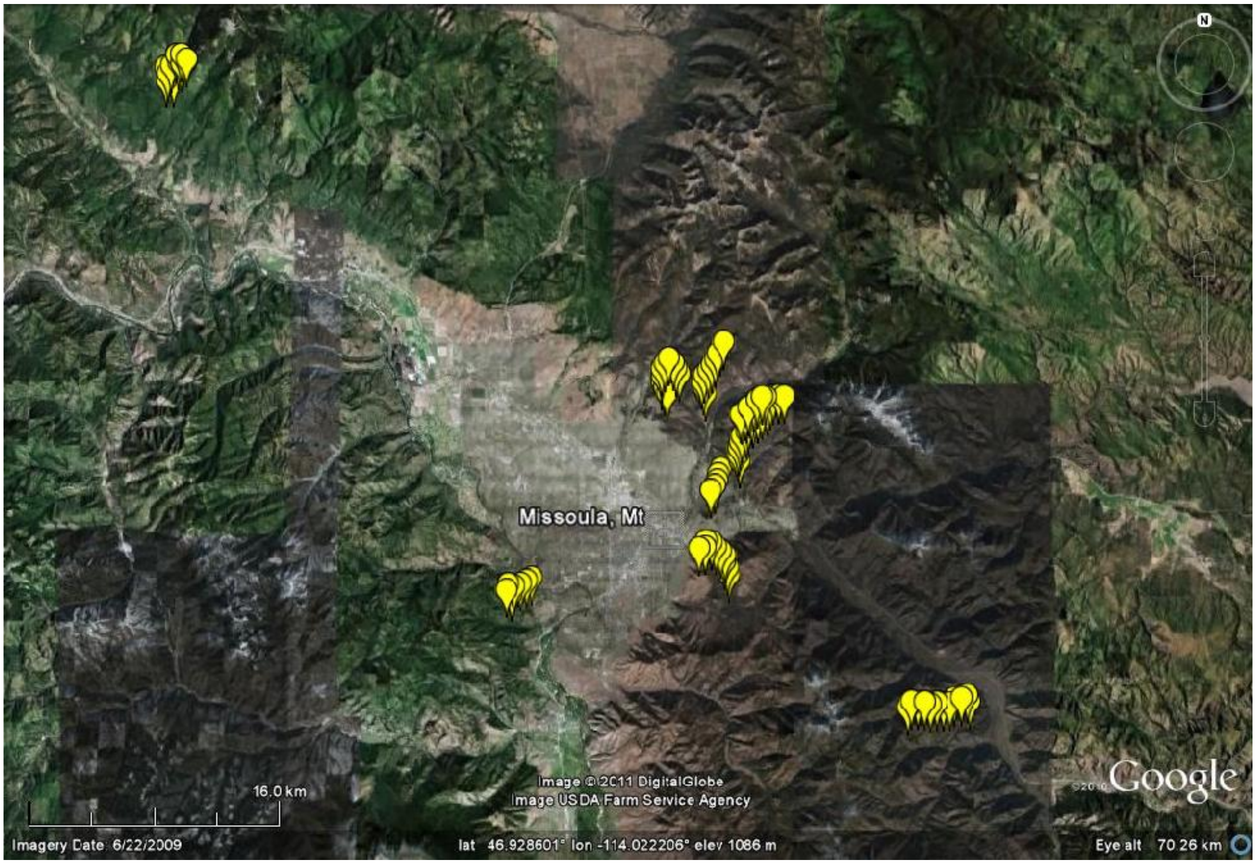


Figure 3. 2009 Survey Routes

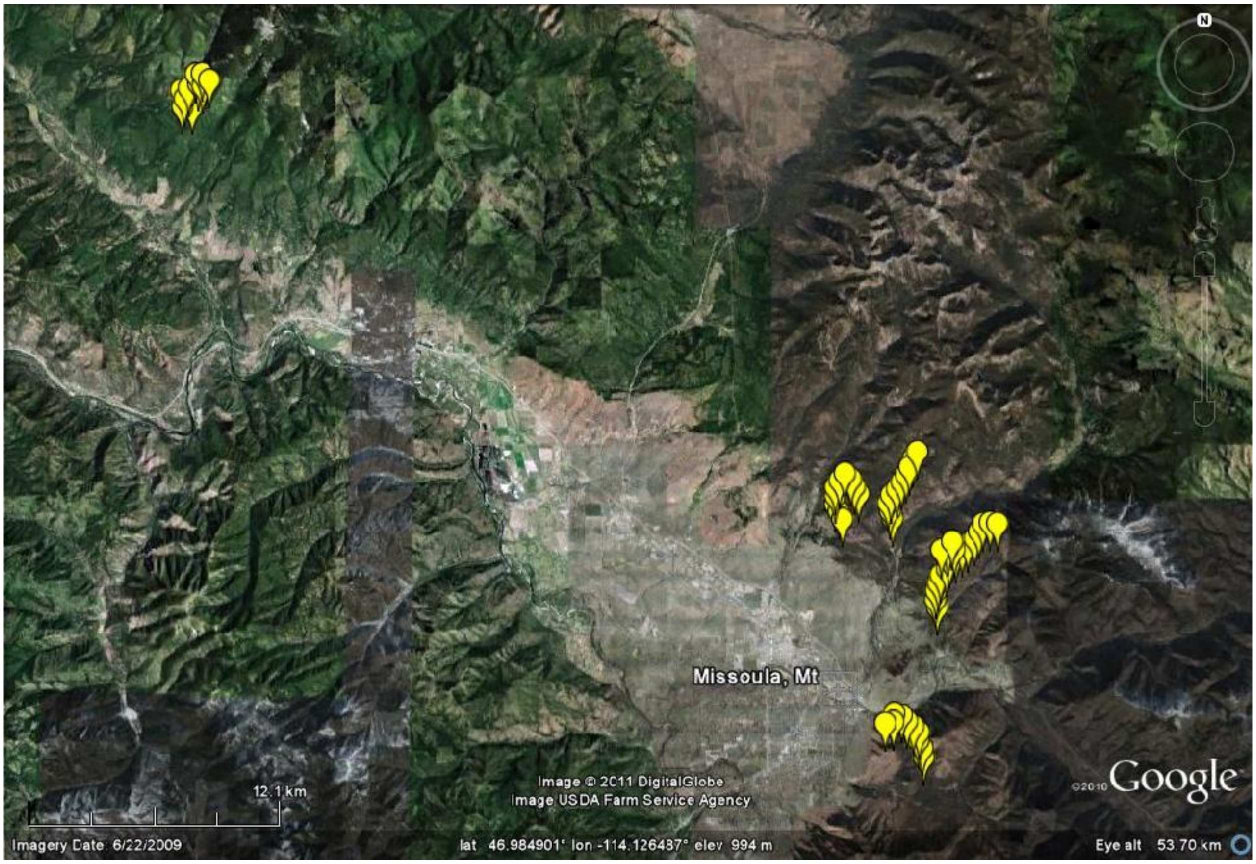


Figure 4. 2010 Survey Routes

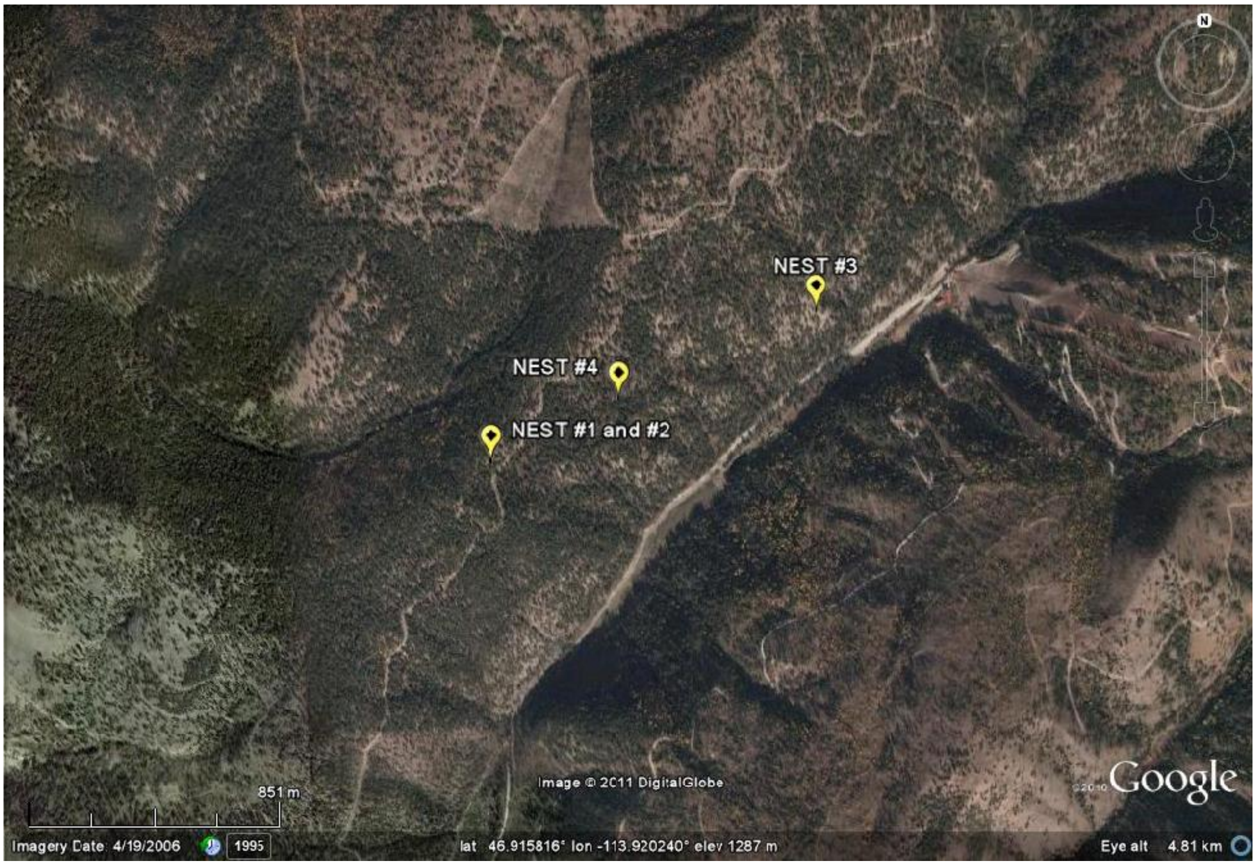


Figure 5. Flammulated Owl Nest Locations 2008-2010, Marshall Canyon, Missoula County

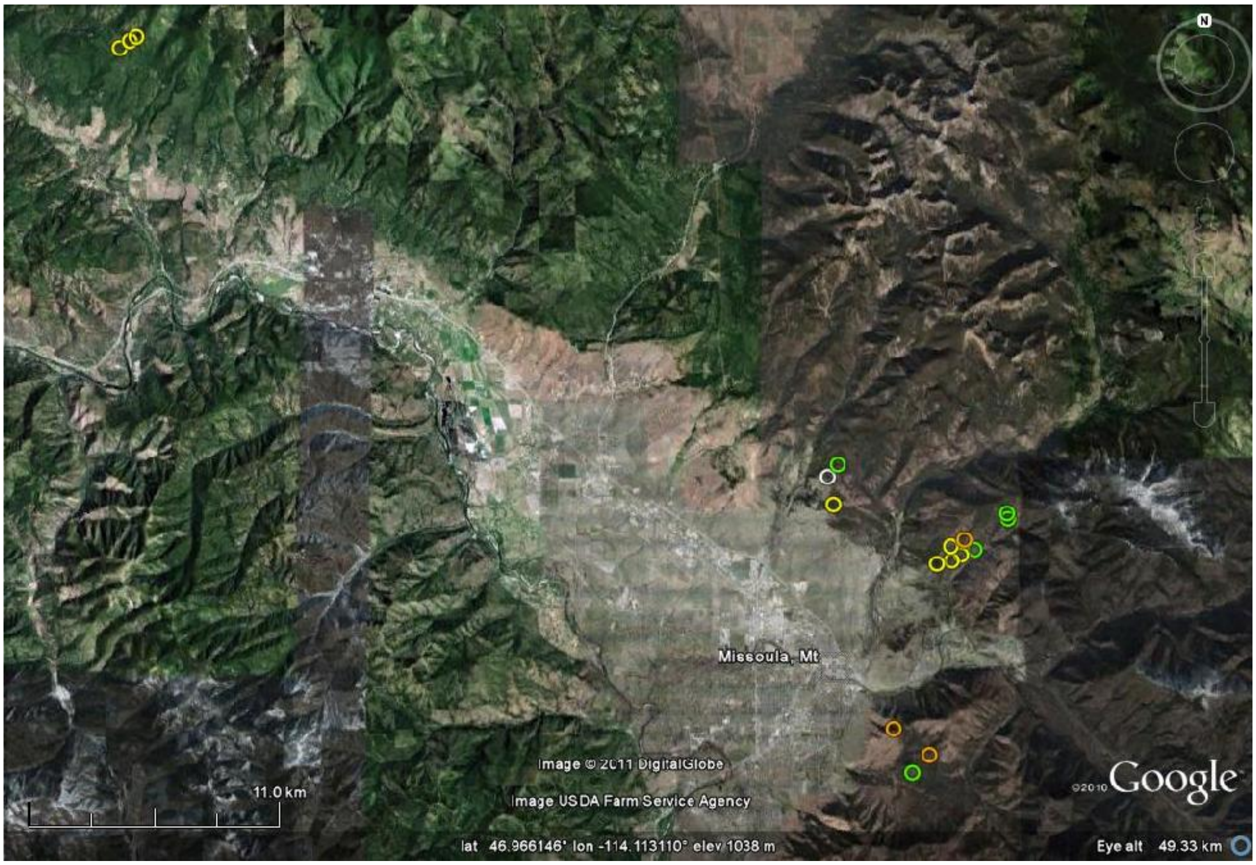


Figure 6. Flammulated Owl territories located from 2008-2010. Orange circles represent territories occupied 3 years. Yellow circles represent territories occupied at least 2 years. Green circles represent new territories discovered in 2010. White circle represents territory occupied in 2009 but not in 2010.

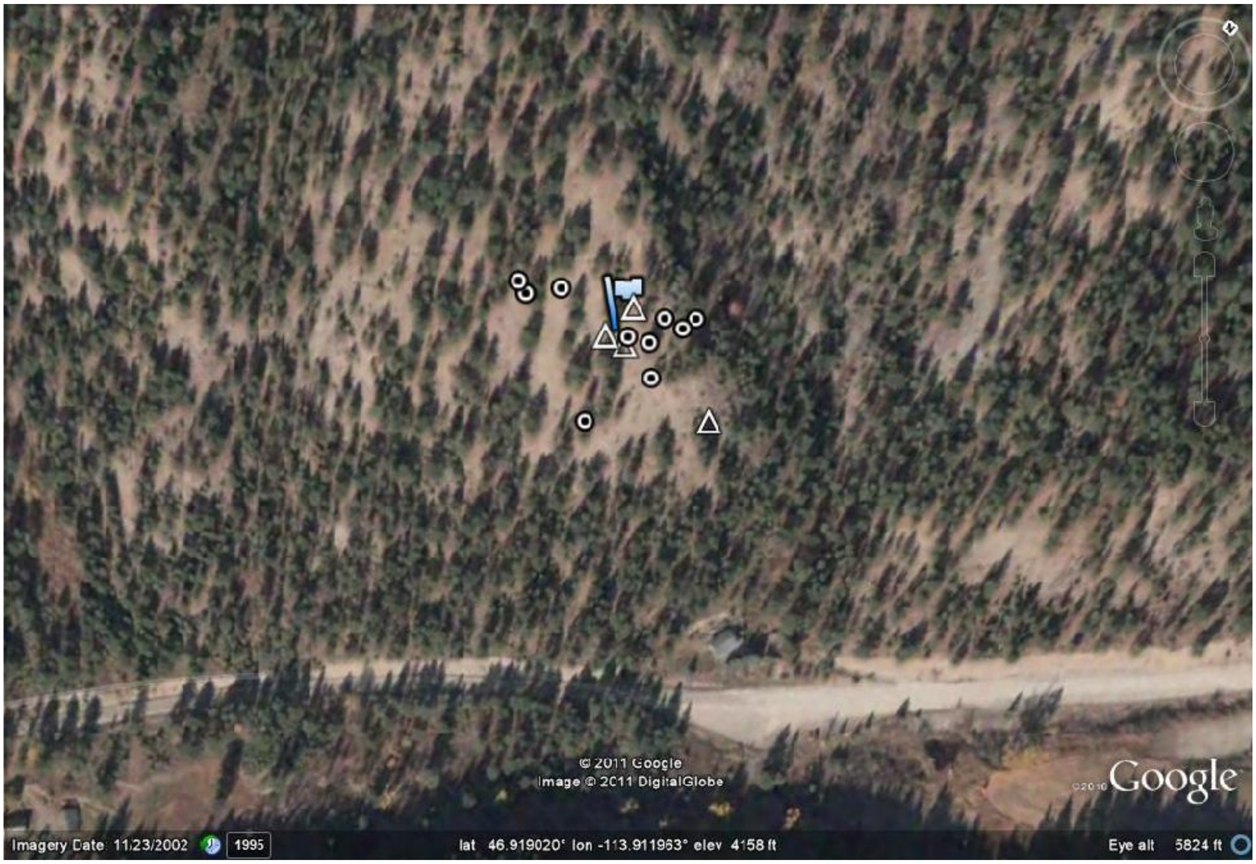


Figure 7. Nest #3 (flagpole) – Roosting (triangles) and Foraging (circles) locations.

Figure 8. Nest #4 (flagpole) – Roosting locations (triangles).

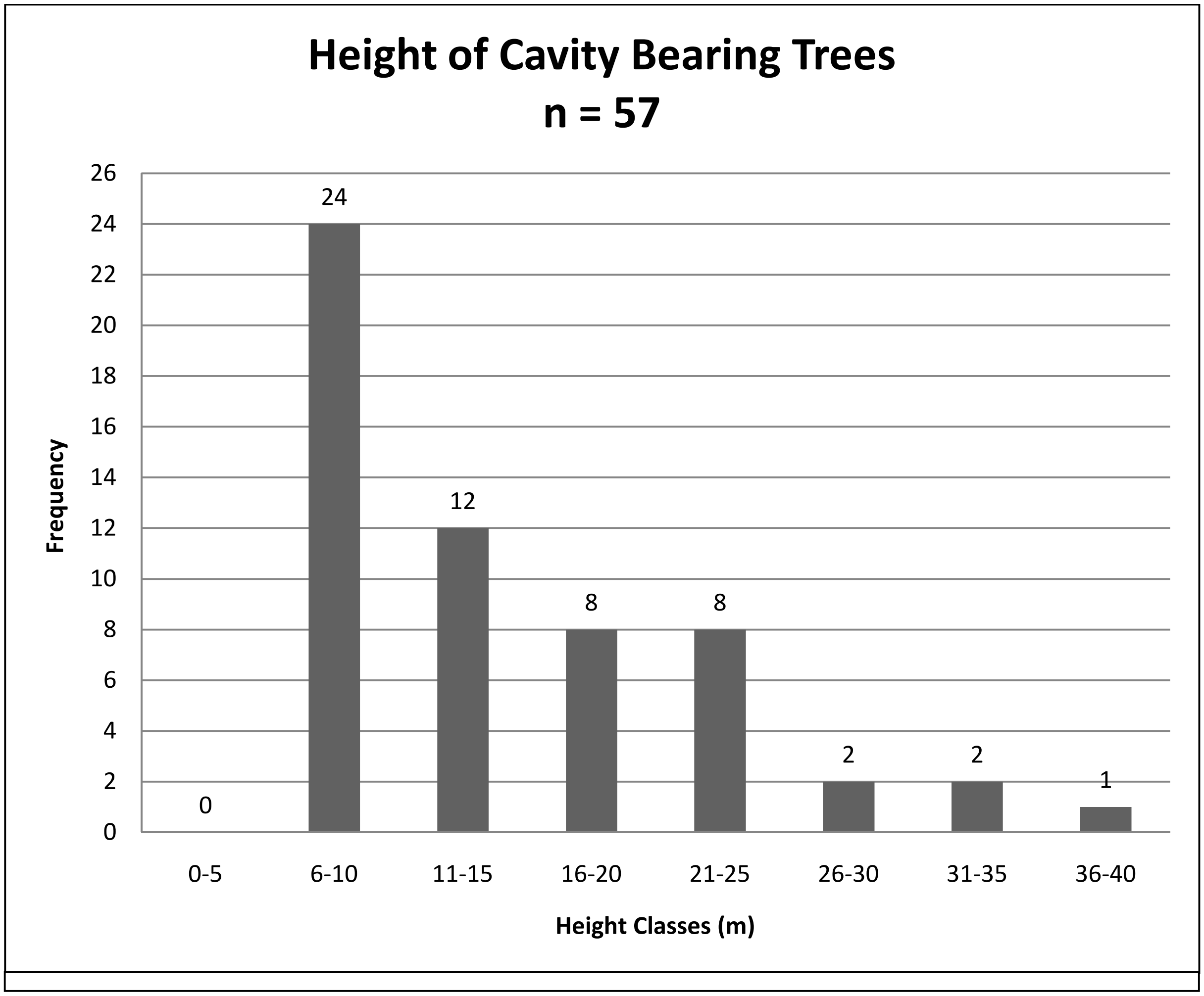


Figure 9. The distribution of height of cavity bearing trees is skewed right. Modal interval 6-10 m height class.

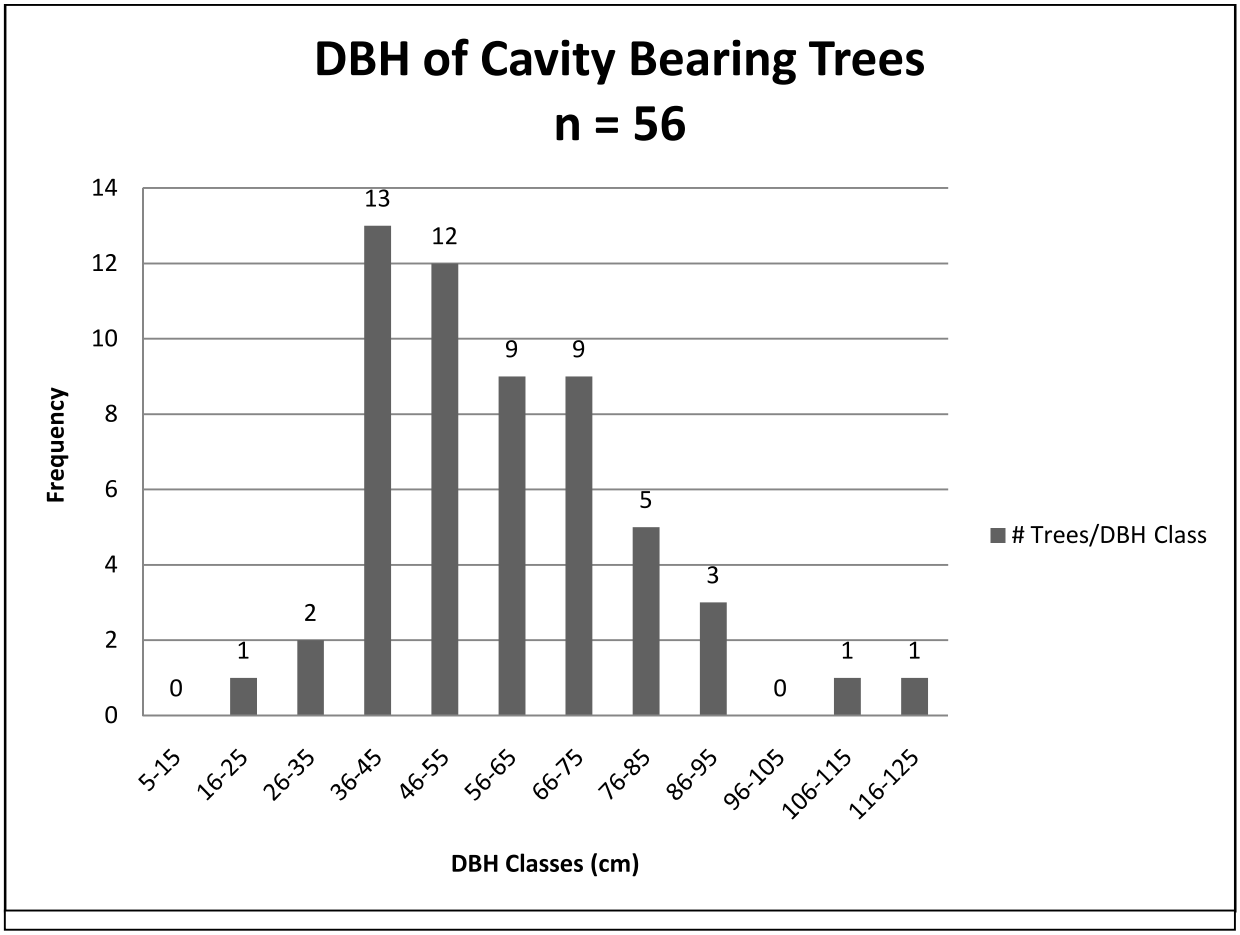


Figure 10. The distribution of DBH of cavity bearing trees appears symmetrical. Modal interval 36-45 cm DBH class.

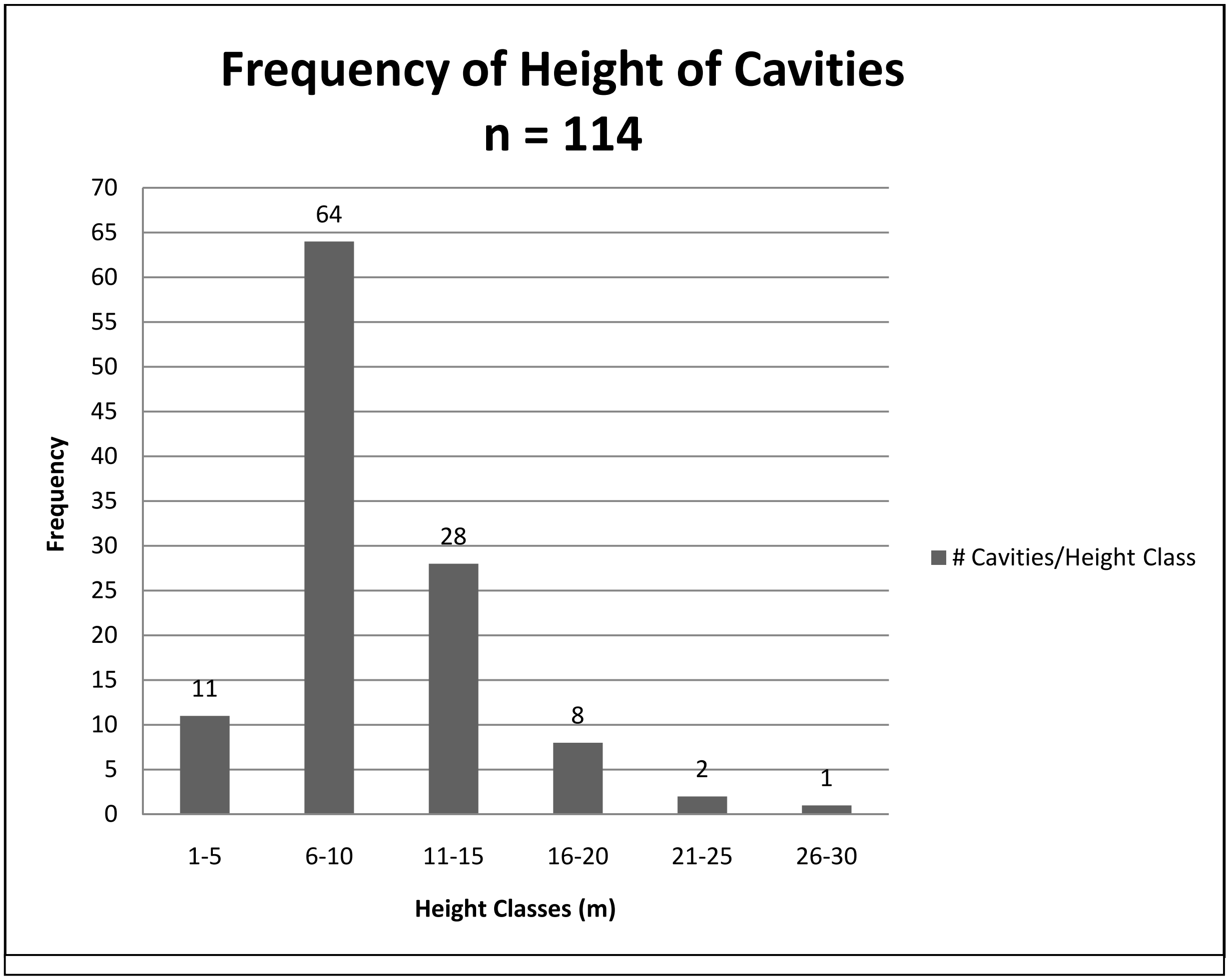


Figure 11. Modal interval 6-10 m height class for distribution of height of cavities.

APPENDIX A

Records of direct evidence of breeding of Flammulated Owls in Montana, 1982-2010.

DATE	LOCATION	COMMENTS
4 September 1975[a, b]	Missoula Co., downtown Missoula	Recently fledged bird found injured, later released. First nesting evidence
11 August 1982[a]	Missoula Co., west of Missoula	Fledgling found by logger
15 July 1986[a, b]	Missoula Co., Blanchard Lookout, Blanchard Creek	Snag felled by logger contained three nestlings, two partially feathered and one mostly downy. First nest record.
20 Augest 1988[a]	Missoula Co., Marshall Canyon area, yard of Kohler home 0.25 mile N of county line	Newly fledged young found in yard, body with downy feathers and feathered wings and tail, reported by Judy Hoy.
26 July 1991[a]	Lewis and Clark Co., Grizzly Gulch last house 0.25 mile N of county line	Juveniles and adults observed at cavity in yard of residence.
27 July 1993[a]	Gallatin Co., Johnson Canyon, E of canyon mouth where road cuts ridgeline	Two biegging fledglings and one adult male responded to territorial hoot from observer.
27 July 1993[a]	Gallatin Co., Johnson Canyon, W of canyon mouth	One begging fledgling and one adult male responded to territorial hoot from observer.
8 August 1993[a]	Gallatin Co., Johnson Canyon, E of canyon mouth where road cuts ridgeline	Observer reports that male "sang one complete song" during visit to measure habitat on 27 July 1993.
21 May – 17 July 1994[a]	Ravalli Co., Robbins Gulch area, Bitterroot National Forest	Observations of adults at nest cavity feeding young during the course of the summer. At last observation (no date) at least one juvenile and the adult female heard outside cavity.

15 July 1994 – 31 July 1994[a]	Ravalli Co., Sula Peak area, Bitterroot National Forest	Male, female and juveniles (family group) heard or seen concurrently after fledging and still in or near the breeding territory.
15 July 1994 – 31 July 1994[a]	Missoula co., Rattlesnake Creek area, Lolo National Forest	Male, female and juveniles (family group) heard or seen concurrently after fledging and still in or near the breeding territory.
15 May 1995 – 7 July 1995[a*]	Ravalli Co., Haley Chute area, Bitterroot National Forest	Observations of adults at nest cavity until early July then activity ceased, no juveniles observed.
8 June 2001 – 20 July 2001[a**]	Ravalli co., Bitterroot National Forest, 7 miles SE of Darby, MT	Nest in depression on ground in low-severity burn, female incubating 3 eggs, later hatched, two young depredated at fledging, fate of third young unknown.
5 July 2005[a]	Missoula Co., Elk Creek tributary	Occupied nest.
15 June – 25 August 2008[b]	Missoula Co., Woods Gulch, Rattlesnake Recreation Area	Cavity nest with two eggs, female and eggs photographed in cavity, eggs hatched, fate of young unknown.
01 June – 01 August 2010[b]	Missoula Co., Marshall Canyon	Cavity nest with three eggs, eggs hatched, adults and young banded and photographed, same nest tree and cavity used in 2008 ORI breeding record, fate of young unknown.
01 June – 01 August 2010[b]	Missoula Co., Marshall Canyon	Cavity nest with two eggs, eggs hatched, adults and young banded and photographed, fate of young unknown.

01 July – 31 August 2010	Missoula Co., Marshal Canyon	Cavity nest with two eggs, only one egg hatched, adults and young banded and photographed, confirmed July egg laying, fate of young unknown.

[a]Montana Natural Heritage Program records
[b]Owl Research Institute records
*Unacceptable records of direct evidence of breeding
**Only known ground nest for Flammulated Owls

APPENDIX B

NARRATIVE SUMMARIES OF FIELD SEASONS

FIELD SEASON 2009

We conducted 13 full surveys of 10 routes, replicating 2 routes three times and 8 routes only once. Six routes consisted of 10 survey points. The other four routes consisted of 5, 6, 7, and 12 survey points, respectively. Of 90 total survey points, we detected FLOWs at 12 points. Detections occurred because owls either spontaneously sang or responded to playback survey. Most detections occurred on SW- to SE-facing slopes, on the upper halves of ridges, and in open-understory ponderosa pine and Douglas fir forests. We did detect one FLOW on a north-facing slope in larch-Douglas fir habitat. The number of visits to detection points ranged from 3-10, the number increasing at sites with greater FLOW activity (i.e. sites with pairs). At 2 points (Rattlesnake Recreation Area, Sawmill Gulch), we detected FLOWs only once, despite continued searches and surveys in June and July.

At 10 points, FLOWs were present all summer. At 6 of these (1 Butler Creek, 2 Woods Gulch/Marshall Canyon, 3 Crazy Canyon) we detected single owls. At 4 of these (2 Butler Creek and 2 Woods Gulch/Marshall Canyon) we detected pairs. We monitored these areas more frequently than those with single owls.

Despite frequent monitoring throughout the breeding season, we found no evidence of eggs, incubating or brooding FLOWs, or nestlings. However, we did observe evidence of breeding activity. In early July, FLOWs copulated and entered cavities of a tree in the Woods Gulch area. Unfortunately, in late July, the tree blew down in a storm. The tree was an old, broken-top, dead ponderosa pine, positioned on a SE-facing slope. It was 24 m in height with a DBH of 81.3 cm. The tree contained 5 cavities. The FLOWs entered three of these, cavities at 16, 20, and 23 m. After the fall, we were able to inspect one of the cavities we observed FLOWs entering and exiting (height 23 m). However, we did not find any nestling carcasses or egg shell fragments. We could not inspect the other two cavities that we observed FLOWs entering and exiting because they were destroyed in the fall.

We were unable to capture adult FLOWs, despite 6 separate attempts at the 4 territories with pairs. During nocturnal surveys, we also detected a Short-eared Owl (1), Common Poorwills (2), Northern Saw-whet Owls (3), and Great Horned Owls (3).

FIELD SEASON 2010

We conducted 13 full surveys of 6 routes. We replicated 2 routes 4 times each, 3 routes twice each, and 1 route only once**.** Four routes consisted of 10 survey points, one route 6 survey points, and one route 12 survey points. Of 58 total survey points, we detected FLOWs at 15.

Our earliest detection was a FLOW that responded to playback on 12 May. The earliest that we detected FLOWs via passive listening was 16 May. After this time, we detected FLOWs because they either spontaneously sang or responded to playback. Once FLOWs began singing in mid-May, we usually detected them by passive listening. Breeding FLOWs typically sang less frequently after egg laying, similar to reports by Reynolds and Linkhart (1987b) and Barnes and Belthoff (2008). Most FLOW detections (14) occurred on SW- to E-facing slopes, on the upper halves of ridges, and in open-understory ponderosa pine and Douglas fir forests. We did detect one FLOW on a north-facing slope in Western Larch-Douglas fir habitat.

Our data regarding differences in passive listening and listening-playback surveys is limited; thus it is too early to draw inferences about these approaches. So far, both methods appear to be effective, and any difference in their timing does not seem to matter. However, we need more seasons of simultaneous survey, using both methods, to clarify results.

Monitoring required considerable effort, and at a few points, extensive hiking. Each night, we monitored one or two detection points, ultimately monitoring 12 of the 15 detection points throughout summer. The number of visits to a point ranged from 3-10, the number increasing with the degree of FLOW activity (i.e., sites with pairs). At each point, we mapped all cavity-bearing trees and searched for nests.

At all 12 points that we intensively monitored, FLOWs were present all summer. At 7 of these (4 Crazy Canyon, 2 Sawmill/Curry Gulch, 1 Woods Gulch/Marshall Canyon,) we detected single owls. At 5 of these (5 Woods Gulch/Marshall Canyon) we detected pairs. Of the 5 territories that we detected pairs we located 3 nests. We also attached radio transmitters to 4 adult FLOWs (2 males, 2 females). A description of activities at each nest site follows:

Nest 1. We discovered one nest during searches around song trees. Due to the height of the cavity and logistical challenges, we were unable to catch the male until later in the nesting season, in mid-July. By then the chicks were almost ready to leave the nest. As a result, it was too late to gain substantive foraging information via radio transmitter. Although we were able to attach a radio transmitter to the female, it fell off in the cavity, keeping us from tracking her post-incubation and brooding movements. We were able to climb to the nest using top-rope climbing techniques and lineman's gear. We banded three young. We also measured entrance dimensions, depth, and internal diameter of the nest cavity.

Nest 2. At this territory we captured, banded, and attached a radio transmitter to a FLOW with a brood patch, indicating a female. We used her radio signal to locate the nest tree. Unfortunately, she shed her transmitter before we could gain any information about her post-incubation and brooding movements. However, we also captured and attached a radio to the male at this nest. We were able to climb to the nest using a ladder and band two young. We also measured entrance dimensions, depth, and internal diameter of the nest cavity.

Nest 3. At a third territory, we radio tracked a male FLOW for nearly two weeks, observing numerous instances of courtship with a female. We also obtained some information about roosting habitat. However, the male plucked off the transmitter before egg laying, preventing us from obtaining foraging information related to productivity for the nest. We were able to climb to the nest cavity using a ladder and band one young. Although this nest contained two eggs, one did not hatch. We also measured entrance dimensions, depth, and internal diameter of the nest cavity.

APPENDIX C

CAVITY BEARING TREE CHARACTERISTICS IN TWO BREEDING TERRITORIES

NEST #1 and #2 TERRITORY

At Nest #1 and #2 territory we located 4 cavity bearing trees containing 10 cavities. We located two species of cavity bearing trees; ponderosa pine and Western Larch (*Larix occidentalis*). Ponderosa pine represented 75% (3) of the trees that we located. Nine of the 10 cavities were usable for FLOWs as they met our six "minimally acceptable" criteria (see Methods). Median height of cavity bearing trees not including nest tree was 16.8 m (n = 4; range 5.2 m (20.4 – 15.2 m)). Median DBH of cavity bearing trees not including nest tree was 69.2 cm (n = 4; range = 68.5 cm (116.8 – 48.3 cm)). Median height of cavities not including nest cavity was 10.35 m (n = 10, range = 7.6 m (13.7 – 6.1 m)). Half (5) of the cavities that we located were bearing E-S aspect on trees.

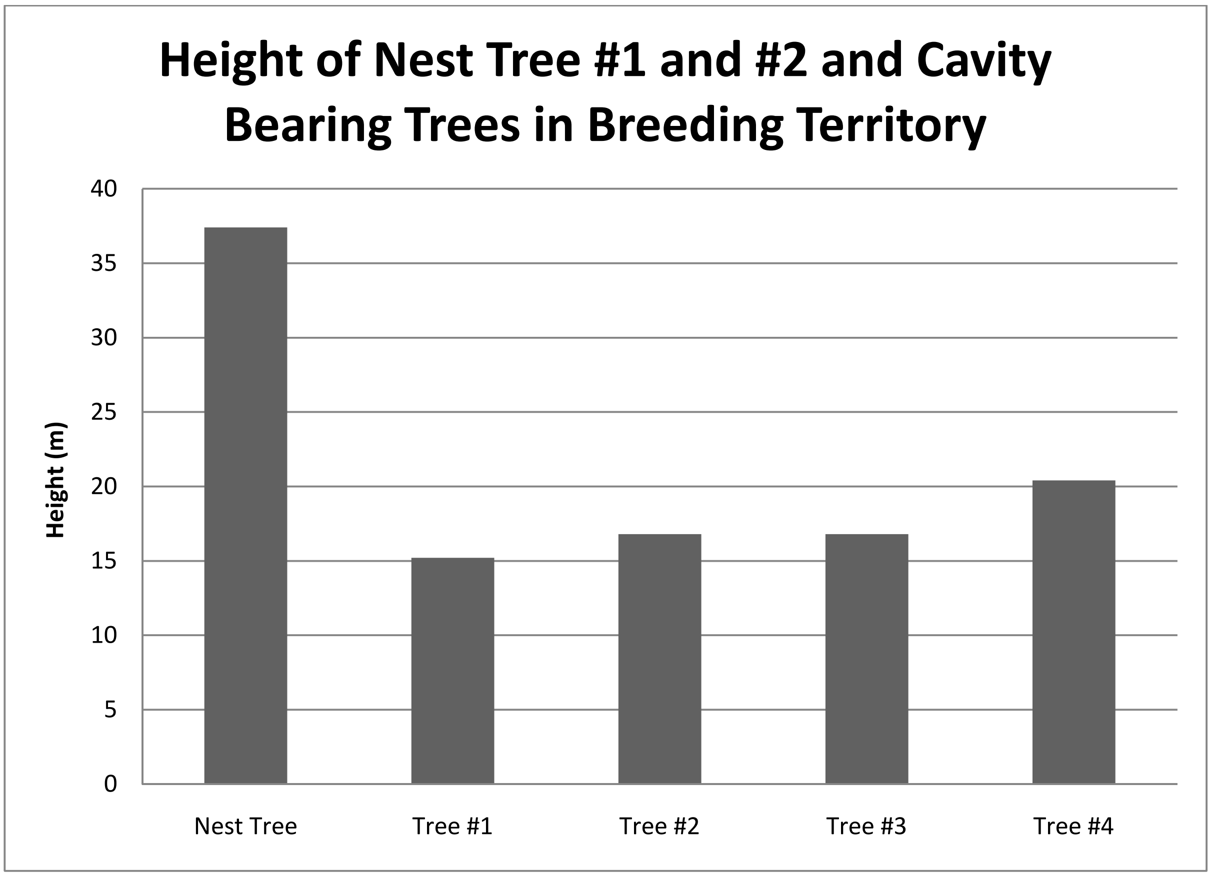
Summary of Cavity Bearing Tree Characteristics at Nest #1 and #2 Territory

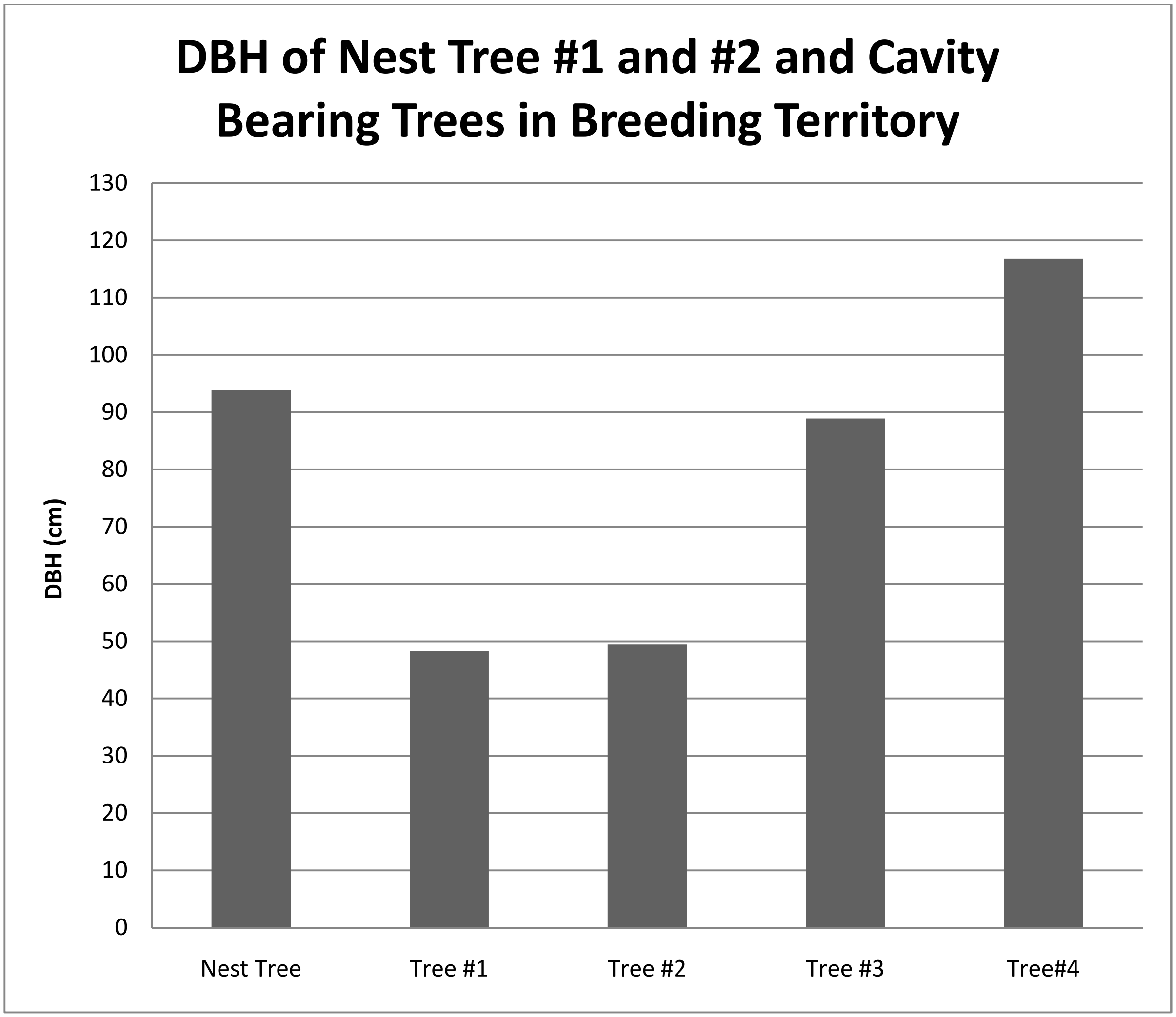
	Species	**Live or Dead**	**Height (m)**	**DBH (cm)**	**Position**	**Aspect**	**Configuration**	**Total Cavities**
Nest Tree	PIPO	Dead	37.4	93.9	Slope	E(SE)	Spike-top	1
Tree #1	PIPO	Live	20.4	116.8	Ridge	W(SW)	Spike-top	1
Tree #2	PIPO	Dead	15.2	88.9	Slope	E(SE)	Broken-top	5
Tree #3	PIPO	Dead	16.8	48.3	Slope	NW	Forked spike-top	2
Tree #4	LARCH	Live	16.8	49.5	Slope	NW	Broken-top	2

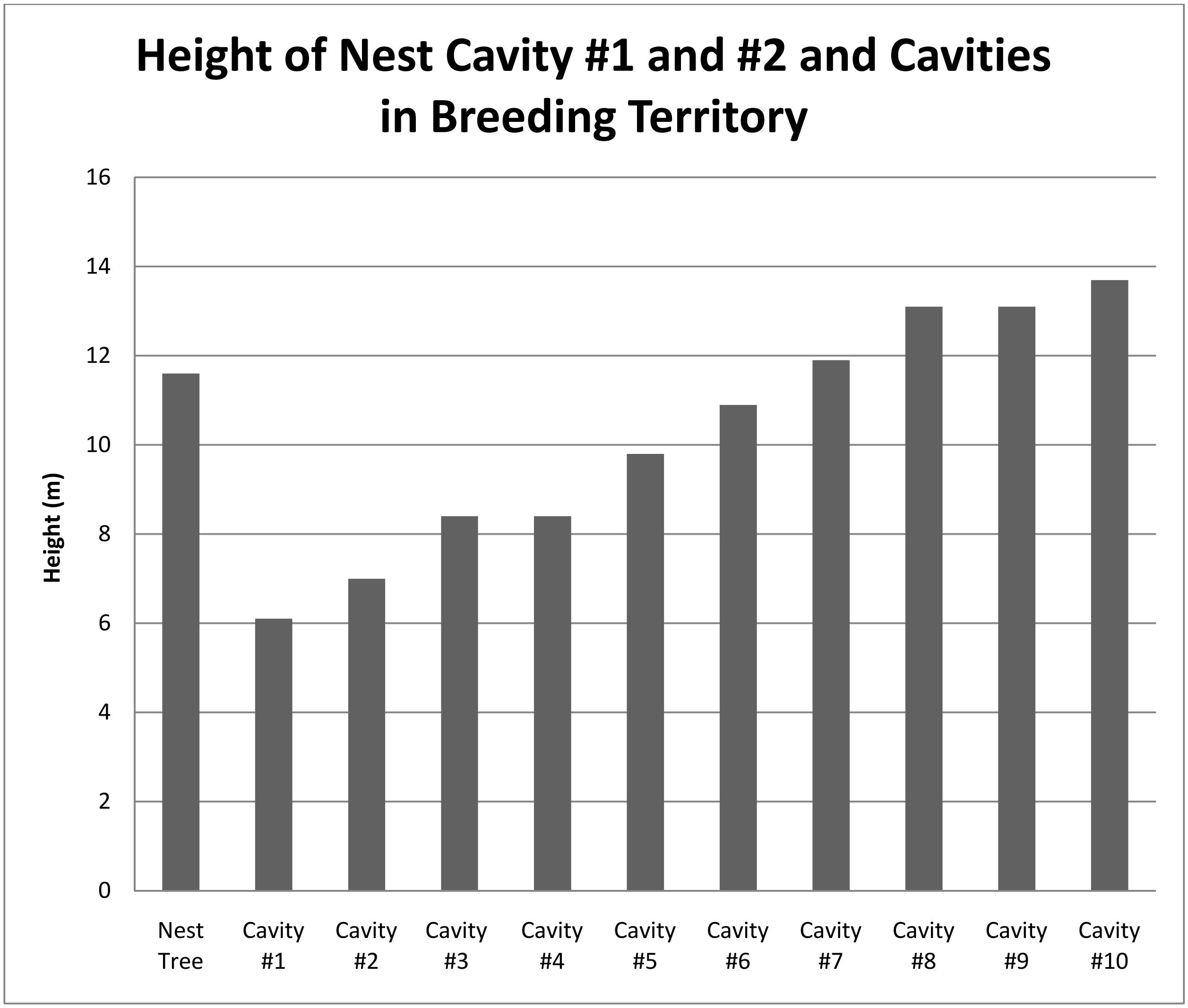
Summary of Cavity Characteristics in Nest #1 and #2 Territory

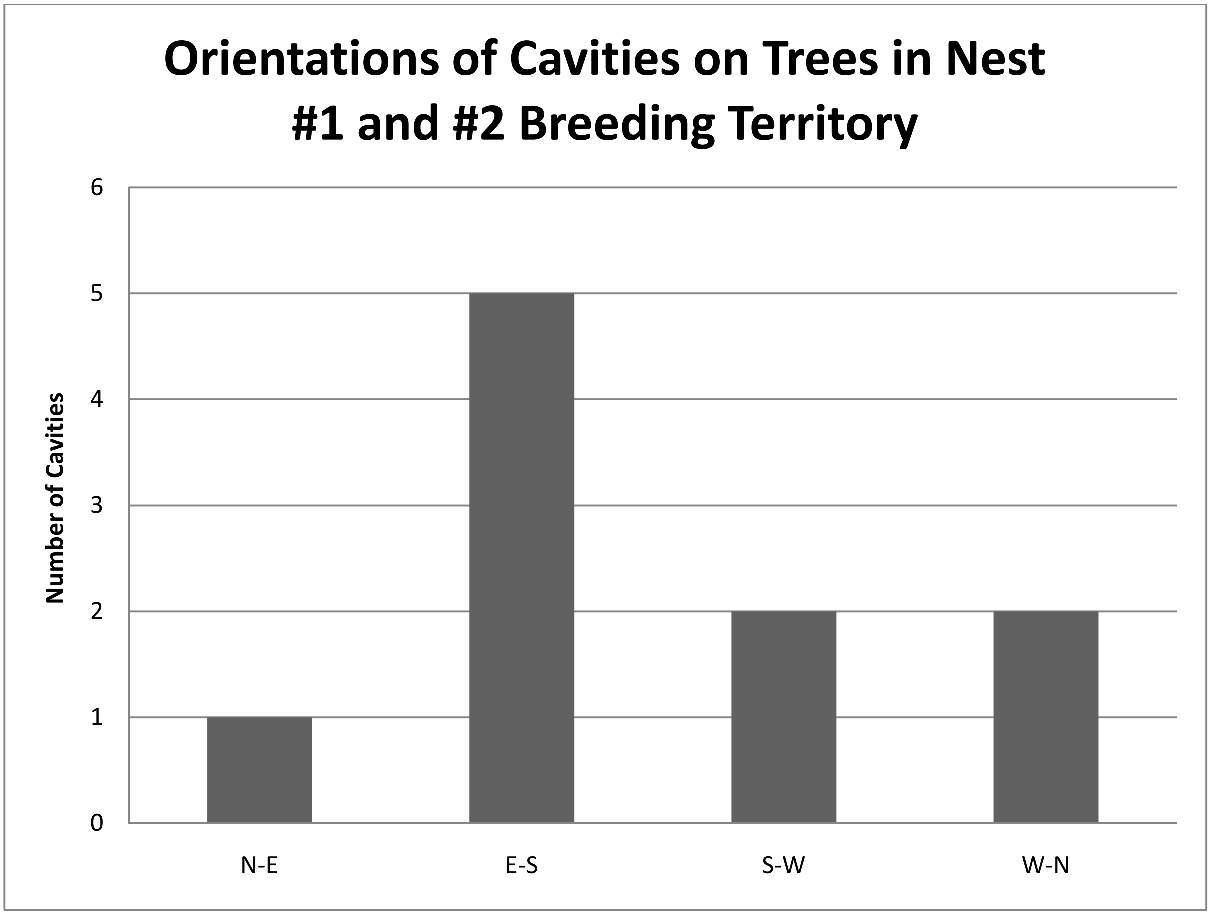
	Height (m)	**Orientation (bearing) on tree**	**Usable (Y/N)**
Nest Cavity	11.6	S	Y
Cavity #1	6.1	NE	Y
Cavity #2	7	S	Y
Cavity #3	8.4	E(SE)	Y
Cavity #4	8.4	E(SE)	N
Cavity #5	9.8	E(SE)	Y
Cavity #6	10.9	E(SE)	Y
Cavity #7	11.9	NW	Y
Cavity #8	13.1	NW	Y

Cavity #9	13.1	SW	Y
Cavity #10	13.7	W	Y




DBH of Nest Tree #1 and #2 and Cavity Bearing Trees in Breeding Territory
DBH (cm)
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Nest Tree
Tree #1
Tree #2
Tree #3
Tree#4


Height of Nest Cavity #1 and #2 and Cavities in Breeding Territory
Height (m)
16
14
12
10
8
6
4
2
0
Nest Tree
Cavity #1
Cavity #2
Cavity #3
Cavity #4
Cavity #5
Cavity #6
Cavity #7
Cavity #8
Cavity #9
Cavity #10



Orientations of Cavities on Trees in Nest #1 and #2 Breeding Territory
Number of Cavities
0
1
2
3
4
5
6
N-E
E-S
S-W
W-N

NEST #4 TERRITORY

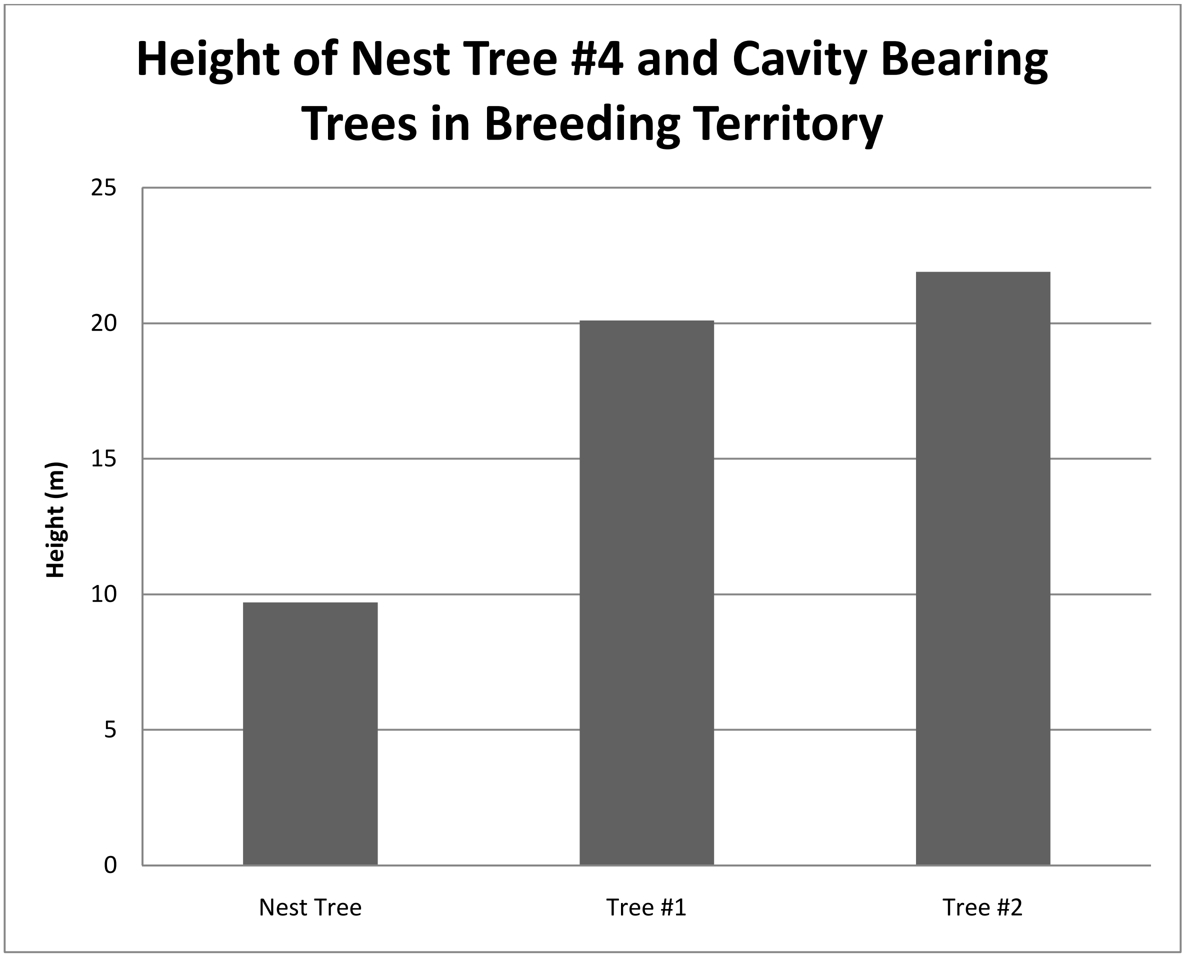
At Nest #4 territory we located two cavity bearing trees containing 4 cavities. Both trees were dead ponderosa pines. All 4 cavities were usable for FLOWs. Including the nest tree, median height of cavity bearing trees was 20.1 m (n = 3; range = 12.2 m (21.9 – 9.7 m)). Median DBH of all three trees was 69.9 cm (n = 3; range = 35.7 cm (82.6 – 46.9 cm)). Median height of cavities not including nest cavity was 8.7 m (n = 4; range = 4.8 m (10.9 – 6.1 m)).

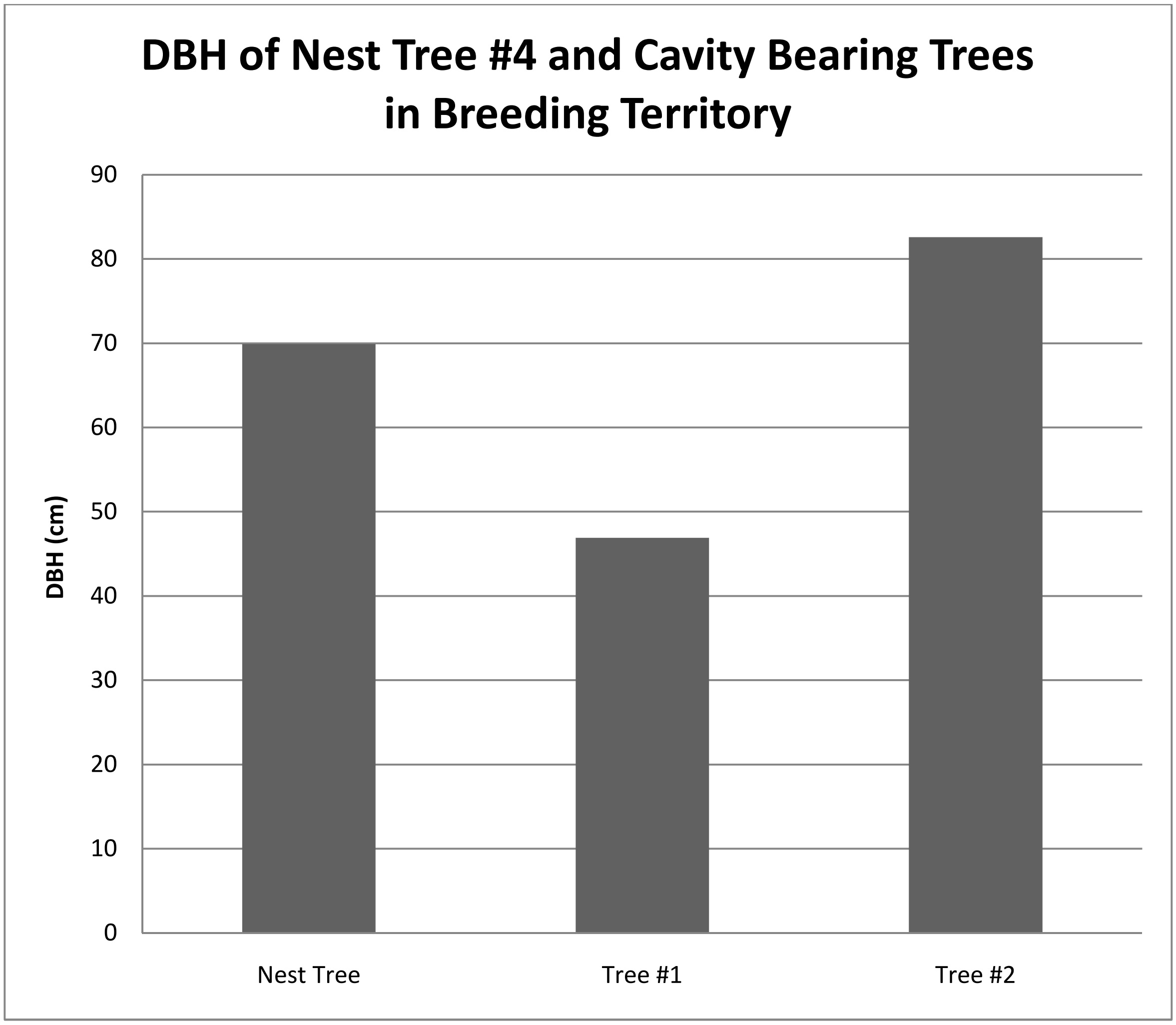
Table 5. Summary of Cavity Bearing Tree Characteristics at Nest #4 Territory

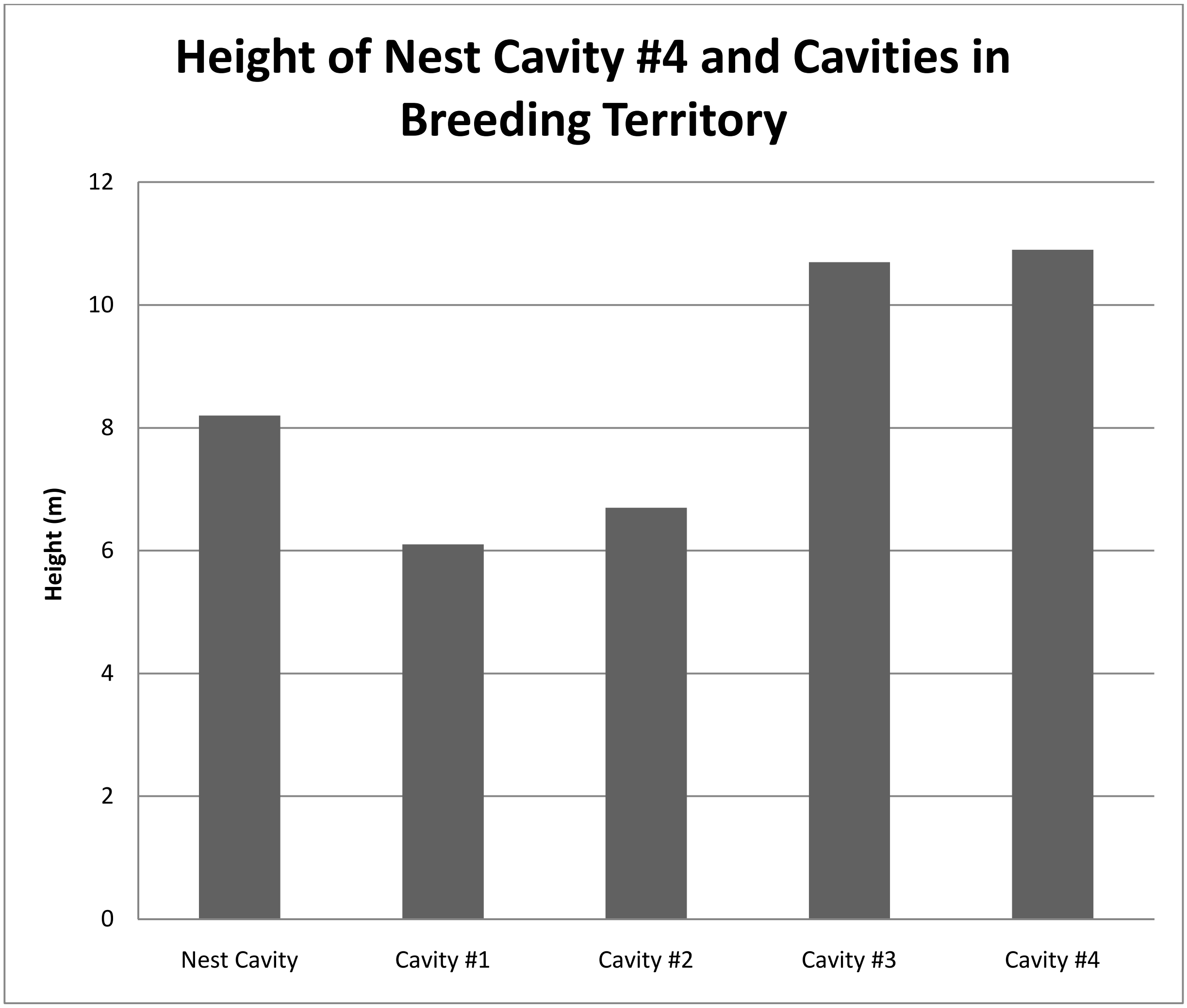
	Species	**Live or Dead**	**Height (m)**	**DBH (cm)**	**Position**	**Aspect**	**Configuration**	**Total Cavities**
Nest Tree	PIPO	Dead	9.7	69.9	Slope	SE	Broken-top	1
Tree #1	PIPO	Dead	20.1	46.9	Slope	E(SE)	Spike-top	2
Tree #2	PIPO	Dead	21.9	82.6	Slope	SE	Broken-top	2

Table 6. Summary of Cavity Characteristics in Nest #4 Territory

	Height (m)	**Orientation (bearing) on tree**	**Usable (Y/N)**
Nest Cavity	8.2	SE	Y
Cavity #1	6.1	S(SE)	Y
Cavity #2	6.7	S(SE)	Y
Cavity #3	10.7	W	Y
Cavity #4	10.9	W	Y


Height of Nest Tree #4 and Cavity Bearing Trees in Breeding Territory
25
20
15
10
5
0
Height (m)
Nest Tree
Tree #1
Tree #2


DBH of Nest Tree #4 and Cavity Bearing Trees in Breeding Territory
DBH (cm)
0
10
20
30
40
50
60
70
80
90
Nest Tree
Tree #1
Tree #2


Height of Nest Cavity #4 and Cavities in Breeding Territory
Height (m)
0
2
4
6
8
10
12
Nest Cavity
Cavity #1
Cavity #2
Cavity #3
Cavity #4