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NEST SITE CHARACTERISTICS OF LEWIS'S WOODPECKER (MELANERPES LEWIS) IN RIPARIAN SYSTEMS OF WESTERN MONTANA

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NEST SITE CHARACTERISTICS OF LEWIS'S WOODPECKER (MELANERPES LEWIS) IN RIPARIAN SYSTEMS OF WESTERN MONTANA

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Environmental Studies

Nest Site Characteristics of Lewis's Woodpecker (*Melanerpes lewis*) in Riparian Systems of Western Montana

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Abstract

The Lewis's Woodpecker (*Melanerpes lewis*) is known to breed in ponderosa pine, cottonwood riparian, aspen, and burned conifer forest types, but is declining in much of its range throughout the U.S. and is listed as a Level II Species of Concern in Montana. In western Montana, Lewis's Woodpeckers commonly breed in riparian bottomlands, but information on characteristics of their preferred nesting habitat within these areas is lacking. I studied nesting habitat use by Lewis's Woodpeckers in two important breeding areas in cottonwood-dominated riparian forest along the Clark Fork and Bitterroot rivers in western Montana. I found 55 nests during the summer of 2012, and measured vegetation characteristics around 38 of those nest sites as well as 30 randomly located sites within the same forests. My main objective was to examine nest-tree, local, and landscape habitat characteristics of Lewis's Woodpeckers at nest sites and random sites to determine whether sites used in western Montana river systems were a nonrandom subset of bottomland conditions and whether used conditions were similar to those reported from other parts of their geographic range. Logistic regression models were developed based on used sites and available sites within the study area. Results showed that Lewis's Woodpeckers used larger snags in areas with relatively high percent shrub cover and relatively high snag density per hectare. Snags provide perches to forage from, cavities for nesting, and an open canopy, while the shrub understory supports arthropod prey. From a landscape perspective, Lewis's Woodpeckers nest sites were closer to agricultural fields than were randomly located sites, suggesting adjacent fields were preferred. Information from this study will be disseminated to land managers and private landowners, recommending desired vegetation conditions to benefit this species, including snag retention. To ensure that conditions suitable for Lewis's Woodpecker are maintained in perpetuity will also require management of the river system in its entirety.

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Introduction

Problem Statement & Background

Lewis's Woodpeckers (*Melanerpes lewis*) have experienced range-wide population declines due to degradation of habitat (Tobalske 1997). They are listed by Partner's In Flight as a priority species across their range, and in Montana as a Tier II Species of Concern. Locally, Montana Audubon identified Lewis's Woodpeckers as an important species when designating the Bitterroot and Clark Fork rivers as Important Bird Areas (IBA). This species was chosen by Montana Audubon, in part, because the river habitats of western Montana are known to support concentrated breeding populations of Lewis's Woodpeckers where nest sites are available. Information about nesting habitat requirements is necessary to effectively manage these river habitats for Lewis's Woodpeckers, yet such information does not exist in Montana.

Throughout the western U.S., open-forest habitats, including cottonwood bottomland, ponderosa pine, and burned pine forest habitat provide the most important breeding habitat for Lewis's Woodpecker (Bock 1970, Linder 1994, Vierling 1997). Within the family Picidae, Lewis's Woodpeckers are uniquely adapted for aerial foraging, so insect abundance is of critical importance, as are prominent perch trees from which they sally to forage for aerial insects. Often described as an opportunistic species, Lewis's Woodpeckers take advantage of abundant food sources and plentiful nest sites, and often occur in clustered or semi-colonial territories (Currier 1928, Bock 1970, Siddle and Davidson 1991). More recently, Lewis's Woodpeckers have been called "burn specialists" because of their relative abundance in post-fire habitat; consequently, many habitat studies of Lewis's Woodpeckers have been conducted in burned pine forests in the West (Linder and Anderson 1998, Saab et. al. 2004, Gentry and Vierling 2007). Studies in aspen habitat in Idaho (Newlon 2011) and Utah (Vande Voort 2011) and in cottonwood habitat in Colorado (Vierling 1997) have also been conducted, but to date, very little replication of habitat studies has taken place in either post-fire or cottonwood bottomland habitats.

Linder and Anderson (1998) described Lewis's Woodpecker macrohabitat and microhabitat features in burned ponderosa pine forests of Wyoming where they found coarse woody debris, leaflitter, presence of perches, and lower canopy cover to be important factors for nest selection. Vande Voort (2011) found that open canopy cover and large trees were important in unburned aspen forest for nesting Lewis's Woodpeckers. Others have suggested that a shrub understory layer is important (Bock 1970, Jackman 1975), as this feature promotes insect production, but litter and coarse woody debris may also support insect populations (Linder and Anderson 1998). Since no formal studies have been conducted in Montana on Lewis's Woodpeckers nest site characteristics, I collected vegetation data that included some of the variables that we know to be important from existing literature and added several other variables I believed might be important to nesting Lewis's Woodpeckers.

The management of river systems remains a controversial topic. Managers, biologists, and land planning groups are forced to prioritize ecological and social needs simultaneously (Fletcher and Hutto 2008). Despite increasing awareness of their ecological significance, riparian areas continue to be affected by development and dewatering. In the Rocky Mountains and Great Plains regions the loss of riparian habitat has been significant; 90-95% of the cottonwood-willow riparian ecosystems of the plains and lower foothills has been eliminated (Johnson and Carothers 1981). The loss of this habitat is a result of urbanization, agriculture, logging, and construction of dams (National Research Council 2002). Further, all considerations of riparian forest dynamics including growth, seedling recruitment, survival, mortality, and snag retention, are managed or affected by humans on most rivers today. Lewis's Woodpeckers are, like other species, subject to the effects of human-influenced landscapes.

Ecologists and managers are increasingly aware of the need to manage for snags in all forest types for cavity-nesting birds, insects, and mammals. As a cavity-nester, Lewis's Woodpeckers require the presence of dead or partially dead trees in various stages of decay (Tobalske 1997). Lewis's Woodpeckers are secondary excavators, meaning they rely upon previously excavated cavities, naturally occurring cavities, or they may excavate their own cavity in decaying trees when the wood is suitably soft. In my study area, they nest in snags along the Clark Fork and Bitterroot rivers where much of the land is privately owned. There, snags are often removed for aesthetic purposes, leading to inadvertent mismanagement of habitat for riparian specialists.

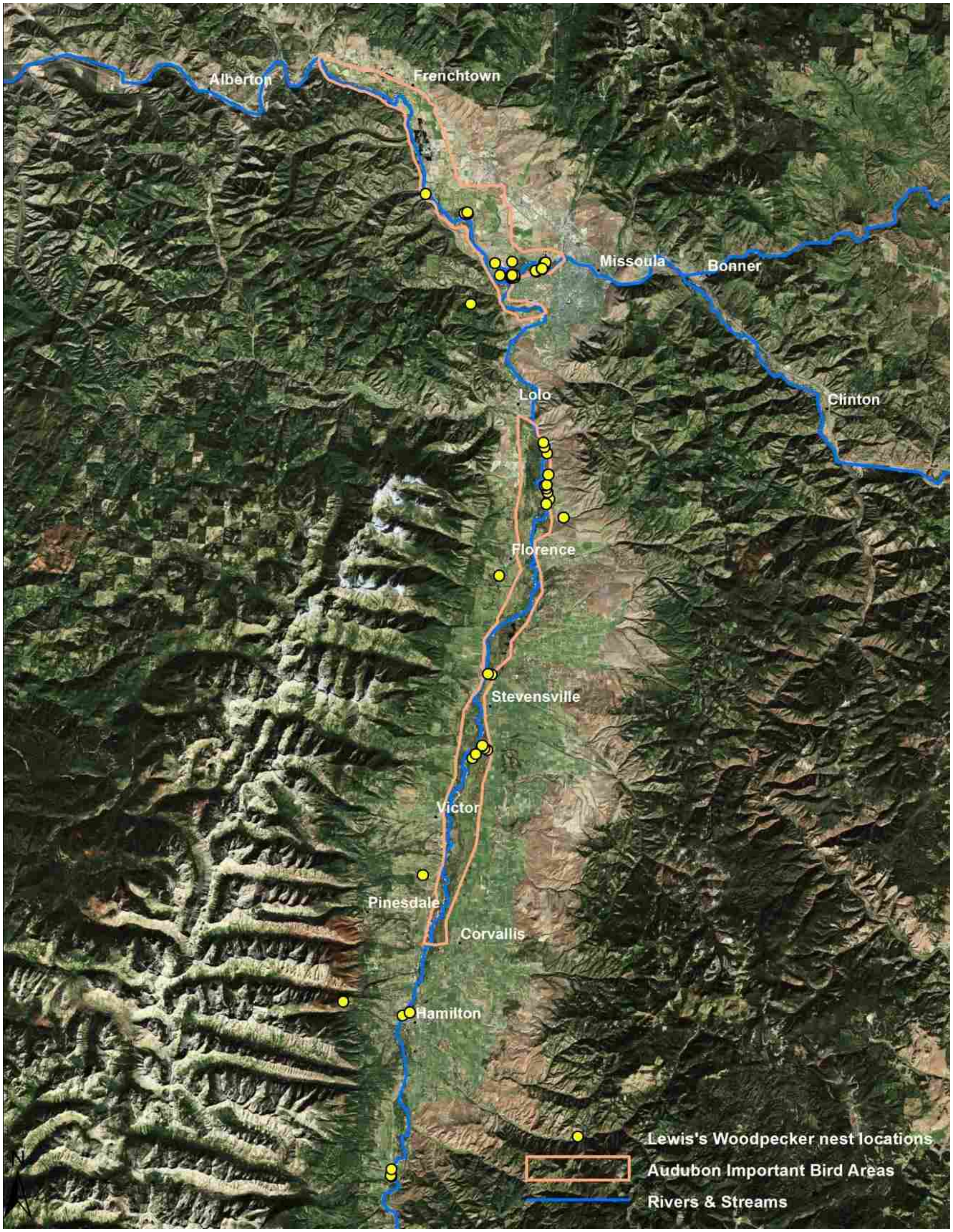
Documenting information that will add to our existing knowledge of habitat needs of Lewis's Woodpeckers in Montana is crucially important for effective management of this species. Although information from other studies provides a launching point for identifying characteristics important to Lewis's Woodpecker, their habitat has not been studied in Montana, which is at the northern end of their breeding range. Additionally, Montana's climate and breeding season length may differ from other areas of their range. By collecting information specific to local and landscape habitat needs of Lewis's Woodpeckers, I will provide insight into the ecology of Lewis's Woodpeckers and habitat needs unique to riparian forests of western Montana. Because of pressures from human development and the increased use of our river corridors, investigating the habitat requirements of Lewis's Woodpecker in river bottoms will provide useful information that can help promote effective habitat management in the region.

The objectives of my thesis were to (1) describe nest habitat characteristics at the tree and local scale in unburned riparian forests, (2) determine how and if land type affects nesting habitat selection of Lewis's Woodpeckers at the landscape scale in those forests, (3) document information on nest phenology and nest productivity, and (4) use findings from this study to help inform management decisions and develop conservation strategies in western Montana.

Study Area

I studied nest site characteristics of Lewis's Woodpeckers near Missoula, MT in the Clark Fork-Grass Valley and Bitterroot River Important Bird Areas (as defined by Montana Audubon). Opportunistically, we collected information at nest sites outside of these boundaries, but the study area was confined to the Clark Fork and Bitterroot River corridors (Figure 1). The vegetative community in the study area was dominated by cottonwood (*Populus trichocarpa*) riparian habitat with some mixed cottonwood-pine (*Pinus ponderosa*) stands. The understory consisted of a mix of grasses, forbs, and shrubs including: willow (*Salix spp.*), rose (*Rosa spp.*), snowberry (*Symphoricarpos albus*), chokecherry (*Prunus virginiana*), red-osier dogwood (*Cornus stolonifera*), serviceberry (*Amelanchier alnifolia*), *Ribes spp.*, gray alder (*Alnus incana*), and blue elderberry (*Sambucus nigra L. spp. cerulea*). Elevation ranged from 921 m to 1189 m.

Figure 1. Map of entire study area including Lewis's Woodpecker nest locations in western Montana.



Methods

Nest Searches

We searched for active nest cavities of Lewis's Woodpeckers from May to July of 2012 by visiting known nesting locations and other accessible areas on both public and private lands. We considered a nest to be active if an adult bird was observed excavating or modifying a nest cavity, incubating eggs, brooding young, or feeding young at the nest cavity. We recorded the location of each nest using an E-trex Legend H handheld GPS unit, so we could easily relocate the nest for monitoring and/or vegetation surveys. Approximately 20 of the nests were monitored every 3 to 4 days for productivity, but because sample sizes were low, I did not attempt to statistically analyze these data.

Nest Monitoring

Given the proximity of the study area to several population centers, the interest of local Audubon groups, and the detectability of the species, using volunteers provided an excellent opportunity to collect data using a cost-effective method. Volunteers contributed significantly to this effort, providing many nest locations, plus information on vegetation characteristics, nest phenology and nest productivity. I provided training for volunteers and used a printed protocol that contained basic information on nesting birds, including behavioral cues, nest phenology, and natural history information (see Appendix II). Another form was provided to participants, called "Get a Behavioral Clue", which is authored by Tom Martin and his team at Montana Cooperative Wildlife Research Unit, and provides detailed behaviors of cavity nesting species (http://www.umt.edu/mcwru/personnel/martin/PDF%20Martin/MT%20Aspen%20Protocols/MT%20GET%20A%20BEHAVIORAL%20CLUE.pdf).

Vegetation Measurements

To compare habitat characteristics measured at Lewis's Woodpecker nest sites, I selected 30 random sites within the study area. Random points were generated using Arc GIS version 10 within suitable cottonwood or mixed cottonwood-pine habitat in the floodplain. Random points that were not in suitable habitat, were inaccessible, or that we could not obtain landowner permission to visit were dropped. For each random point we visited, we used the closest tree ≥ 23 cm diameter at breast height (DBH) as the point center. This minimum size requirement was selected based on results from Newlon (1996), where she identified that Lewis's Woodpeckers never nested in trees smaller than 21 cm DBH in her study (n=76). Because a natural cutoff at 23 cm DBH would match existing vegetation protocols, I selected this as a minimum requirement for random trees. The same vegetation measurements were collected at all random sites and nest sites (other than those specific to the nest cavity). Stand-level vegetation data was collected at all sites using a modified version of the Avian Science Center's riverine vegetation protocol: http://avianscience.dbs.umt.edu/projects/documents/Riverinesurveysmethodsmanual_final_002.pdf, which was originally adapted from Martin et al. (1997). Vegetation measures were collected at 4 sub-plots: the point center and 25 m from center at 0, 120, and 240 degrees (Figure 2). Vegetation measures were taken at the 50-m-radius plot to reflect conditions for the local scale, and for each sub-plot, vegetation measures were taken at two scales: within a 5-m plot and an 11.3-m plot. For a list of all vegetation variables measured at nest and random sites, see Table 1.

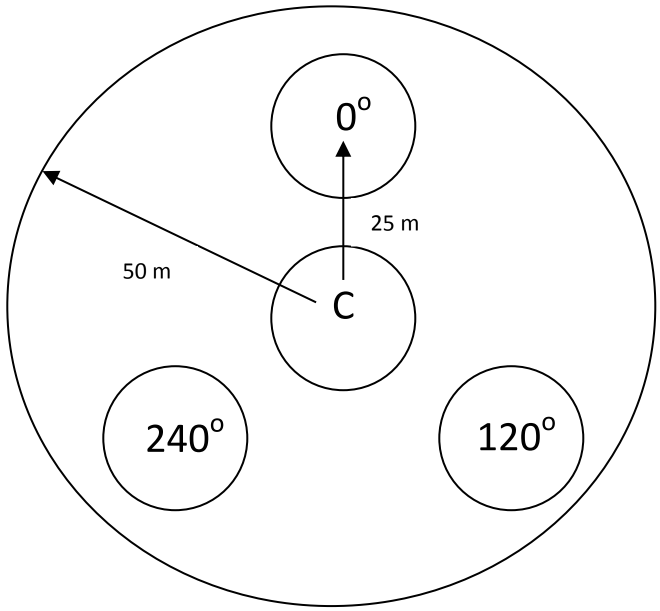


Figure 2. Diagram depicting how plots were set up to measure stand level habitat characteristics at Lewis's Woodpecker nest and random sites in 2012.

I defined the nest-tree scale as measurements at the nest tree (or random point center), local-scale as measurements within 50 m of the nest tree, and landscape-scale as measurements within 200 m and 1 km of the nest tree.

To aid in explaining selection at the nest-tree scale, I collected additional measurements at the nest tree including tree height, tree size (DBH), cavity height, cavity orientation, tree condition, and percent dead if the tree was in a dying state. I used a method developed by Thomas (1979) to assess tree condition: trees were categorically assessed by their stage of decline (see Appendix I).

I collected additional information on snags within 50-m of the nest sites, that allowed me to investigate differences in used versus available nest sites. I recorded tree species and tree DBH for all large snags within the 50-m plot. Large snags were defined as ≥ 23 cm DBH and considered to be at least 25% dead. Bock (1970) and others (Saab and Dudley 1996) describe Lewis's Woodpeckers as weak excavators; they prefer dead or decaying wood for excavation, and also re-use cavities excavated by other woodpecker species. Although it has not been well studied, it is thought that as an evolutionary tradeoff associated with the development of aerial foraging ability, Lewis's Woodpeckers lost some of the cushioning in their heads that other woodpeckers possess (Tobalske 1997). For this reason, I focused my research efforts on dead and decaying trees.

Landscape-scale measures were calculated in ArcGIS 10. Around all nest and random points, a 1-km buffer was drawn, which is the area that defines the home range sizes of most songbirds, as well as some woodpeckers (Dixon and Saab 2000). Additionally, a 200-m buffer was drawn to investigate habitat conditions at a scale more tightly associated with the nesting area. Within the 1-km and 200-m buffers, all riparian areas were hand-digitized using the best available aerial imagery. Riparian vegetation is often categorized incorrectly using remotely sensed classification schemes, so to ensure the most accurate measures for my analyses I hand-digitized all riparian habitats using high-resolution color-infrared aerial imagery. Riparian habitat (for the purpose of this analysis) was described as the plant community associated with the river corridor consisting of shrubs and trees and included small, natural openings within vegetation. The riparian vegetation zone was generally narrow, except for areas where the river was braided, in which case the riparian zone was much wider. I measured the distance from nest and random trees to the nearest agricultural areas, defined as areas with presence of irrigated or dryland fields, livestock, or agricultural structures and equipment. Distance to urban areas was measured from nest and random sites to areas with a density of greater than 1 unit/39.9 acres. The urban density was extracted from the 2000 U.S. Census dataset for housing units made available on Montana Fish, Wildlife, and Parks website.

Table 1. Description of cavity, tree, stand, and landscape variables that were collected at nest sites (n=38) and random sites (n=30).

Variable	Description
Tree	
Species	Tree species
DBH	Tree diameter at breast height, in cm
Height	Tree height, in m
Health	Categorical measure of 1-9
% dead	If dying tree, % dead
Cavity	
Height	Cavity height, in m
Orientation	Cavity orientation, in degrees
5-m plot	*from 4 subplots*
Shrub cover	% cover using ocular estimation
Shrub height	Average height of shrubs combined, in m
Grazing intensity	None, low, moderate, high
Tree seedling density	Tree seedlings ≤ 8 cm DBH
11.3-m plot	*from 4 subplots*
Small tree density	Trees 8-23 cm DBH, density/ha.
Medium tree density	Trees 23-38 cm DBH, density/ha.
Large tree density	Trees > 38 cm DBH, density/ha.
Mature tree density	All trees and Snags > 23 cm DBH, density/ha.
50-m plot	
Snag density	Snag density/ha. (≥ 23 cm DBH)

Snag species	Tree species of each large snag
Snag DBH	Snag diameter at breast height, in cm
Landscape scale	
Amount of riparian area within 1K	Total area, in ha.
Amount of riparian area within 200m	Total area, in ha.
Distance to urban area	From nest/random location to nearest edge, in m^2
Distance to agricultural area	From nest/random location to nearest edge, in m^2

Analytical Methods

I compared used and available habitat to determine selection by Lewis's Woodpeckers (Manly et. al. 2002) and to address the following null hypothesis:

H_o: There are no differences between variable values measured at used and available sites.

Analyses and descriptive statistics were conducted using R (version 2.15.2) and SPSS (version 21). Comparisons of used and available sites for all vegetation variables were done using t-tests, or Mann-Whitney U tests when assumptions of normality were violated. Results demonstrate similar conclusions using either test in all but one case (percent shrub). I used logistic regression to identify habitat characteristics that distinguished used nest sites from available sites. I developed an *a priori* p-value threshold of $P < 0.10$ for removal of terms.

For all models, I first determined whether variables were correlated. For the nest tree scale I used Spearman's rank correlation ($r^2 \geq \pm 0.65$), and dropped all but tree DBH to explain selection at this scale. At the local (50-m) scale, Mature Tree Density was correlated with both Medium Tree Density and Large Tree Density. I chose to keep Mature Tree Density, since it provided a better overall measure of the total number of larger trees at the plot level. No variables at the landscape scale (see Table 1) were correlated, so all were included in the logistic regression analysis. When multiple variables were included in the logistic regression model, I removed variables one at a time until I found the model with the best fit. Logistic regression analysis was conducted at each of three scales: microhabitat, local, and landscape.

I used stepwise discriminant function analysis (DFA) to reveal which combination of the vegetation variables best discriminated used sites from random sites (McGarigal et. al. 2000). I then used standardized canonical discriminant function coefficients to demonstrate which variables explained the maximum differences between the pre-specified groups. Classification results indicate how well the DFA classifies the observations into groups and can be used to interpret how clearly the groups are classified based on the correct number of classifications or misclassifications.

For snag use versus availability, I took into account the random effect of plot-level variation within sites using the function glmmPQL, which is a generalized linear mixed model, from the MASS package in R (Venables and Ripley 2002). After conducting the analysis, I determined that there was little variation within plots, and continued the analysis using a traditional generalized linear model in R.

Results

Phenology

Nest initiation date varies widely in this species throughout its range (Tobalske 1997) and tends to begin later in the northern part of the range. Weather and, presumably, nest site competition also affect nest initiation. We found most Lewis's Woodpecker nests during the nestling phase, when adults are making frequent trips to the cavity with food deliveries, so initiation of nesting was determined for very few nests.

Most Lewis's Woodpecker nests fledged in mid-July, with a range of 9 July to 4 August. The nest on the Sapphire Ranch, which fledged on 4 August, had very small chicks on 17 July, which is unusual given that most other nests with young had fledged or were very close to fledging. Lewis's Woodpeckers are known for attempting just a single brood each season, but it may be possible that if their nests fail early enough in the season, they will attempt a second nest. A second nest attempt during the nesting season will affect the timing of fledging, potentially causing the fledged young to be at a disadvantage if the timing does not coincide with the fruit and insect food sources they rely on after fledging (Martin 1987, Daan et. al. 1988). This Sapphire Ranch nest was an outlier in terms of timing, however, and the majority of nests fledged in mid-July when food availability is abundant. Table 2 provides dates of nest initiation, incubation, nestling, fledging, along with nest success, and a minimum number of young we observed for all 32 nests, if known.

Productivity

During the 2012 breeding season, I monitored 55 Lewis's Woodpecker nests in the Clark Fork and Bitterroot river valleys, and attempted to monitor 32 nests for productivity. Of the 32 nests, fate was determined for 18. Sixteen nests (89%) were successful, meaning that they fledged at least one chick. Of the 16 successful nests, productivity averaged 3.06 birds fledged per nest with a range of 1 to 6 birds.

Table 2. Phenology and productivity data from Lewis's Woodpecker nests.

Lewis's Woodpecker nest observations						
Nest ID	**Initiation**	**Incubating**	**Nestling**	**Fledging**	**Nest Success**	**Min # of young**
MPG 01	5/30/2012	6/7/2012	7/2/2012	7/18/2012	Success	1
MPG 04				8/4/2012	Success	1
MPG 05			7/11/2012	7/16/2012	Success	1
Pump slough 2			7/11/2012	7/23/2012	Success	2
MPG 06					Unknown	-
MPG 07				7/18/2012	Success	4
MPG 08				7/12/2012	Success	1
Water treatment plant	5/7/2012		7/8/2012	7/17/2012	Success	4
Adirondack Ave.				7/22/2012	Success	2
Sapphire Ranch 2			7/20/2012		Unknown	-
MPG 11			7/12/2012		Unknown	-
MPG 10	5/18/2012	6/22/2012	7/20/2012		Unknown	-
BS 05			7/14/2012		Unknown	-
BS 03			7/14/2012		Unknown	-
BS 04			7/14/2012		Unknown	-
BS 06			7/14/2012		Unknown	-
N47			6/18/2012		Unknown	-
N36			6/18/2012		Failed	-
N38			6/18/2012	7/12/2012	Success	4
N42			6/27/2012	7/9/2012	Success	5
N31			6/27/2012	7/17/2012	Success	4
N56			6/27/2012	7/23/2012	Success	6
N58			6/27/2012	7/10/2012	Success	5
N41			6/28/2012	7/16/2012	Success	4
N34			6/28/2012		Unknown	-
N43		6/12/2012			Failed	-
TS 02			7/11/2012	7/23/2012	Success	4
LM 01	6/7/2012	6/28/2012	7/6/2012		Unknown	-
LM 02		6/15/2012	6/28/2012	7/23/2012	Success	1
N27	6/19/2012	7/3/2012	7/15/2012		Unknown	-
N26		7/3/2012	7/11/2012		Unknown	-
Sapphire Ranch 1			7/15/2012		Unknown	-

Nest-tree Selection

In general, Lewis's Woodpeckers used large trees for nesting ($\bar{x}$ = 76.74 cm), and they tended to nest in dead or dying trees. Lewis's Woodpeckers exhibit strong nest site fidelity, or philopatry (Bock 1970). When the birds find a suitable nest site, it may be used from year to year either by the same individuals or by another Lewis's Woodpecker pair. Although individuals in this study were not marked, we observed the use of the same nest trees in both 2011 and 2012 in several locations, suggesting a level of nest site fidelity consistent with that reported in existing literature.

The nest tree species was recorded for 40 of 55 nests found in the study area. Thirty-three Lewis's Woodpecker nests (82.5%) were in black cottonwood (*Populus trichocarpa*) and seven nests (17.5%) were in ponderosa pine (*Pinus ponderosa*). Tree species that Lewis's used did not reflect the availability of those species and cottonwood, in particular, was used more than expected (χ^2 = 11.63, df = 4, P = 0.02) (Figure 3). In my study, tree height and tree health did not differ between nest and random trees, but tree DBH was significantly greater in used than in unused trees (P < 0.003) (see Table 3).

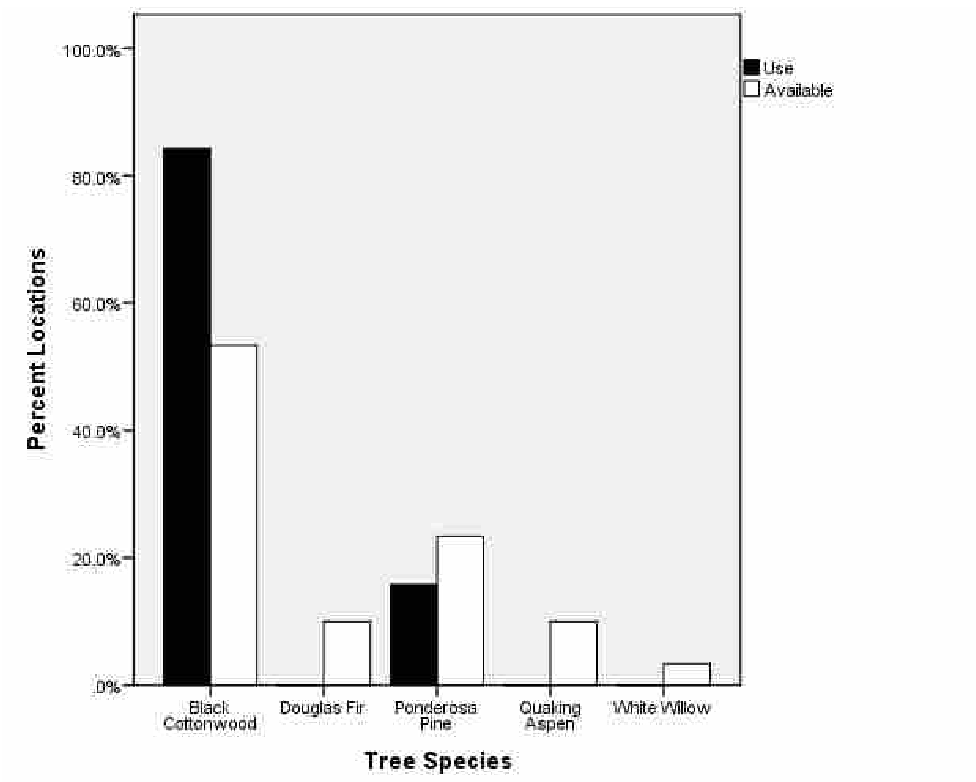


Figure 3. Use and availability of tree species for Lewis's Woodpeckers in the Clark Fork and Bitterroot river valleys of western Montana, 2012.

I expected to find a significant difference in tree health (i.e., live, dead, or dying condition) between nest and available trees, given that these secondary excavators have a preference for dead or dying nest trees. Surprisingly, I did not find a significant difference (see Table 3); however, Lewis's Woodpecker nests were never found in a 100% live tree (n = 55). On two occasions during the study season, active Lewis's Woodpecker nests failed due to a decayed tree (or decayed limb of a tree) being blown down during a thunderstorm.

Although I recorded orientation of nest cavities, I did not analyze the data to see if nests differed from randomly generated orientations since both Linder (1994) and Vierling (1997) found that orientation did not differ between used and available sites.

Table 3. Lewis's Woodpecker nest tree characteristics at used and available sites.

Nest tree characteristics					
	Used (n=38)		**Available (n=30)**		
Variable	mean	SE	mean	SE	**p-value from t-test***
tree DBH (cm)	76.74	5.16	51.1	3.92	**0.00034**
tree height (m)	17.83	1.05	15.55	1.11	0.143
cavity height (m)	13.37	0.85	-	-	
tree health**	3.0	-	3.0	-	0.7623

* values in **bold** are significant, when α is set at ≤ 0.05

** tree health was measured on a scale from 1-9 (see Appendix I), and was calculated as a median.

Tree height and cavity height were highly correlated (r^2 = 0.88), tree height and tree DBH were correlated (r^2 = 0.71), and tree height and tree health were negatively correlated (r^2 = -0.69). Because several independent variables were correlated, I chose to use only tree DBH in my logistic regression model. According to the logistic regression results, tree DBH (P = 0.002) was associated with Lewis's Woodpecker nest selection (Table 4). According to these results, the odds that a Lewis's Woodpecker uses a tree doubles when size of tree increases from 40 cm to 75 cm.

Table 4. Coefficients and standard errors obtained from a logistic regression of Lewis's Woodpecker use at the nest-tree scale. Residual deviance: 78.41 on 66 degrees of freedom, n=68.

Coefficients:				
	Estimate	Std. Error	z value	p-value
(Intercept)	-2.32972	0.81294	-2.866	0.004
Tree DBH	0.04181	0.0133	3.143	0.002

Snag Use versus Availability

In surveying for Lewis's Woodpecker nests, I observed that they often used what appeared to be the largest tree in the area (as reflected by results presented in Table 4). Using measurements of all snags in the 50-m-radius nest tree plots, I compared used trees with available trees in woodpecker nest plots. After determining that there was no random plot effect in the model, I found that a one cm change in DBH of a snag is estimated to increase the probability of Lewis's Woodpecker use by a factor of 1.02 (Table 4) within used nest plots.

Local Scale

Among the local-scale variables in the 50-m-radius plot, I found snag density and shrub cover to differ significantly between used and available sites (see Table 5). The mean snag density at used sites (7.93 ± 0.95) was higher than the mean snag density at available sites (2.96 ± 0.65; Figure 4). Similarly, Lewis's Woodpeckers selected nest sites with higher shrub cover (17.64 ± 2.24), than was found at available sites (11.28 ± 2.62), and selected sites with higher (dead and live) Mature Tree Density as well (83.42 ± 7.84 at used sites vs. 63.33 ± 9.10 at available sites). Shrub height was also suggestive of differences between used and available sites (P = 0.067).

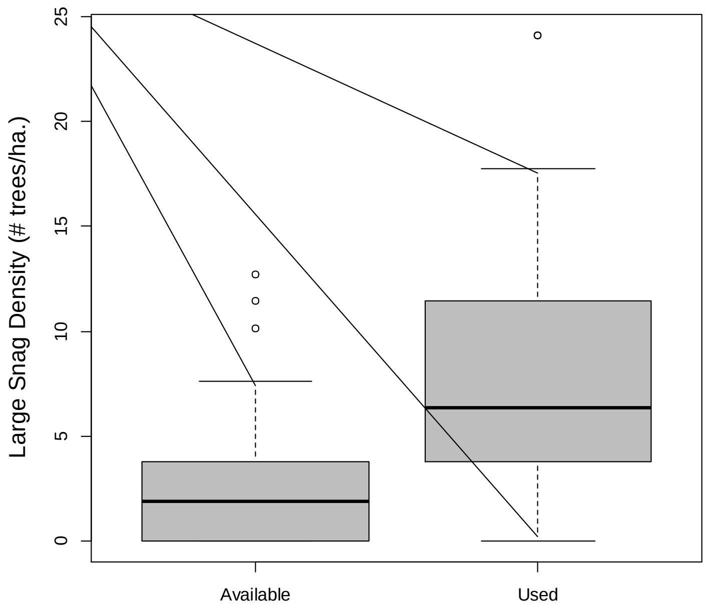


Figure 4. Boxplot displaying Large (≥ 23 cm DBH) Snag Density per hectare in Lewis's Woodpecker used versus available sites. The gray box represents the middle 50% of each group's measurements.

Table 5. Lewis's Woodpecker local and landscape scale characteristics at used and available sites.

Local and landscape vegetation characteristics					
	Used (n=38)		**Available (n=30)**		
Variable	mean	SE	mean	SE	**p-value from Mann-Whitney U-test***
Snag density (per ha.)	7.92	0.95	2.96	0.65	**<0.001**
Seedling density (per ha.)	94.00	20.41	141.68	41.79	0.920

Small tree density (per ha.)	52.73	11.25	84.22	18.80	0.532
Medium tree density (per ha.)	35.37	3.88	30.70	5.70	0.175
Large tree density (per ha.)	40.12	5.90	29.66	5.81	0.192
Mature Tree & Snag Density (>23 cm DBH)	83.42	7.84	63.33	9.10	**0.034**
Shrub cover (%)	17.64	2.24	11.28	2.62	**0.015**
Shrub height (m)	0.97	0.06	0.91	0.13	0.067
Amt. riparian/1 Km (total ha.)	105.49	5.74	101.14	9.17	0.801
Amt. riparian/200 m (total ha.)	24.41	1.63	20.46	2.00	0.106
Distance to agricultural area (m)	450.39	100.50	945.00	141.40	**<0.001**
Distance to urbanized area (m)	138.32	31.63	341.33	63.58	**0.014**

* values in **bold** are significant, when α is set at ≤ 0.05

Seven of nine independent variables were used in logistic regression analysis at the local scale. High correlations between Mature Tree Density and both Medium Tree Density ($r^2 = 0.71$) and Large Tree Density ($r^2 = 0.80$) forced me to drop the latter two variables. The model containing Snag Density alone provided a good fit; however, the best model resulted from use of the Small Tree Density, Snag Density, and % Shrub variables (Table 6).

Table 6. Coefficients and standard errors obtained from a logistic regression of Lewis's Woodpecker use at the local scale. Residual deviance: 68.24 on 64 degrees of freedom, n=68.

Coefficients:				
	Estimate	Std. Error	z value	p-value
(Intercept)	-1.20295	0.535532	-2.246	0.02469
% Shrub	0.053946	0.025547	2.112	0.03472
Small Tree Density	-0.00937	0.005184	-1.807	0.07079
Snag Density	0.253958	0.07919	3.207	0.00134

The model can be interpreted by considering the odds of Lewis's Woodpecker selection given the explanatory variables. Small Tree Density was the least significant factor, and when the odds ratio is calculated, we see that the odds of a Lewis's Woodpeckers selecting a site with 25 small trees/hectare was twice as likely as selecting a site with 100 small trees/hectare. However, the 95% confidence interval of the Small Tree Density coefficient spans across zero (-0.0195, 0.00079). The odds that Lewis's Woodpecker selected a site increased by a factor of 1.055 (95% CI: 1.004, 1.110) with a 1% increase in shrub cover. For example, given a 5% increase in shrub cover we expect a 31% increase in the odds that a Lewis's Woodpecker selects the site. Snag Density was the most significant variable in this model, and should be treated as the best predictor of selection: the odds of a site being selected for nesting was 3.56 times greater with an increase in Snag Density of 5 trees/ha (Figure 5).

Landscape Scale

At the landscape scale, distance to agricultural areas (450.39 ± 100.50 vs. 945.00 ± 141.40) and distance to urban areas (138.32 ± 31.63 vs. 341.33 ± 63.58) were significantly different (*P* = 0.0006, *P* = 0.0135) between used and available locations. There was also suggestive evidence of a difference in amount of riparian habitat with 200 m between used and available locations (Table 5).

For logistic regression analysis at the landscape level, I used two of four variables in the model. Amount of riparian within 200 m was highly correlated with amount of riparian within 1 km ($r^2 = 0.75$), so I dropped the latter. Using backward elimination, distance to urbanization was also dropped (*P* = 0.38), leaving two variables in the model (Table 7).

Table 7. Coefficients and standard errors obtained from a logistic regression of Lewis's Woodpecker use at the landscape scale. Residual deviance: 78.42 on 65 degrees of freedom, n=68.

	Coefficients:			
	Estimate	Std. Error	z value	p-value
(Intercept)	-0.32249	0.624681	-0.516	0.60569
Riparian within 200 m	0.064806	0.027973	2.317	0.02052
Distance to Agriculture	-0.0013	0.000419	-3.104	0.00191

Distance to agriculture was highly significant in the landscape-scale logistic regression. Lewis's Woodpeckers were 52% more likely to select a site that is 500 m from an agricultural field than one that is 1000 m away. Amount of riparian habitat within 200 m was also significant; when riparian area increased from 15 m^2 to 25 m^2, there was a 91% increase in the odds of site selection (Figure 5).

Analysis Across Scales

Measures at the nest-tree scale (tree DBH), local scale (snag density), and landscape scale (distance to agriculture) best discriminated used sites from available sites (DFA; Wilk's *Lambda* = 0.530; df = 3; *P* < 0.0001). Factors that accounted for the variation in the discriminant function analysis model included snag density (CS = 0.660), tree DBH (CS = 0.856), and distance to agriculture (CS = -0.588).

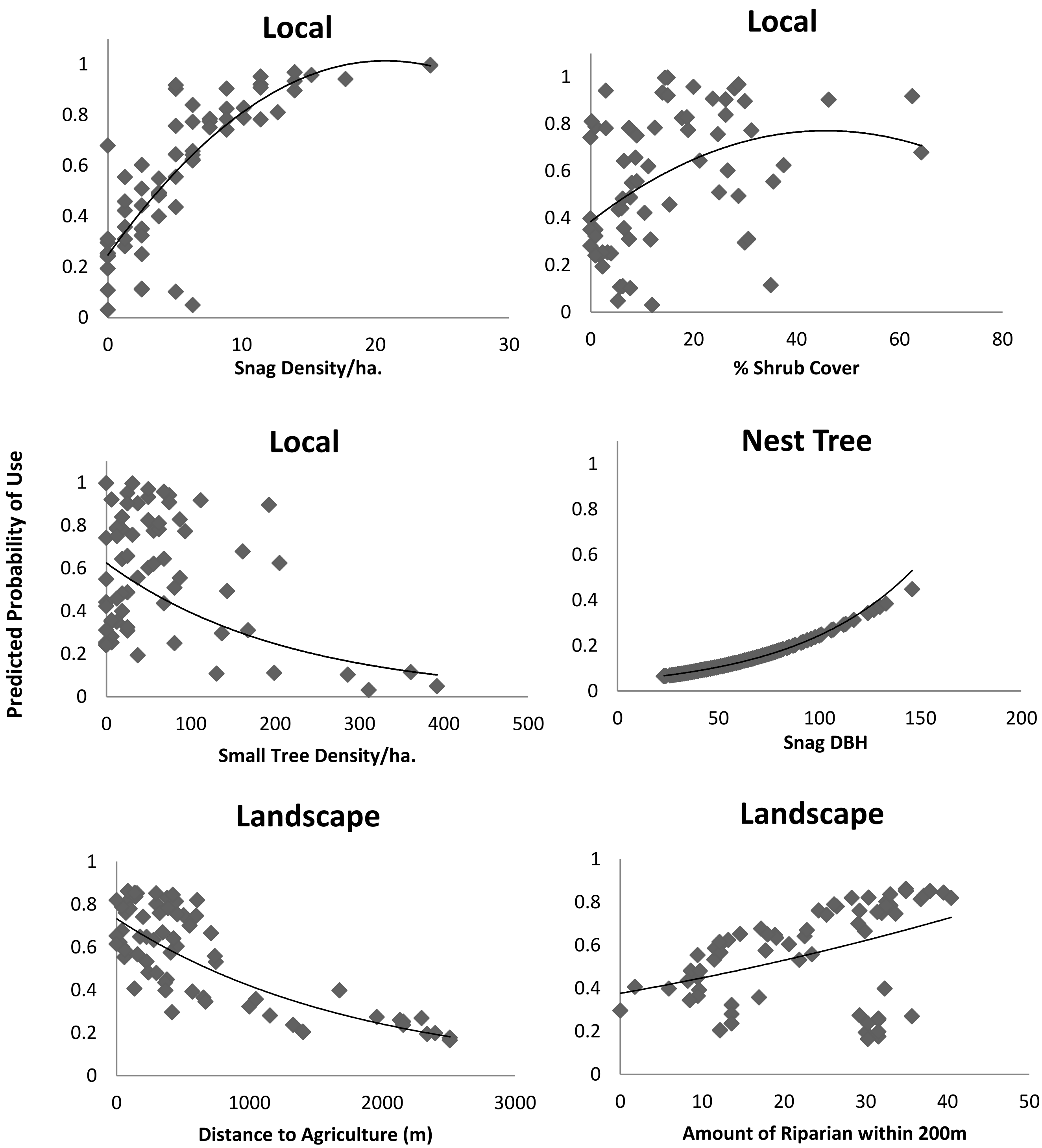


Figure 5. Predicted probability of use by Lewis's Woodpeckers at three spatial scales: Nest-tree scale, Local Scale, and Landscape Scale.

Discussion

Cavity-nesting birds are known for their relative high probability for nesting success (Martin and Li 1992), and this proved to be true for Lewis's Woodpeckers in this study (16/18). Although the sample size of nests monitored is insufficient to conduct a comprehensive analysis, these data provide general demographic information and can inform future Lewis's Woodpecker research.

Characteristics of the nest trees were generally similar in this study area to other studies conducted on Lewis's Woodpeckers (Vierling 1997, Linder and Anderson 1998, Newlon 2005, various works by V. Saab), including tree DBH (76.74 cm ± 5.16), tree height (17.83 m ± 1.05), and cavity height (13.37 m ± 0.85). Vierling (1997) reported that just 1 of 47 trees that Lewis's Woodpeckers used were alive, and similarly, I did not find a single Lewis's nest in a 100% live tree. Even when they usurp another cavity, it is most likely to be in a decaying tree, such that they can modify the cavity.

Local-scale characteristics were also similar to those reported in other studies. Lewis's did not nest near dense tree stands; they require open habitats from which to effectively forage (Bock 1970, Linder 1994, Tobalske 1997). Percent shrub cover averaged 17.64% in my study; similarly, Linder and Anderson (1998) reported that average shrub cover was 16.1%. I found mature tree density to average 83.42 ± 7.84 trees per hectare, versus 63.33 ± 9.10 in available sites. Others have also found that sites with higher mature tree densities suit Lewis's Woodpecker habitat needs, as opposed to sites with smaller, even-aged trees (Bock 1970, Newlon and Saab 2011).

The variables from my analyses which were significant at the two smaller scales included nest tree size, percent shrub cover, and snag density. Not surprisingly, these characteristics match well with what others have found: large snags for nesting, shrubs to support arthropod prey, and open areas for foraging. The naturally open character of older cottonwood stands in riparian areas suits Lewis's Woodpeckers well: old cottonwood stands tend to have natural openings that allow for an established shrub layer, places for perching, and cavities to nest in.

I considered several landscape measures that might influence nest selection of Lewis's Woodpeckers. Not surprisingly, I found a positive association with the amount of riparian habitat in the landscape, suggesting that Lewis' prefer nesting in areas with more riparian habitat, while Linder (1994) found that distance to water and distance to nearest human disturbance did not appear to be important factors in nest site selection of Lewis's Woodpeckers in burned conifer forests of Wyoming. Distance to agriculture and distance to urban areas were both closer at used sites in my study. Within the study area, Lewis's Woodpeckers can regularly be seen foraging in agricultural fields adjacent to forested nesting areas. Because the fields can be hunted from perches in the riparian forest, Lewis's may be taking advantage of these artificial openings. In my analyses, Lewis's also did not appear to avoid sparse development. Lewis's have been described by some as "shy", but within this study area they are often seen opportunistically feeding from neighborhood suet feeders. The density of houses that occurred in this study was very low, however, and this relationship may not occur with higher levels of urbanization.

Furthermore, it is important to note that habitat selection or density of species that are present do not always relate to habitat quality (Van Horne 1983); while both agriculture and urbanization were positively associated with the Lewis's Woodpecker nesting locations, further research is needed to measure the influence of human land use on reproductive success. Habitats other than cottonwood riparian forest also provide important breeding areas for Lewis's Woodpeckers. According to Saab and Vierling (2001), nest success of Lewis's Woodpeckers was much higher in burned pine forest in Idaho (78%) than in cottonwood riparian forest in Colorado (46%). Nests in cottonwood riparian areas, which often have adjacent agricultural fields and are increasingly pressured by development, tend to be at higher risk for predation. While cottonwood riparian forests in Montana may not reflect the same pattern of being a potential "sink", as Saab and Vierling suggest for Lewis's Woodpeckers, this finding certainly indicates the need for further research into the relative importance of ephemeral post-fire habitats versus increasingly impacted riparian forests for continued conservation of this species.

Management Implications

Although several features seem to provide ideal conditions for nesting, studies suggest that leaving snags intact is the single most important feature necessary for Lewis's Woodpeckers (Bock 1970, Tobalske 1997, Linder and Anderson 1998, Saab et. al. 2004, Gentry and Vierling 2007). Snag density, which is likely related to both prior disturbance and stand age class, is also an important feature in nest selection. In Saab et. al. (2002), they report that 62.1 ± 3.7 snags/ha was associated with use by Lewis's. However, these findings were in burned pine forest habitat where they indicate that the fire burned at moderate to severe intensity leaving most standing trees dead. In my study area, the riverine habitat includes both snags and live trees contributing to the overall structure of their preferred habitat. When medium trees (23-38 cm DBH), large trees (> 38 cm DBH), and large snags (≥ 23 cm DBH) are combined, the overall mature tree density is 63.33 ± 9.10, which is much more closely matched with Saab's results, and gives a more appropriate representation of the structure of nesting stands in the riparian areas I studied.

A study conducted on the Tonto National Forest in Arizona reports that 2.49 snags/hectare (minimum size of 38 cm DBH) would be necessary to sustain 100% maximum Lewis's Woodpecker populations (Bull 1977). Snag densities I calculated were based on a minimum size of 23 cm DBH and averaged 7.92 snags/ha at nest sites (see Table 5). Though the minimum size requirements compared here are smaller in my study, the densities far exceed the snag density of 2.49 snags/ha recommended for Arizona populations. Even at randomly selected sites, snag densities averaged slightly higher than 2.96 snags/ha. Although snag density is higher at used sites versus available sites, the overall density is still relatively low compared to densities in other forest types. This information certainly suggests that the snag densities are suitable for breeding

Lewis's in this study area. However, to evaluate whether these existing snags can provide the right kind of cavity for breeding Lewis's, further research may be necessary. If snag availability is not currently a concern for Lewis's, this leaves room for other ecological factors that may be important conservation concerns for Lewis's Woodpeckers, such as food resource limitations, predator interactions, breeding behaviors, and cavity features (Zhu 2012).

Many have suggested that cottonwood forests should be managed to preserve snags so as to maintain the historic structure of natural forest succession, but we know that not all snags (or cavities) are created equal (Thomas 1979). Cottonwood trees in river bottoms of Montana can take a hundred or more years from the seedling stage to become suitable for cavity-nesters. Once trees are old enough for use, removing them from an area would result in subsequent loss of nesting habitat for cavity-nesters which could affect the local population on a long-term basis. Besides leaving any and all snags, the snag itself must consist of the right elements for nesting birds: cavity features such as size of entrance, depth, integrity, and concealment. Occasionally, snags look suitable from the outside, but are rotted out internally. Given this uncertainty, preservation of used nesting sites is of special conservation priority.

The minimum management activity required to maintain populations of Lewis's Woodpeckers is to leave snags intact. This means leaving existing snags for species that use them, while at the same time allowing for continuous cottonwood recruitment. Management of lands along river corridors has been a controversial subject. Pressures from social, industrial, and environmental groups exist, meaning fewer river systems are simply left to run wild. Dynamics of a river, including flooding, seedling recruitment, survival, and mortality, essentially dictate the processes by which a river maintains its health and vigor (Friedman et. al. 1997, Friedman and Lee 2002). Non-natural flow regimes, cattle grazing, and human alteration have created conditions unfavorable for cottonwood regeneration because they interfere with the natural dynamics of the river system (Sedgwick and Knopf 1989, Scott et. al. 2003, Miller et. al. 2003). These stands are created, lost, and replaced in a staggered time series, of perhaps decades, thus continually providing snags of an appropriate age for cavity-nesters (Howe and Knopf 1991).

Managing for species individually presents many challenges. By managing for the riparian ecosystem in its entirety, we manage for all species that belong there. The functioning processes of the river help maintain the health of the whole river system, and while recent research has provided us with insight as to how to protect our rivers, we must continue to push for healthy, wild rivers to support the full community of species, including Lewis's Woodpeckers. A confounding issue of this localized breeding area is that much of the land is privately owned, restricting our ability to manage those lands. An effort to reach private landowners in this study area is needed: by educating private landowners about the importance of riparian habitat, we can promote the retention of natural habitat features (e.g., trees, snags, shrubs, downed wood) that provide nesting and foraging habitat for Lewis's Woodpeckers as well as other species.

The scale of conservation management, although small in this study, is relatively important at the state level. The Clark Fork and Bitterroot rivers remain areas where relatively high numbers of Lewis's Woodpeckers breed. Lewis's are restricted to the west side of the divide in Montana and, furthermore, restricted to habitats that provide suitable nesting and foraging features. In Montana, several habitats appear to be suitable for this species, including post-fire forest, cottonwood riparian forest, and open ponderosa pine forest. There is no doubt that the cottonwood riparian forests of the Bitterroot River and Clark Fork River corridors are important breeding areas for Lewis's Woodpeckers: in two years surveying for active nests, a total of 142 nests were located (n=87 in 2009 by Montana Audubon, n=55 in 2012). Because this is a Tier II Species of Concern in Montana, wildlife managers ought to focus conservation efforts in this core breeding area if possible.

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Appendix I. Vegetation form for Lewis's Woodpecker nesting sites and random sites.

Lewis's Woodpecker Nest Vegetation Form

Nest ID/Random Nest ID:	
Mo/Day/Year:	
Observer:	
Photo (Y or N):	
Photo number:	
Tree Species:	
DBH (cm):	
Tree Height (m):	
Tree Health* (1-9):	If stage 2, % dead:
Cavity Aspect (degrees):	
Cavity Height (m):	

5 m Plot					# tree seedlings		
Point	Plot	% Shrub cover	Avg. Ht. Shrubs	Grazing intensity N, L, M, H	Cottonwood	Other_____	Other_____
Nest/Random Site	C						
	0°						
	120°						
	240°						

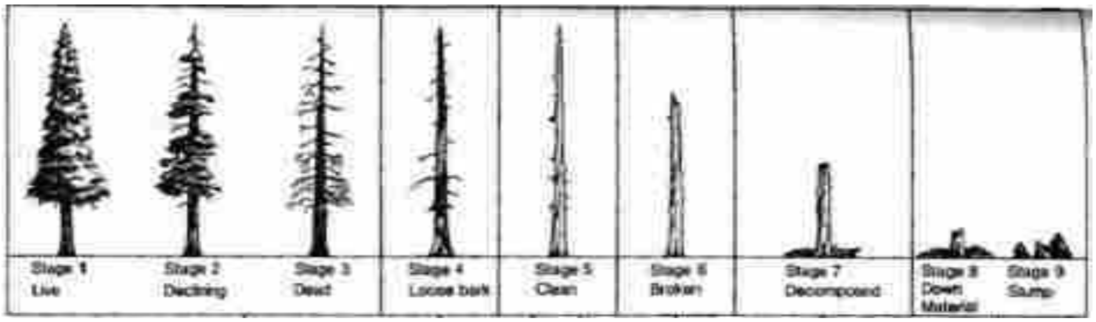
11.3 m Plot: Live Tree Counts

		spp1_______			spp2_______			spp3_______			spp4_______			spp5_______		
Point	Plot	8-23 cm	23-38 cm	>38 cm	8-23 cm	23-38 cm	>38 cm	8-23 cm	23-38 cm	>38 cm	8-23 cm	23-38 cm	>38 cm	8-23 cm	23-38 cm	>38 cm
Nest/Random Site	C															
	0°															
	120°															
	240°															

50 m Plot: Snag Counts (give DBH for all dead & dying trees ≥ 25% dead)														
spp1_________														
spp2_________														
spp3_________														
spp4_________														

Comments:

***Tree Health:**


Stage 1
Live
Stage 2
Declining
Stage 3
Dead
Stage 4
Loose bark
Stage 5
Clean
Stage 6
Broken
Stage 7
Decomposed
Stage 8
Down
Material
Stage 9
Stump

Appendix II. Protocol and nest monitoring data sheet provided to interns and volunteers.

Lewis's Woodpecker Protocol & Data Sheet

Thanks for helping out on this important project by becoming a field biologist! The data sheet is to help you collect important information in a standardized way. Think of these as guidelines to help you collect information, and please feel free to write down any additional notes or interesting observations you make.

For more information or if you have any questions contact me at: megan.fylling@mso.umt.edu or (406) 243-2035. As soon as you find a Lewis's Woodpecker or its nest, you can scan and email or mail this information to:

Megan Fylling

Division of Biological Sciences HS 104

The University of Montana

Missoula, MT 59812

Your contact information

Name: Phone: Email:

Nesting Information for Lewis's Woodpeckers

In the table below, you will see rough guidelines for timing of Lewis's woodpecker's (LEWO) breeding behavior. Keep in mind that males and females look alike, and both can be observed excavating, incubating, and feeding young. LEWOs tend to nest in large cottonwood or pine trees and they are known to reuse old nest cavities.

Activity	**Timing (approx.)**	**Behaviors observed during this phase**
Arrival in MT	Early May	First sightings!
Excavation	Mid to late May	Drumming, calling, nest modification or excavation, entering/leaving cavity
Egg-laying	Mid to late May	Entering/leaving cavity, copulation, courtship
Incubation	Early to mid June	Long stretches of time in cavity, one bird leaving the nest & another bird entering the nest
Nestling	Mid June through July	Frequent trips to nest cavity with food
Fledgling	Late July to early August	Feeding young near nest cavity

Study Area

As you are choosing a site to visit along the Clark Fork and Bitterroot, I encourage you to visit just about anywhere from Missoula to Hamilton on the Bitterroot, and from Missoula to Huson on the Clark Fork. Going outside of these river stretches is also welcome, but the focus will be on the above described areas.

Bird or Nest Location Info

Species:	Nest ID:	Mo/Day/Year:	Observer:
Location Description* (detailed description of location, river put-in, side of river, distance from bank, etc. If nest: nest tree species, nest height, behavior):			

If you have found a nest, please complete this section:

Nest Tree (circle one)	**Cottonwood Tree**	**Pine Tree**	**Other (describe)**
Health of Tree (circle one)	**Live Tree**	**Partially Live/Dying**	**Dead Snag**

GPS Information (if possible)	**Lat:**	**Long:**
Nest Fate: Success Fail Unknown	**# Fledged:**	
Evidence:		

* The location description to find the bird or nest is very important so that we are able to find it again. Call Megan with questions – thanks!

Nest Monitoring Card – if you are willing to monitor the nest you have found, please fill out all applicable information here

Nest ID:				Species:				Location:
Obs	**Date**	**Time**	**Min @ Nest**	**Stage**	**Adults**	**# Eggs**	**# Yng.**	**Comments**

Nest ID = Year, Observer Initials, nest # (e.g. 12AN1) **Stage:** B = building; L = egg laying; I = incubating; N = nestling, F = fledgling. **Adult pres:** Adults present when nest checked; Y or N. **#Egg:** Number of eggs. **#Yng:** Number of nestlings. **Comments:** Record any additional info used to determine the stage and/or activity of the nest (e.g. evidence of predation, feeding of fledglings,etc.)