University of Idaho
College of Natural Resources

Assessing Lewis' Woodpecker Habitat Using Hyperspectral Imagery

SENIOR THESIS

Presented in partial fulfillment of the requirements for the degree of

Bachelors of Science

in

Natural Resource Ecology

Stephanie Jenkins
DeVlieg Undergraduate Researcher

May 21, 2004

Abstract

Lewis' woodpecker populations are declining in certain geographic areas due to snag removal and urban development (Sedgewick and Knopf 1986), yet appear to have increased in number in the Big Creek Drainage of the Frank Church River of No Return Wilderness. This may be related to the presence of burnt cottonwood snags from recent wildfires (2000) that offer potential nesting habitat preferred by Lewis' woodpeckers.

Hyperspectral imagery was trained on a live cottonwood (*Populus trichocarpa*) spectral signature and was used to identify cottonwood distribution and Lewis' woodpecker nesting activity in the study area. Although hyperspectral imagery can accurately map live cottonwoods and may to lead to the location of dead cottonwoods snags, it was not an accurate indicator of Lewis' woodpecker nesting habitat. Mapping dead cottonwood distribution by analyzing subpixel dead cottonwood signatures is proposed to map nesting habitat for the Lewis' woodpecker.

1.0 Introduction

Lewis' woodpecker (*Melanerpes Lewis*) populations are declining due to decreasing habitat because of fire control, snag salvaging, urban settlement, and flood control (Marshall 1996, MBTA 1998, Sedgewick and Knopf 1990). This species typically uses areas that have been previously burned with large snags remaining as nest sites (Velland 1999, Bock 1970). Designated as sensitive, decreasing habitat may lead to lower Lewis' woodpecker abundance (Marshall 1996). Lewis' woodpeckers are of high conservation concern because of fire suppression which creates dense stands unsuitable for Lewis' woodpecker habitat (Raphael and White 1984). Principle habitat requirements include the need for an open canopy, burned cottonwood (*Populus trichocarpa*) or Douglas fir (*Psuedotsuga menziezii*) snags for nesting, and insect availability (Bock 1970, Raphael and White 1984).

The Big Creek Drainage in the Frank Church River of No Return Wilderness (FCRNRW) offered an excellent opportunity to study the Lewis' woodpecker due to the occurrence of a large wildfire in 2000 that appeared to have caused an increase in local numbers of Lewis' woodpecker. Due to wilderness status, the FCRNRW is not significantly impacted by logging, salvaging, and traditional fire suppression methods (Cubbage 1993). As a result, a significant amount of riparian areas in the Big Creek Drainage have been burned, leaving cottonwood snags and open canopies for Lewis' woodpecker habitat.

A remote sensing technique, hyperspectral imagery, can be used to identify plant species distribution at a much finer scale than traditional remote sensing techniques such as LandSat (Chang 2003, Mertes 2002). Hyperspectral imagery consists of analyzing light reflectance data for ground surface features. Hyperspectral maps can be generated by plotting the unique spectral signature emitted by live cottonwoods to accurately identify live cottonwood distributions (Mertes 2002). These maps may be used for selecting sampling areas to study the Lewis' woodpecker. Hyperspectral maps can then be compared to dead cottonwood snags and predict Lewis' woodpecker use along the Big Creek Drainage.

2.0 Purpose

The purpose of this project was to map cottonwoods using hyperspectral imagery and to evaluate use of cottonwoods by Lewis' woodpeckers within the Big Creek Drainage. A post-fire distribution of cottonwoods and assessment record of Lewis' woodpeckers will result from this study.

3.0 Objectives

- Assess accuracy of mapping live cottonwood distribution using hyperspectral imaging
- Determine if dead cottonwoods are identified by hyperspectral mapping of live cottonwoods
- Evaluate if Lewis' woodpecker use of cottonwoods identified by hyperspectral imagery can be verified by ground reconnaissance.

4.0 Hypotheses

H_1: Hyperspectral imagery can be used to identify live and mixed (live/dead) cottonwood stands.

H_2: Cottonwood sites identified by ground reconnaissance and not by hyperspectral imagery will have larger proportion of dead cottonwoods than hyperspectral mapped (hypmap) cottonwood sites.

H_3: Cottonwood sites identified solely by ground reconnaissance will have higher occurrence of nest sites than hypmap cottonwood sites.

H_4: Cottonwood sites identified solely by ground reconnaissance will have greater occurrence (presence/absence) of Lewis' woodpeckers than hypmap cottonwood sites.

5.0 Methods

5.1 Study Area

The study area is located in riparian areas within the Big Creek Drainage and its tributaries in the FCRNRW. This area spanned approximately 11 stream miles and included Cave Creek, Cabin Creek, Spring Creek, Rush Creek, Pioneer Creek, and Cougar Creek. Sites were designated by observing natural topography and clustered riparian trees that were usually separated by stream channels or large areas of coniferous and shrub vegetation (see maps 1-5)

5.2 Hyperspectral imagery

Hyperspectral imagery has been used for a variety of ecological and geological purposes including vegetation and mineral identification, and plant disease detection (Inoue 2001). Hyperspectral imagery was originally developed by NASA and the US military for detection of camouflage, thermal emissions, and hazardous waste areas (IRIA 1994).

In this study, hyperspectral remote sensing was used to analyze and map cottonwood distribution using Environment for Visualizing Images 3.6 (ENVI 3.6, Research Systems Inc). This remote sensing method measures solar absorption and reflection data from ground surface features in 1-4m^2 pixels. Hyperspectral imaging spans 126 wavelengths bands (0.44 μm – 2.5 μm) in the electromagnetic spectrum. The hyperspectral data was acquired on June 30, 2002 using HyVista's airborne Hymap hyperspectral sensor (Integrated Spectronics Pty Ltd, Baulkham Hills, Australia) and gathered solar absorption/reflection data with a spectral resolution of 4m^2 pixels. This method of remote sensing was preferred because it allows higher precision of measurements compared to traditional remote sensing such as LandSat (Chang 2003). Hyperspectral remote sensing can gather data on species identifiable traits such as leaf water absorption, chlorophyll reflection, and atmospheric light absorption (Fuentes 2001).

5.2.1 Image Analysis Procedures

Hyperspectral data must first be geographically referenced (georeferenced) to associate true ground coordinates with hyperspectral images. This flightline data was georeferenced with a variance of approximately 20 meters of true ground coordinates; therefore, GPS was not used for exact location, but as general reference for additional study. Once georeferenced, reflectance images of the 126 wavelengths within the visible and near infrared light spectrum were generated with true color using red, green, and blue wavebands of 0.40-0.49, 0.50-0.50, 0.60-0.69 μm, respectively. Wavelengths of 0.45, 0.55, and 0.65 μm accurately represented true color with this flightline (note: different flightlines may vary within the selected micron parameters of red, green, and blue).

The next step was to refine the image to a minimum noise fraction (MNF). The MNF process was used to locate wavelengths with the most distinguishable features and minimal noise as well as identify which wavelengths were not useful in further data processing that could be discarded. The wavelength was recorded where distinguishable features were no longer visible and noise or "fuzz" is prominent. The remainder of the processing used only that subset of wavelengths with least amount of noise (ex. 36/126).

The Pixel Purity Index (PPI) followed the spatial refining process of MNF. PPI is a spectral refining process for locating the purest pixels on the reflectance image. This process records the most "pure" pixels (i.e. without mixed spectral signatures) by taking all the pixels in the entire image and rotating them n-dimensionally. The PPI was run with 10,000 iterations using a threshold of 2.5 standard deviations. For each iteration, the two pixels with the highest and lowest spectral purity scores were recorded.

The N-dimensional visualizer (n-d viz) was then applied. The n-d viz allows for the 10,000 points identified in the PPI to be rotated in a plot of n-dimensions. As the points rotate, points scoring the highest spectral purity will be on the outskirts of the cloud, whereas, points of low spectral purity (mixed spectral signatures in the $4m^2$ pixel) are clustered towards the center of the rotating cloud (see figure 2). Each outlier was then manually color coded and exported as a region of interest (ROI) endmember onto the reflectance image. Spectral profiles for each endmember revealed chlorophyll absorption and leaf reflection values useful in identifying vegetation (Rahman 2003). (see figure 1)

Each ROI was individually assessed in the spectral angle mapper (SAM) classification system. This final process identifies other pixels that have similar reflectance values to that of the ROI and portrays those pixels on the reflectance image. Those pixels had the potential to be less than 100% pure, meaning they contain a mixture of vegetation and may not fully represent the exact spectral profile of a cottonwood canopy. Using SAM, an accuracy value may be designated between 0 – 1.0 of a degree that the spectral profiles of potential pixels must lie within before being mapped. For this research, 1.0 degree was first used to get a broad distribution of pixels that were similar to the trained cottonwood pixels. After groundtruthing these areas, the accuracy value was refined to 0.4-0.8 of a degree.

This SAM representation provided an accurate distribution map of pixels dominated by the live cottonwood spectral profile to which the imagery was trained. The imagery was not trained on burned cottonwood signatures because subpixel identification would have been necessary in the training of dead or burned material. That added factor of distinguishing burned cottonwoods from other burned species within pixels would have induced large error into the mapped image. The purpose of this research was to map live cottonwoods in which dead cottonwoods preferred by Lewis' woodpeckers would be associated and, in effect, provide an accurate map of Lewis' woodpecker use.

5.3 Cottonwood Sites

Since a live cottonwood spectral profile was used to generate hyperspectral maps of cottonwood distribution, hypmap sites represented live cottonwoods, but some contained dead cottonwoods (see appendix A). After ground surveys, dead cottonwoods not identified by hyperspectral remote sensing because of isolation from live cottonwoods were recorded as sites identified by ground reconnaissance (see maps 1-5).

Overprediction of live cottonwood distribution was determined by visiting all hypmap sites using Universal Transverse Mercator (UTM) locations gathered from the hyperspectral reflectance image (see appendix D). To compensate for offset georeferencing, presence of cottonwoods was verified within 30 meters with a Garmin Handheld GPS Unit (Garmin). Thirty meters was used to account for 20 meters that the georeferencing of the hyperspectral imagery was offset plus the accuracy inherent to handheld GPS units (approximately 7 meters).

Underprediction was determined by surveying the study area for all live cottonwoods. True ground UTM locations were gathered for all cottonwoods sites not identified by the hypmap (see appendix D).

To determine if dead cottonwoods were identified by the hypmap of live cottonwoods, all sites were visited and the number of dead and live trees recorded. Trees with green foliage were counted as live trees, including regrowth and sprouting. The cause of death and degree of burn was recorded for dead cottonwoods. All cottonwoods were counted within each site (site size varies significantly between sites). Due to the number of trees and error associated with counting individual trees at site #12, three subsets of 30 meters (m) radii were designated within site. One subset was designated by randomly choosing a primary cottonwood in which a 30 m radius revolved. A radius of 30 m was designed to account for patchy distribution and other stand characteristics recorded in initial walk through of site. One hundred meters was paced southerly and 75 meters westerly to designate primary cottonwoods for the other 2 subsets. All cottonwoods were counted within these subsets (ratio of live/dead cottonwoods) along with Lewis' woodpecker activity.

By counting the number of dead and live cottonwoods in each site, proportions of dead trees as well as the percentage of dead and live cottonwoods in hypmap sites and cottonwood sites identified by ground reconnaissance were compared.

5.4 Lewis' Surveys

A 30 minute survey was conducted at all cottonwood sites to document Lewis' woodpecker use in the last two weeks of June and into the first two weeks of July. Presence/absence, number, behavior, activities, occurrence of active nest, and presence of other birds were recorded. Length of survey was determined from preliminary field studies that recorded the average amount of time in which Lewis' woodpecker activity was normally observed (Chelan PUD 1999, Gionfriddo 2003, Lehmkuhl 2004).

Identified nest trees were measured 1.5 meters vertically from ground surface to ascertain diameter at breast height (dbh) (see appendix C). All sites and nest trees were documented using a Kodak DCZ10 Zoom Cam Digital Camera. (See attached Appendix E: Compact Disc)

6.0 Results

6.1 Cottonwood Sites

53 cottonwood sites were documented in the study area. Of those 53 cottonwood sites, 36 cottonwood sites were hyperspectrally identified (68% of all cottonwood sites)

and 17 cottonwood sites (32%) were identified by ground reconnaissance and not by the hypmap.

The 36 hypmap sites included:

a) 5 cottonwood sites completely live

b) 3 cottonwood sites completely dead

c) 17 cottonwood sites with mixed live and dead trees

d) 11 overpredicted sites containing water birch *(Betula occidentalis*) and quaking aspen (*Populus tremuloides*).

(see figure 3)

The 17 cottonwood sites not identified by hypmap included:

a) 4 cottonwood sites with mixed live and dead trees

b) 13 cottonwood sites completely dead.

(see figure 4)

Number of trees varied within each cottonwood site from 1 to more than 412 trees. Hypmap sites accounted for 1046 out of 1166 total cottonwoods (90%) counted in study area. Of these hypmap cottonwood trees, 561 (54%) were live and 485 (46%) were dead. Fire was the sole cause of tree mortality. The degree of burn varied from bark absent with cambium burns to bark burned only at trunk base. A small amount of trees showed signs of regrowth and stump sprouts though burn was apparent.

Cottonwood sites not identified by the hypmap, but instead by ground reconnaissance, accounted for 120 out of 1166 total counted trees (10%). Ten of those trees (8%) were live and 110 trees (92%) were dead (See Figure 5).

6.2 Lewis' use

Forty three Lewis' woodpeckers were documented in the total study area, 18 in hypmap sites and 25 in sites not identified by the hypmap. Fourteen Lewis' woodpecker nests were identified. Possible Lewis' woodpecker cavities were found in additional trees, but Lewis' woodpecker use of those cavities was not documented. Of the 14 nests, 4 were affiliated with hypmap cottonwood sites and 10 were affiliated with cottonwood sites not identified by hyperspectral imagery. All nests were located in dead cottonwoods. Sites that had more than one nest were: ground reconnaissance site #31(3 nests) and hypmap sites #20 (2 nests) and #38 (2 nests). Nest tree diameter at breast height (dbh) ranged from 32-101 cm.

Nesting pairs were present at each nest site and at each nest site juvenile Lewis' woodpeckers were heard. Two to three adult birds were present at sites with only one nest. More than 4 adult birds were documented at sites with more than one nest. Odd numbers were common. Frequent flights to and from nest cavity and flycatching were observed as well as perching and tree foraging. Intraspecific interactions but no interspecific interactions were observed. Other birds at cottonwood sites included: Northern Flicker (*Colaptes auratus)*, Magpie *(Pica spp.)*, Western bluebird *(Sialia mexicana*), Sapsucker *(Sphyrapicus spp.)*, Downy woodpecker *(Picoides pubescens),* Hairy woodpecker (*Picoides villosus)*, Swallow *(Petrochelidon spp*.) Cowbird *(Molothrus spp.)*, Song sparrow (*Melospiza melodia)*, and Starling *(Sturnus vulgaris*). At site #11, one cottonwood contained both a Starling nest and Lewis' woodpecker nest. No interaction between these nesting pairs was observed.

Returning three weeks after initial survey, fledglings were observed in and around the nest cavity. Fledglings lacked light gray collar or pink belly and red cap on the head was less defined. Fledgling number ranged from 4 to 7 per family/nest.

7.0 Discussion

Hyperspectral maps accurately identified 98% of live cottonwoods in study area. Dead cottonwoods were commonly associated with these hypmap live cottonwoods. Overpredicted sites contained water birch and quaking aspen instead of cottonwoods and is due to the similar spectral signatures of these species. Twenty out of the twenty five remaining hypmap sites contained both live and dead cottonwoods. Six to one-hundred percent of the cottonwoods within these sites were dead and contained 29% (4/14) of Lewis' woodpecker nests and 42% of Lewis' woodpecker use (see appendix A,B).

When comparing number of cottonwoods identified by hypmap sites with cottonwoods identified by ground reconnaissance, 10% (120/1066) cottonwoods were not identified by hypmap. One hundred and ten out of one hundred and twenty of these non hypmap cottonwoods were dead and had no live cottonwood signature. That small percentage, however, accounted for 71% of Lewis' woodpecker nests (10/14 nests) and

58% of Lewis' woodpecker use. This data reveals that more than half of Lewis' woodpecker use was recorded in a small set of sites not identified by hypmap (see figure 6).

Only two percent (10 out of 1066) of the total number of live cottonwoods were not detected by hyperspectral imagery. This is probably due to shadowing effect of cliffs, or errors in hyperspectral processing. Potential errors associated with hyperspectral processing may be due to blending of spectral profiles in the $4m^2$ pixels. Foliage may also have been too sparse to be detected. Another explanation is possible when considering that the imagery was flown two years after the fire of 2000 and one year before the study took place. This may have created discrepancy between the current numbers of live and dead trees relative to amount detected from the hyperspectral flightline. Regrowth may be a possible answer to the cottonwood sites not identified by hyperspectral imagery that contained live trees. Delayed mortality related to heat stress may be a factor in hyperspectral sites in which no live trees were apparent (site 16 and 27) (Dwire and Kauffman 2003).

Results showed Lewis' woodpeckers prefer nesting trees greater than 32 cm dbh. Other factors affecting nesting included degree to which the nest tree had been burned. No nests were observed in unburned live cottonwoods, and all observed nests were located in burned dead trees. Burn scars were present on all nest trees. Bark was either absent or in the process of shedding. Nest trees that had more than one nest were 101 cm dbh or larger and lacked bark. Lewis' woodpecker nests and activity was largely in sites consisting of dead cottonwoods not identified by hyperspectral analyses. No live cottonwoods or mature trees were closely associated with nest trees, thus leaving an open canopy available for fly catching, forage opportunities, and nest protection (Raphael and White 1984). This could be a potential measure of the severity of burn preferred by Lewis' woodpeckers. As burn severity increased the ratio of live to dead cottonwoods decreased. This would lead to a preference for severe burns where live trees were rare.

Other birds appeared to have little, if any effect on Lewis' woodpecker activity. When in close association (on same tree), Lewis' woodpeckers did not communicate and appeared to ignore Cowbirds, Starlings, and Northern Flickers.

Inactive cavities were found in a few cottonwoods. Suspect cavities were associated by adequate dbh and other nesting characteristics. Since Lewis' woodpeckers have been recorded to occupy uninhabited cavities of other species (Sedgewick and Knopf 1990), further monitoring of inactive cavities may lead to identification of additional Lewis' woodpecker nests.

8.0 Conclusion and Management Implications

Data revealed that 11% (3/36 sites) of hypmap sites of live and mix of live/dead cottonwoods had a Lewis' woodpecker nest, whereas 41% (7/17 sites) of cottonwood sites (largely dead stands) not identified by hypmap contained a nest (see table 1, figure 6). This leads to the conclusion that Lewis' woodpecker nests were more common in dead cottonwood trees not associated with cottonwood sites identified by hypmap using a live cottonwood spectral profile. It was found that hyperspectral imaging of live cottonwoods can lead to the location of dead cottonwoods, but the majority of those cottonwood sites may not be conducive to Lewis' nesting preferences and is a only a partial indicator of Lewis' woodpecker habitat.

Live cottonwood distribution was accurately mapped using hyperspectral remote sensing. Almost half of Lewis' woodpecker numbers in the entire study area were documented in cottonwood sites identified by hyperspectral mapping of a live cottonwood spectral profile. However, Lewis' woodpecker nests were largely located in isolated cottonwood snags not defined by hyperspectral imaging

This data suggests that Lewis' woodpeckers prefered solitary dead cottonwoods over live cottonwoods or live/dead mix cottonwood stands (see figure 6, table 1). Further analyses of hyperspectral imagery is needed. It is possible to enter into an individual pixel of 1-4m^2 to ascertain spectral profiles of specific features (Farrand, 1999). This could lead to identifying a burned cottonwood spectral signature. Burned cottonwoods may then be mapped and could lead to potential Lewis' woodpecker habitat site locations. However, it remains unclear if hyperspectral imagery could distinguish between spectral signatures of burned snags and that of different species composition. For additional research, it is proposed to map sub pixel spectral profiles of burned features to ascertain the feasibility of locating potential Lewis' woodpecker habitat.

Because human development in valley bottoms and snag removal is detrimental to Lewis' woodpecker habitat (Velland 1990), knowledge of Lewis' woodpecker distribution within areas not significantly impacted by humans is valuable in further prescribed fire and fire suppression management decisions concerning this sensitive species.

The ability to locate prime habitat for sensitive species such as the Lewis' woodpecker using hyperspectral imaging is a promising research and management strategy to identify habitat for species of special concern. This research provides information useful to initiate active management techniques such as prescribed burns, human developments that minimize impact on habitat quality, and rehabilitation and retention of standing burned snags that would facilitate conservation of habitat for the Lewis' woodpecker.

9.0 Works Cited

Bock, C. E. 1970. The ecology and behavior of the Lewis woodpecker (Asyndesmus lewis). Univ. Calif. Publ. Zool. 92:1-100.

Chang, Kang-Tsung. Introduction to Geographic Information Systems. MGrawHill, 2nd ed. 2003.

Chelan County Public District (Chelan PUD). 1999. Lake Chelan riparian zone investigation status report. Lake Chelan hydroelectric project (Project – FERC No. 637).

Cubbage, Frederick W., Jay O'Laughlin, and Charles S. Bullock III. 1993. Forest resource policy. New York: John Wiley & Sons, Inc. 562 p

Dwire, Kathleen A. and J. Boon Kauffman. 2003. Fire and riparian ecosystems in landscapes of the western USA, *Forest Ecology and Management,* Volume 178, Issues 1-2, 3, Pages 61-74.

Farrand, William H. 1999 "Sub-pixel Detection and Mapping of Spectrally Unique Materials on Mars Using ISM Data." Fifth International Conference on Mars. Space Science Institute, Boulder, CO.

Fuentes DA, Gamon JA, Qiu H, Sims DA, Roberts DA. 2001. Mapping Canadian boreal forest vegetation using pigment and water absorption features derived from the AVIRIS sensor. *Journal of Geophysical Research* 106:33565-33578.

Gionfriddo, James P. and Joe Stevens. 2003. Survey of Bent's Old Fort National Historic Site for breeding birds and anurans. Report submitted to the National Park Service. Colorado Natural Heritage Project. Colorado State University.

Identifying the Benefits and Risks of Fire Improves Planning. 2003. Highlight for National Fire Plan R&D 2003 Business Summary. Aldo Leopold WildernessResearch Institute, Rocky Mountain Research Station.

Inoue, Y., and J. Pen Uelas. 2001. An AOTF-based hyperspectral imaging system for field use in ecophysiological and agricultural applications. *International Journal of Remote Sensing.* vol. 22, no. 18, 3883–3888.

IRIA. "Military Utility of Multispectral and Hyperspectral Sensors." Nov 1994. A report.

Lehmkuhl, John. 2004. Birds and Burning Progress Report 2003. Okanogan and Wenatchee National Forest. State of Washington.

Marshall, D.B., M. Chilcote, and H. Weeks. 1996. Species at Risk: sensitive, threatened, and endangered vertebrates of Oregon. Oregon Dept. Fish and Wildl., Portland. Second edition.

Mertes L.A.K, Dekker A.G, Brakenridge G.R, Birkett CM, Letourneau G (in press) Rivers & Lakes. In: Ustin S (ed) John Wiley and Sons, New York, Manual of Remote Sensing, Vol. 5 : Andy Rencz, General Editor. 2002

Migratory Bird Treaty Act (MBTA). 1918, revised 1998. Code of Federal Regulations, Title 50, Sec10.13. US Fish and Wildlife Service, Division of Migratory Bird Management.

Sedgewick and Knopf. 1990. Habitat relationships and nest site characteristics of cavity-nesting birds in cottonwood floodplains. Journal of Wildlife Management 54(1):112-124

Rahman, A. F., J. A. Gamon, D. A. Sims, and M. Schmidts. 2003. Optimum pixel size for hyperspectral studies of ecosystem function in southern California chaparral and grassland. Remote Sensing of Environment 84:192-207.

Raphael, M. G., and M. White. 1984. Use of snags by cavity-nesting birds in the Sierra Nevada. Wildlife Monographs 86:1-66.

Velland, Mark and Véronique Connolley. 1999. COSEWIC Status Report on the Lewis' Woodpecker, Melanerpes lewis. Committee on the Status of Endangered Wildlife in Canada. 18 pp.

Vierling, K. T. 1997. Habitat selection of Lewis' Woodpeckers in southeastern Colorado. Wilson Bulletin 109:121-130.

Figure 1. Cottonwood spectral profile

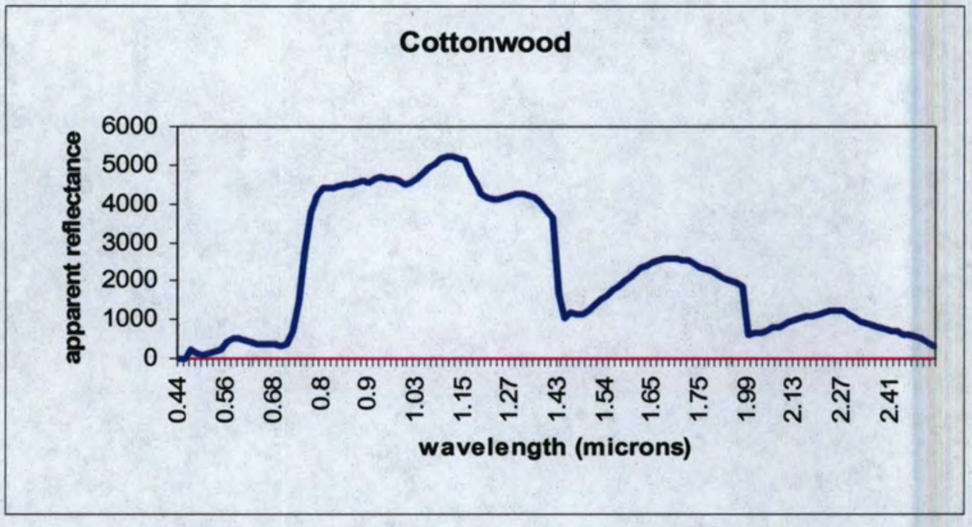


Figure 2. N-d visualizer. Outliers were highlighted to denote pixels with high spectral purity. These highlighted points were further processed to identify which, if any, of those pure points matched a live cottonwood spectral signature.

Figure 3.

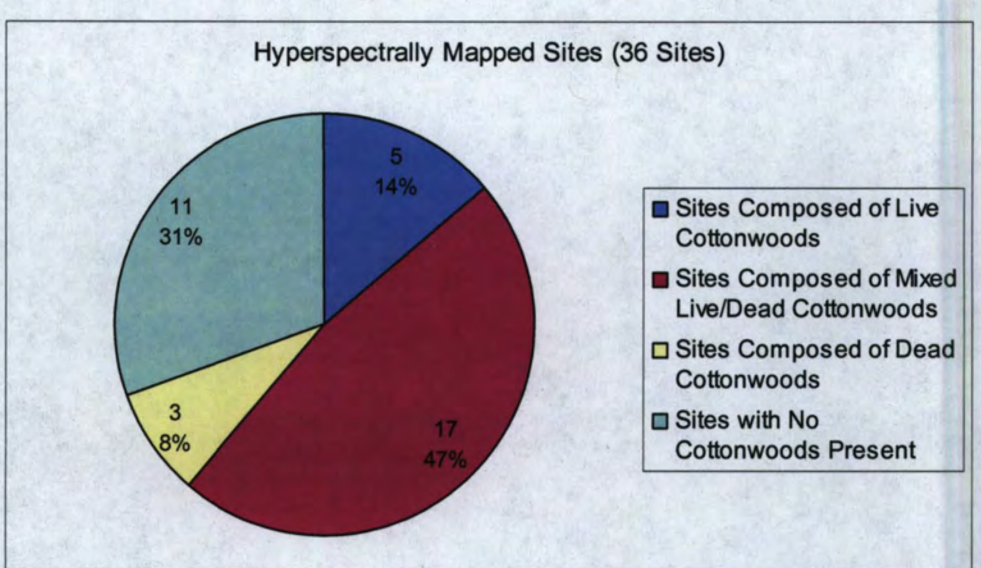


Figure 4.

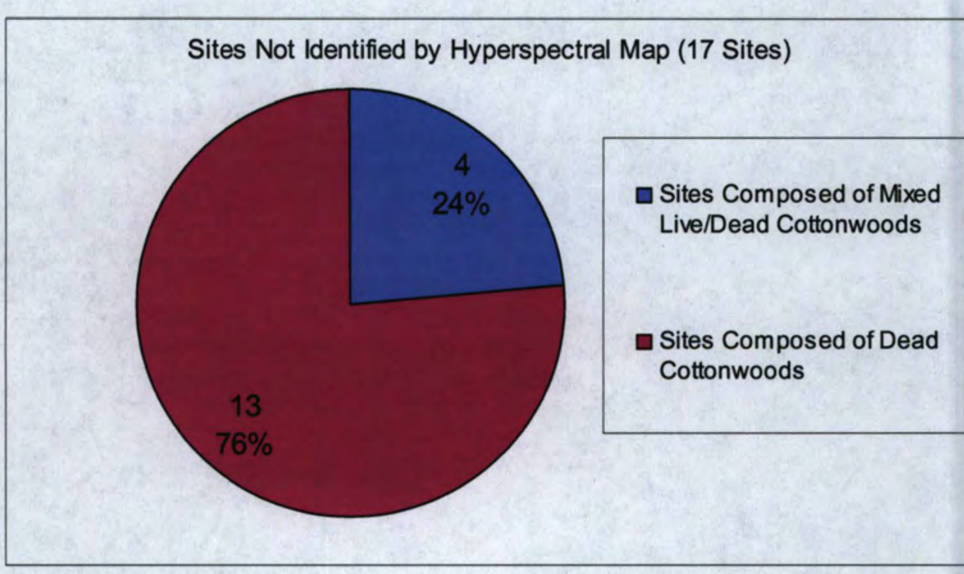


Figure 5. Number of live and dead cottonwoods identified by hypmap in relation to the number of live and dead cottonwoods not identified by hypmap in study area.

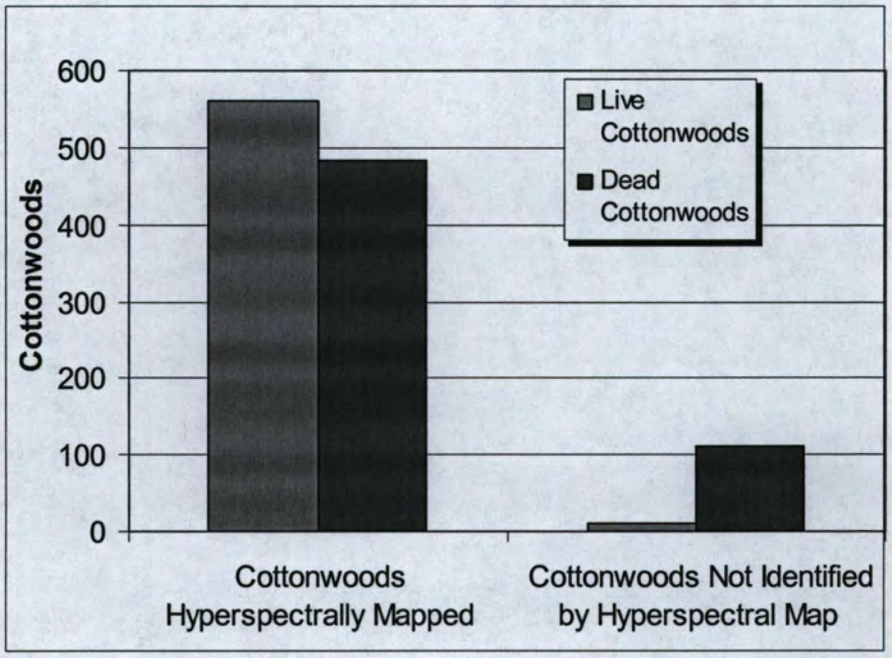


Figure 6. Lewis' woodpeckers significantly preferred isolated burned cottonwoods not closely affiliated with live cottonwoods when taking into consideration amount of sites not identified by hypmap (17) to sites identified by hypmap (36).

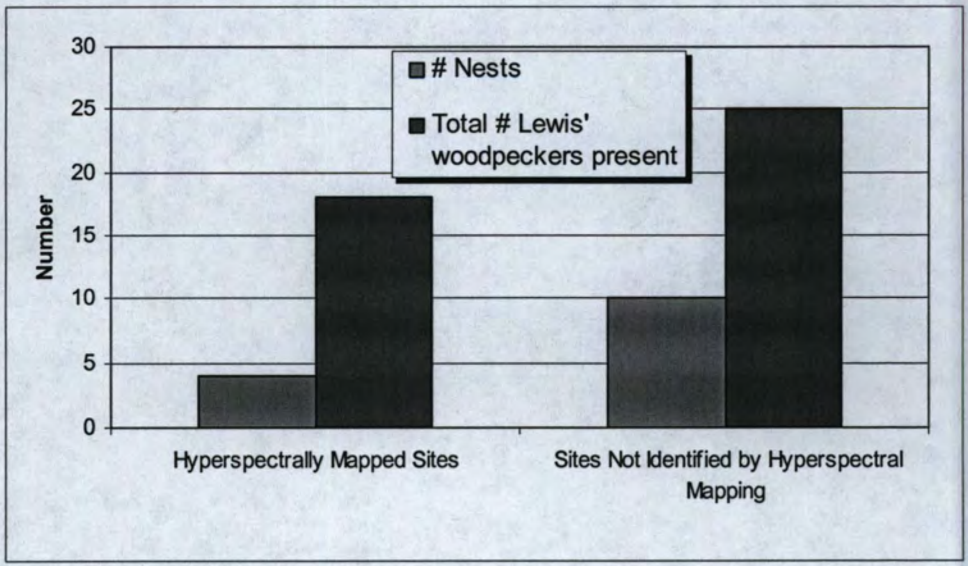


Table 1. Distribution of cottonwoods, Lewis' woodpecker nests, and Lewis' woodpecker use according to site type.

	Hypmap Cottonwood Sites	Non Hypmap Cottonwood sites *(completely dead)*	Non Hypmap Cottonwood sites *(with live cottonwood present)*	total
Sites	36	13	4	53
# of Nests	4	9	1	14
Total Lewis' woodpeckers present	18	22	3	43
Live Cottonwoods	561	0	10	571
Dead Cottonwoods	485	89	21	595
Total Cottonwoods	1046	89	31	1166

Legend for Appendix A, B

Sites	Species Composition	Bark
Red = Overpredicted Sites	0 = Birch	0=Intact
Black = Mixed (dead/live) Cottonwoods	1 = Cottonwood	1 = Partial
Blue = Completely Live Cottonwoods	2 = Aspen	2 = Not Present
Green = Completely Dead Cottonwoods		

Appendix A.

Hyperspectral Sites							
site #	**Species Composition**	**#Live**	**#dead**	**Bark**	**# Lewis' Observed**	**Active Nest**	**DBH (cm)**
1	0	0	0	-	-	-	-
2	0	0	0	-	-	-	-
3	0	0	0	-	-	-	-
4	1	4	7	0	0	-	-
6	1	2	2	1	0	-	-
8	1	1	0	0	0	-	-
9	1	3	12	0	0	-	-
10	1	21	1	2	0	-	-
41	1	0	19	1	0	-	-
12a	1	73	0	0	0	-	-
12b	1	131	0	0	0	-	-
12c	1	108	0	0	0	-	-
13	1	10	9	1	3	suspect	-
14	0	0	0	-	0	-	-
15	0	0	0	-	0	-	-
16	1,0	0	2	2	0	-	-
17	1	34	209	0	1	-	-
18	1	15	61	0	0	-	-
19	1,2	12	17	0	3	1	48.38
20	1	3	32	1,2	4	2	100.90
							102.17
21	1,2	7	3	0	0	-	-
22	1	20	87	1	4	1	77.98
23	1	11	4	0	1	suspect	-
24	0	0	0	-	-	-	-
25	2	0	0	-	-	-	-
27	1	0	2	0	0	-	-
37	1	12	4	0	0	-	-
43	1	38	2	0	1	-	-
44	1	18	7	0	1	-	-
45	2,0	0	0	-	-	-	-
46	1	8	3	0	0	-	-
47	1	10	2	0	0	-	-
48	1	1	0	0	0	-	-
49	1	15	0	0	0	-	-
53	0	0	0	-	-	-	-
54	0	0	0	-	-	-	-
55	0	0	0	-	-	-	-
56	1	4	0	0	0	-	-

Appendix B.

Cottonwood Sites Not Identified by Hyperspectral Imagery

site #	Species Composition	# Live Cottonwoods	# Dead Cottonwoods	Bark	# observed	Active Nest	DBH (cm)
5	1	0	2	0	0	-	-
7	1	0	3	1	0	-	-
42	1	0	20	0	0	-	-
11	1	0	17	1	3	1	31.83
26	1	0	5	2	0	Suspect	-
28	1	0	1	1	0	-	-
29	1	0	1	2	0	-	-
30	1	0	1	2	2	1	72.26
31	1	0	19	1,2	7	3	53.48
							0.43
							0.43
32	1	0	2	0	2	1	66.85
34	1	1	2	0	0	-	-
35	1	0	9	1	2	1	82.76
36	1	1	3	1	2	1	79.58
38	1	0	5	2	3	2	100.27
							100.00
39	1	0	4	1	3	-	-
50	1	7	11	0	0	-	-
51	1	1	5	0	1	-	-

Appendix C.

NEST SITES
Site Type
1 = hyperspectral sites
0 = Cottonwood sites identified by ground reconnaissance

site #	Site Type	DBH (cm)
11	0	31.83
19	1	48.38
20	1	100.90
20	1	102.18
22	1	77.99
30	0	72.26
31	0	53.48
31	0	42.97
31	0	42.65
32	0	66.85
35	0	82.76
36	0	79.58
38	0	100.27
38	0	100.27

Appendix D. UTM Coordinates of Sites

Hypmap site UTM coordinates were obtained from the imagery and have an accuracy of approximately 30m. Cottonwood sites identified by ground reconnaissance will have accuracy within 10m unless otherwise stated and represent true ground coordinates. UTM coordinates denoted in *italics* represent location of nest tree within site.

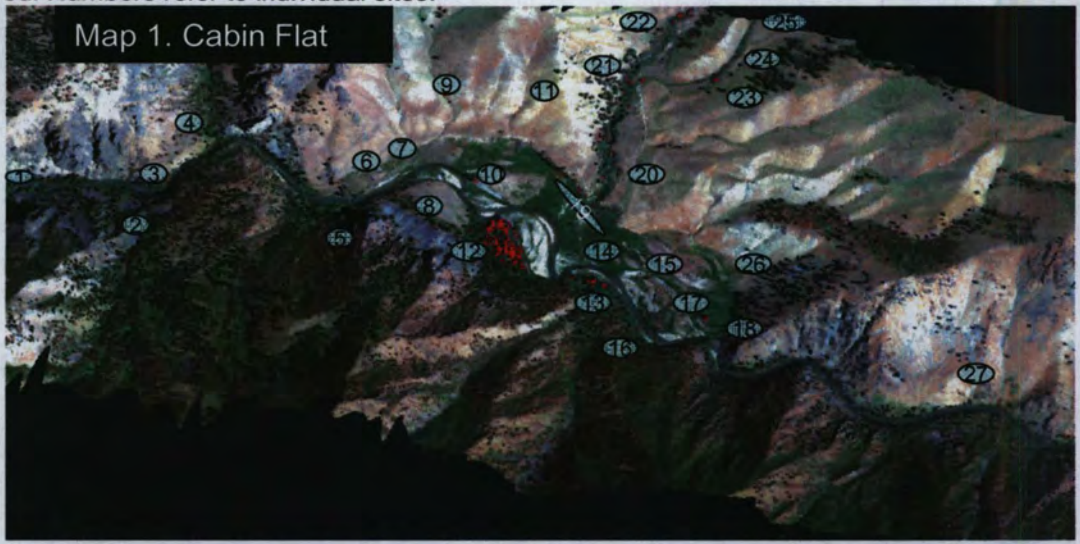
Site Type
o = overpredicted hypmap site
h = hypmap cottonwood site
gr = cottonwood site identified by ground reconnaissance

Site Type	Site No.	UTM Coordinates		
		Easting	Northing	
o	1	**660074**	**4999486**	
o	2	**660398**	**4999406**	
o	3	**662477**	**4998943**	
h	4	**660746**	**4999690**	
gr	5	**661232**	**4999399**	(40m accuracy)
gr	6	**661366**	**4999498**	
gr	7	**661532**	**4999543**	
h	8	**661590**	**4999502**	
h	9	**661666**	**4999861**	
h	10	**661774**	**4999486**	
gr	11	*661903*	*4999753*	
h	12a	**661922**	**4999262**	
h	13	**662250**	**4999006**	
o	14	**662182**	**4999142**	
o	15	**662466**	**4999018**	
h	16	**662418**	**4998774**	
h	17	**662554**	**4998886**	
h	18	**662694**	**4998822**	
h	19	*662207*	*4999421*	
h	20	*662300*	*4999543*	
		662296	*4999464*	
h	21	**662390**	**4999974**	
h	22	*662581*	*5000258*	
h	23	*662714*	*4999970*	(possible nest)
o	24	**662814**	**5000110**	
o	25	**662878**	**5000258**	
gr	26	**662825**	**4998965**	
h	27	**663866**	**4998414**	
gr	28	**664698**	**4997928**	
gr	29	**664755**	**4997638**	
gr	30	*665924*	*4997177*	
gr	31	*666320*	*4997039*	
		666357	*4997100*	
		666397	*4997126*	
h	32	*666688*	*4997014*	

h	34	**667950**	**4996882**	
gr	35	*668201*	*4996307*	
gr	36	*666357*	*4997100*	
h	37	**668165**	**4996557**	
gr	38	*668711*	*4996779*	(two nests on same tree)
gr	39	**668132**	**4996839**	
h	41	**661955**	**4999656**	
gr	42	**661728**	**4999701**	
h	43	**668950**	**4996706**	
h	44	**669030**	**4996754**	
o	45	**669026**	**4996546**	
h	46	**669054**	**4996454**	
h	47	**669150**	**4996730**	
h	48	**669158**	**4996782**	
h	49	**669242**	**4996614**	
gr	50	**669421**	**4996618**	
gr	51	**669502**	**4996622**	
o	53	**670678**	**4996610**	
o	54	**670838**	**4996594**	
o	55	**671097**	**4996730**	
h	56	**671379**	**4996878**	

Site Maps 1-5

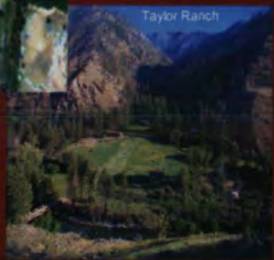
SAM representation of cottonwood signatures in study area. Cottonwood pixels denoted in red. Numbers refer to individual sites.



Map 4. Taylor Ranch

Map 5. Below Taylor Ranch to Cougar Creek

Hyperspectral Map of Taylor Ranch Cottonwood Distribution



Assessing Lewis' Woodpecker Habitat Using Hyperspectral Imagery

Stephanie Jenkins
DeVlieg Undergraduate Research
Major: Natural Resource Ecology
Minor: Fire Ecology and Management

University of Idaho

Hyperspectral Map of Cabin Flat Cottonwood Distribution

Abstract

While Lewis' Woodpecker populations are declining in certain geographic areas, Lewis' have appeared to increase in number in the Big Creek Drainage of the Frank Church River of No Return Wilderness. This may be due to the presence of burnt cottonwood snags from recent wildfires of 2000 that offer potential habitat for Lewis'. Hyperspectral imagery was used to identify cottonwood (*Populus trichocarpa*) distribution and Lewis' use of cottonwoods in the study area was recorded. Although hyperspectral imagery can be used to accurately map live cottonwoods and was shown to lead to the location of dead cottonwoods, it was not an accurate indicator of Lewis' habitat.

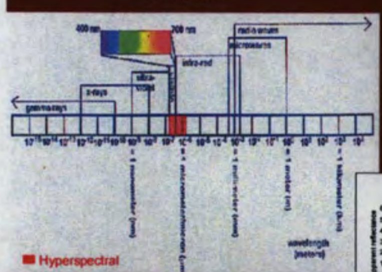
Objectives

- Assess accuracy of mapping live cottonwood distribution
- Determine if dead cottonwoods are identified by mapping of live cottonwoods
- Evaluate Lewis' woodpecker use

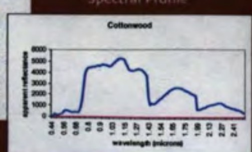
Hyperspectral Imaging

- Remote sensing technique
- Acquired on June 30, 2002 using HyVista's airborne hyperspectral sensor HyMap
- Collects information from the electromagnetic (EM) spectrum using 126 bands covering the 0.44 μm – 2.5 μm spectral region
- Measures solar absorption and reflection data on ground surface features in 4m. pixels

Light Spectrum



Spectral Profile



Background

A live cottonwood spectral profile was used to generate hyperspectral maps of cottonwood distribution. These hyperspectral sites represented live cottonwoods, but may contain dead cottonwoods. After ground surveys, dead cottonwoods not identified by hyperspectral remote sensing because of isolation from live cottonwoods were recorded as *unmapped* sites.

Lewis' Woodpecker

Methods

- Map cottonwood distribution using hyperspectral imagery
- Ground truth study area for accuracy
- Survey study area for additional cottonwoods
- At each site record:
  - GPS location
  - Number of live/dead cottonwoods
  - 30 minute Lewis' woodpecker survey
    - Record data for presence/absence, #, behavior, and active nest

Results

- 53 sites
  - 36 Hyperspectral mapped sites
    - 5 Completely live sites
    - 3 Completely dead sites
    - 17 Mixed live/dead sites
    - 11 Overpredicted sites
  - 17 Unmapped sites
    - 13 Completely dead sites
    - 4 Mixed live/dead sites
- Accurately mapped 98% of live cottonwoods
- 80% of Hyperspectral mapped sites contained dead trees
  - Dead trees ranging from 8%-100% of total trees on site
- Lewis' woodpecker use
  - 14 nest sites located in burned cottonwood snags
  - 4 in Hyperspectral sites 10 in Unmapped sites

Results	Hyperspectral Cottonwood Sites	Unmapped Cottonwood Sites
Total % of Dead Cottonwoods	46%	92%
% Sites with Dead Cottonwoods	80%	100%
% Sites with Nest Present	16%	59%
% Sites with Lewis' Activity	52%	65%

Conclusion

Live cottonwood distribution was accurately mapped using hyperspectral remote sensing. Hyperspectral imagery can be used to locate dead cottonwoods in association with live cottonwoods. Lewis' use was documented in hyperspectral sites, however Lewis' nests were primarily located in isolated cottonwood snags not defined by hyperspectral imaging. Hyperspectral mapping of live cottonwoods led to the location of dead cottonwoods, but was not an accurate indicator of Lewis' habitat.

Acknowledgements

- DeVlieg Foundation
- Janet DeVlieg Pope
- Jim and Holly Akenson
- Jeremy Shive, ISU
- Taylor Ranch interns and employees: Corey Shake, Mackenzie Shardlow, Rafi Mehdura
- Dr. Jeff Braatne