TFW-WL3-98-001

Effectiveness of Riparian Management Zones in Providing Habitat for Wildlife

TIMBER/FISH & WILDLIFE

A Workshop

October 14-15, 1998 - Ellensburg, Washington

EFFECTIVENESS OF RIPARIAN MANAGEMENT ZONES IN PROVIDING HABITAT FOR WILDLIFE

AGENDA

WEDNESDAY, OCTOBER 14 **Lombard Room**

8:00-10:00 Registration at Courson Conference Center

9:00-9:30 Introductions and CMER/TFW and RMZ Project Background

Doug Rushton, CMER Chair
Lenny Young, DNR

Riparian Buffers- overview

Peggy O'Connell, Eastern Washington University

9:30-10:00 Study Design - general experimental approach and buffer design

Westside	Steve West, University of Washington
Eastside	Peggy O'Connell

10:00-10:15 Break

10:15-10:45 The Habitat: structure and vegetation response to treatments

Westside	Kathryn Kelsey, University of Washington
Eastside	Jim Hallett, Washington State University

10:45-12:00 Vertebrate Response I: effects of riparian vs. upland habitat

Westside	Dave Manuwal, University of Washington, Birds Kathryn Kelsey, Amphibians Steve West, Small Mammals
Eastside	Peggy O'Connell and Jim Hallett

12:00-1:00 Lunch at the Tunstall Dining Hall

1:00-2:15 Vertebrate Response II: effects of alternate buffer designs

Westside — Dave Manuwal, Birds
Kathryn Kelsey, Amphibians
Steve West, Small Mammals

2:15-2:30 Break

2:30-3:30 Vertebrate Response II: effects of alternate buffer designs

Eastside — Peggy O'Connell and Jim Hallett

3:30-4:30 Summary and Management Implications

Steve West and Peggy O'Connell

5:00-6:00 Dinner at the Tunstall Dining Hall

THURSDAY, OCTOBER 15 **Lombard Room**

7:00-8:00 Breakfast at the Tunstall Dining Hall

8:30-12:00 Panel Discussion

Moderator: Jon Gilstrom, US Fish & Wildlife Service

Lorin Hicks, Plum Creek Timber Company
David Jennings, Black Hills Audubon Society
John Lemkuhl, USDA Forest Service
Peggy O'Connell, Eastern Washington University
Tim Quinn, Washington Department of Fish & Wildlife
Lenny Young, Washington Department of Natural Resources
Joe Weeks, Colville Confederated Tribes
Steve West, University of Washington

10:00-10:30 Break

12:00 Adjourn

INTRODUCTION TO THE WORKSHOP

The managed forests of Washington State encompass approximately 17.9 million ha of which about 51% are managed by the State, tribal, and private landowners. The Timber Fish and Wildlife (TFW) Agreement of 1987 introduced both a framework for forest management practices on the State of Washington's state and private lands to protect natural and cultural resources within the context of the managed forest, and a mechanism to evaluate and modify management practices. The Agreement incorporated recommendations and guidelines for the protection of water, fish, wildlife, and archaeological resources. The representatives of state resource agencies, Native American tribal organizations, timber companies, and conservation organizations who forged this Agreement recognized both the immediate need for new forest management policies to protect these resources and the long-term need for these policies to be flexible and responsive to new information. Thus, a central feature of the TFW Agreement was the introduction of adaptive management to Washington State's natural resources. Adaptive management involves the continual evolution of management practices in response to scientific knowledge gained through careful monitoring of natural resources and well-designed experimental studies to evaluate how resources are impacted by management practices.

A set of management goals for the different resources provided the starting point for participants to develop the TFW Agreement. For wildlife, the goal "... is to provide the greatest diversity of habitats (particularly riparian, wetlands, and old growth), and to assure the greatest diversity of species within those habitats for the survival and reproduction of enough individuals to maintain the native wildlife of Washington forest lands" (TFW Agreement 1987, p.2). Inherent in this statement was the recognition of the importance of maintaining habitat diversity to ensure wildlife species diversity and of the disproportionate importance of certain habitats, including riparian habitats. Given the importance of riparian habitats for some wildlife, it is critical that we understand wildlife response to habitat conditions created by management practices in riparian habitats. In an attempt to balance the wildlife goal with the timber resource goal, the TFW Agreement established Riparian Management Zones (RMZs) for the protection of riparian areas and recommended appropriate sizes, tree densities, and management practices for RMZs associated with several defined water types. These guidelines were incorporated into the Forest Practices Board Rules and Regulations. The goal of this project was to examine the effectiveness of RMZs in providing habitat for wildlife. The specific objectives were 1) examine the terrestrial vertebrate species richness and abundance of riparian and adjacent uplands in forests of western and northeastern Washington, 2) examine how different harvest practices in the riparian zone affect species richness, diversity, and abundance of terrestrial vertebrates, and 3) to examine the habitat correlates that might provide insight into the observed patterns of species richness, diversity, and abundance.

This workshop is organized into five main sections. First, we review information on the importance of riparian habitat for wildlife. Second, we describe our technical approach including experimental design, general sampling strategies, selection and general description of study sites, the design of Riparian Management Zones under the TFW Agreement, and the rationale and design of our Modified RMZs. Third, we present an overview of the habitat, comparing riparian versus upland vegetation and examining effects of harvest treatments on the vegetation. The fourth section presents our examination of the riparian vs. upland habitat associations of wildlife. In the fifth portion we present our findings on the effects of harvest treatment on the wildlife. Each section provides information on the results of the West-side portion and then the East-side portion of the research project. The final portion summarizes our management recommendations.

Riparian Habitats - General Background

Riparian zones are found adjacent to watercourses such as streams, rivers, springs, ponds, lakes, or tidewaters and represent the interface between terrestrial and aquatic environments. The riparian zone can be variously defined in terms of vegetation, topography, hydrology, or ecosystem function. The latter approach integrates the former factors and defines the riparian zone as the zone of interaction between the aquatic and terrestrial. This definition encompasses the concept that the terrestrial system influences the aquatic system and, in turn, is influenced by the aquatic system.

Watercourses associated with riparian zones have been variously classified.. For regulatory purposes, The Washington State Forest Practices recognizes five water types on the basis of size and presence of anadromous fish, with Type 1 corresponding to large rivers and shorelines and Type 5 to small headwaters that do not support fish. The function of the riparian zone is closely related to the size of the watercourse. In the Pacific Northwest, most riparian zones are found adjacent to streams and rivers and this is especially true for the forestlands of the region.

The structure and function of riparian zones are determined by several key elements: topography, surface water, soils, microclimate, and vegetation. The interaction between terrestrial and aquatic environments that occurs in the riparian zone is mediated by these elements. On one hand, they combine to create common features that distinguish riparian zones from upland areas. On the other hand, differences between these key elements result in differences observed among riparian habitats.

The hydrological, topographic, substrate, and microclimatic features of riparian zones result in distinctive physiological, compositional, and structural features of riparian vegetation. Riparian plant communities exhibit increased primary productivity relative to upland communities. Composition considers both the number of plant species and the abundance of each species. Riparian areas typically have greater species diversity than upland sites. Variation in the diversity of vegetation between riparian sites is related to a site's size, aspect, soil moisture, amount of woody debris, and time since disturbance. The riparian vegetation is composed of generalized species that inhabit both riparian and upslope sites, but are often more abundant in riparian areas because of favorable conditions, as well as specialized species that are found only in the moist riparian habitat. The structure of the vegetation refers to the horizontal and vertical stratification of the plant community. Riparian areas typically have greater structural diversity than upland sites and broader riparian zones have greater structural diversity than narrow, steep-sided riparian areas.

Many characteristics of riparian plant species and communities are shaped by the presence and flow of water; however, riparian vegetation, in turn, has a direct effect on stream structure and function. First, roots of riparian vegetation stabilize streambanks and stream beds that help define stream morphology and reduce erosion. Second, riparian vegetation is an important source of large organic debris (LOD) in Pacific Northwest streams. Third, standing riparian vegetation has an important effect on stream function. Riparian vegetation influences the chemistry of the stream through nutrient assimilation and transformation. Fourth, the shading of streams by riparian vegetation can affect water temperature, and the magnitude of the effect is directly related to stream size. The interaction between the terrestrial and aquatic environment which occurs in the riparian zone changes with stream size. On the one hand, stream size is one of the main factors determining the size of the riparian zone. Small streams produce smaller riparian zones than larger streams. On the other hand, the effect of the terrestrial system on the aquatic system is inversely related to stream size. The forest dominates in small streams, controlling the physical structure and energy base. Understanding this relationship between stream size and interaction between aquatic and terrestrial systems is important when we examine the effects of disturbance in the riparian zone.

Riparian zones are a product of disturbance and an understanding of how natural disturbance affects riparian zone structure and function provides insight into how human activities can alter riparian zones. In Pacific Northwest forests natural disturbances such as flooding, fire, and wind, vary in frequency, magnitude, and relative importance in upland versus riparian areas.

Although riparian habitats are the products of disturbance, they can also be especially susceptible to human disturbance because 1) humans are attracted to and therefore concentrate many activities in riparian habitats, 2) riparian habitats constitute a relatively smaller amount of area than upland areas, 3) the long, thin shape of riparian areas creates extensive interface with upland areas and makes riparian areas vulnerable to upland disturbances, 4) riparian habitats support a unique flora that is often sensitive to disturbance. Human impacts on riparian habitats are varied and include timber harvesting, livestock grazing, road building, impoundments, channelization, introduction of toxic compounds, hunting and fishing, and non-consumptive.

The impact of timber harvesting in riparian and adjacent upland habitats varies with the type of harvest and characteristics of the watershed. The effects of timber harvesting can include: increase in water temperature, increase in sedimentation, changes in stream flow, microclimatic changes, and alteration of the composition and structure of plant communities. Maintenance of vegetative buffer zones adjacent to streams can decrease many of these negative impacts.

Anthropogenic modifications potentially reduce the value of riparian habitat for native wildlife. The high value of riparian habitats to wildlife has long been recognized by naturalists. Quantitative studies conducted during the past several decades, especially in relatively arid regions, have generally supported observations and have identified biological and physical attributes of riparian habitats which enhance their value to wildlife. In particular, wildlife respond to 1) the presence of open water, 2) increased food availability, 3) the breeding, hiding, and escape habitat created by the water and vegetation structural complexity, 4) the natural edge habitat, and 5) the natural travel and migration routes of riparian habitats Riparian areas provide habitat for many wildlife species, but assessing the relative value of a particular riparian area for wildlife must take into account a variety of ecological characteristics. Therefore, habitat management of riparian areas becomes a critical element of wildlife management. To mitigate the effects of timber harvesting in managed forests many states have adopted the use of buffer zones along streams. The primary intent of mandating buffer zones along streams has often been the preservation of water quality and fisheries habitat. The maintenance of buffer zones can also benefit terrestrial wildlife species, but the effectiveness of these buffers must take into account a variety of factors.

In the managed forests of the Pacific Northwest buffer zones can serve two distinct roles. Historically, when the prevailing successional stage in PNW was old forest, a function of riparian zones was to provide refugia for species characteristic of early successional stages. Aside from the presence of water, the unique features of riparian zones centered on the admixing of early successional characteristics within old forests. The presence of such areas was especially important for the continued existence of species with limited powers of dispersal. For example, the small strips of open ground supporting grasses and herbs were needed by herbivorous small mammals, which survived at low population densities in such areas, and from which they could rapidly colonize large areas after forest disturbance. With the maintenance of riparian buffer zones in managed forests, a second function envisioned for riparian zones is in providing elements of old forest in a predominantly young forest landscape. Forest harvest, which creates riparian buffer zones in managed forests, however, results in the fragmentation of existing habitat. This leads to the creation of a mosaic of forest patches which are scattered over the landscape and which vary spatially and temporally. Fragmentation of forest habitats results in a reduction in total area of forest habitat, an increase in the amount of edge between previous and newly created habitats, and an increase in isolation of remaining forest patches. Examination of the effectiveness of riparian buffer zones in the two above mentioned functions must therefore take into consideration the effects of forest fragmentation on wildlife. In particular, it is necessary to examine species-area relationships and the potential negative effects of increased induced edge. Considering the potential dual function of riparian buffer zones in providing habitat for both early and late successional species, managing for species diversity becomes a complex issue.

As background it might be helpful to realize that a riparian zone will be inhabited by three sorts of wildlife species. The first group includes riparian obligates. The second, and larger group of species, are those that are characteristic of the old successional stages. Numbers of these species will increase as the area of old forest available to them in the riparian zone increases, resulting in relatively few of these species in small forest blocks and generally a full complement of species in large blocks. These species might not require the resources of the riparian zone to survive, but will inhabit it and might even have more productive populations within the zone than in the adjacent uplands. The third group of species consists of those characteristic of early successional stages. They have an interesting relationship to riparian zones in that, as previously mentioned, riparian zones almost always provide some level of resources to support these species. This is the result of the periodic disturbance regimes characteristic of riparian zones. They will inhabit riparian zones embedded within old forest in small but persistent numbers. Should the adjacent forest be harvested, the forest successional sequence will be initiated, and these species will rapidly colonize these areas. Given this scenario, they might exert considerable pressure on the resources available to species characteristic of old forest which might be trying to exist within the riparian management zone. How much pressure they exert will be related to the width of the zone.

The potential negative impacts of forest fragmentation on wildlife, the unique features of the riparian habitat, and the dual function envisioned for riparian zones in providing wildlife habitat, require that careful attention be given to the design of buffer zones if they are to be effective in providing that habitat. Although there is general consensus for the need to provide riparian buffers in managed forests, there is much less agreement as to the size and desired characteristics of these buffers. As discussed in the following, our study incorporated a site-specific approach to riparian management, identifying and protecting habitat features of importance to wildlife.

Study Design—West Side

Stephen D. West

Statewide Project Objectives and Approach—The objectives of the statewide study were threefold:

1) to determine whether current Riparian Management Zone (RMZ) habitat specifications provide adequate habitat to maintain wildlife as specified in the TFW wildlife goal (TFW Agreement 1987, Wildlife Action Plan 1990), and if they do not,
2) to identify those habitat conditions created by current RMZ management practices that adversely affect species assemblages, and
3) to provide recommendations for improving RMZ guidelines.

This was approached on each side of the state in an experimental fashion by monitoring the population responses of selected wildlife species and species groups within riparian zones and nearby upland habitats on 18 sites of harvestable age. Six sites would be harvested according to RMZ guidelines current at the time, six according to modifications of the guidelines which the research team would design in cooperation with the Wildlife Steering Committee, and six would remain unharvested as controls. Wildlife monitoring would be for 2 years prior to and 2 years immediately after harvest. This strategy would establish the baseline conditions from which to compare future changes in the RMZ.

West Side Realities—Site selection for this project was difficult. Avian sampling was not done during spring and early summer of the first year because of the lack of sites. Thirteen sites were available for wildlife censusing during the fall sampling period of the first year, 1992. Trapping for small mammals and terrestrial amphibians was completed for all sites; stream surveys for aquatic amphibians were conducted on 12 sites; and bat echolocation surveys conducted on 10 sites. During the winter of 1992, we acquired the full complement of 18 sites (Table 1). Avian censusing was completed the following spring/early summer on all sites.

At the conclusion of state funding for the project (early summer 1993) we had one year's sampling stratified by riparian and upland habitat. Fortunately, cooperators (Washington Department of Natural Resources, The Washington Forest Protection Association, The Weyerhaeuser Company, and Plum Creek) funded the fall sampling period. Given delays in harvesting on four sites and funding shortfalls, we did not sample in 1994. Sampling resumed in 1995 on all but two sites, which were harvested in 1996. These sites were available for field sampling during 1997 and 1998. Funding for 1995 was provided by the Washington Forest Protection Association and the Washington Hardwoods Commission. Funding for 1996 was provided by the state, as was funding to complete the post-harvest sampling on the two remaining sites during 1997 and 1998. At present, we have full data (vertebrates and vegetation) for both post-harvest years, excluding the two sites for which we are completing field sampling this month.

The final report of the west-side portion of the study, which will incorporate data from all 18 sites, will be submitted early next calendar year.

Site Selection—Site selection criteria were chosen to make the study broadly applicable to forest lands in western Washington. In consultation with the Wildlife Steering Committee, we selected sites that had the following characteristics:

- low elevation (<620M)
- second-growth forest (55-65 years old), dominated by Douglas-fir
- Type 3 water by forest regulations; Type 4 could be chosen if streams differed only in the presence of salmonids
- predominately coniferous riparian canopy with deciduous tree component
- at least 500m in stream length
- road access within $\frac{1}{2}$ km
- could be harvested according to the project's specifications and time lines.

The selection process resulted in the 18 sites listed in Table 1.

Field Sampling—Due to the broad range of wildlife taxa, the field season extended from April until November. Vertebrate sampling occurred on the following schedule each year:

Mid-April - Early July	Breeding Bird Surveys: variable circular plots
Mid-June - End August	Bat Echolocation Surveys: echolocation detectors
Mid-July - Mid-September	Stream Amphibian Surveys: stream searches
Early October - Early November	Small Mammal and Terrestrial Amphibian Surveys: pitfall trapping

Vegetation sampling occurred during mid-July-August in 1993 (pre-harvest), 1996 (second post-harvest year), and in 1998 (second post-harvest year for the two late sites).

Table 1. West side study sites by treatment type, harvest completion date, and ownership

Abernathy	Control	No harvest	Washington State DNR
Blue Tick	Modified	Mar 1994	Washington State DNR
Elbe Hills	Control	No harvest	Washington State DNR
Eleven Creek 31	Modified	Sep 1994	Weyerhaeuser Company
Eleven Creek 32	State	Mar 1994	Weyerhaeuser Company
Griffen Creek	Modified	Mar 1994	Weyerhaeuser Company
Hotel Creek	Control	No harvest	Cedar River Watershed, Seattle
Kapowsin	State	Mar 1995	Champion Pacific Timberlands
Ms. Black	Modified	Jan 1994	Washington State DNR
Night Dancer	State	Mar 1995	Washington State DNR
Porter Creek	Control	No harvest	Washington State DNR
Pot Pourri	State	Mar 1994	Washington State DNR
Ryderwood 860	Modified	Mar 1994	International Paper/Hampton Tree Farms
Ryderwood 1557	State	Jun 1994	International Paper/Hampton Tree Farms
Side Rod	Modified	Mar 1994	Washington State DNR
Simmons Creek	State	Mar 1994	Plum Creek Timber
Taylor Creek	Control	No harvest	Cedar River Watershed, Seattle
Vail Control	Control	No harvest	Weyerhaeuser Company

Study Design —East Side

Margaret A. O'Connell and James G. Hallett

The East Side study focused on the forests of the Selkirk Mountains of northeastern Washington. Forests in this region are managed primarily by the USDA Forest Service, the WA Department of Natural Resources, USDI Fish and Wildlife Service, private timber companies, and several Native American tribal organizations. Successful identification and selection of study sites and implementation of the study design was dependent upon the cooperation of many parties. We gratefully acknowledge this cooperation.

Site Selection —Selection of the 18 study sites was based on the following criteria: 1) managed forests of harvestable age, 2) $\geq$ 800m reach of Type 3 or permanent Type 4 stream, 3) $\geq$ 16.2 ha previously harvested stands on either side of stream, 4) mixed coniferous forests, 5) > 600 and < 1200 m elevation, and 6) landowners agreed to either leave sites unharvested for 10 years (controls) or to harvest sites within timeframe and specifications of study design.

Initially we had planned to have 6 sites in each of the 3 treatments, but harvest schedules on one of the Modified RMZ sites could not be accommodated, resulting in 7 Control, 6 State RMZ, and 5 Modifid RMZ. The 18 sites are listed in Table 1.

Table 1. East side study sites ownership and treatment type.

Stream	Ownership	Treatment
Amazon	DNR	State RMZ
Bear	USFWS	Control
Browns	USFWS	Control
Buck East	Boise Cascade	Modified RMZ
Buck West	Boise Cascade	State RMZ
Butte	USFS	Modified RMZ
Calispell	USFS	Control
Cee Cee Ah	Plum Creek	Modified RMZ
Chewelah	USFS	Control
Middle	DNR	State RMZ
Mill	USFS	Modified RMZ
Muddy Control	DNR	Control
Muddy East	DNR	State RMZ
Muddy West	DNR	State RMZ
Power	USFS	Control
Rocky Control	USFS	Control
Rocky Cut	USFS	Modified RMZ
Sherry	DNR	State RMZ

Upland harvest —The harvest prescription of the upland harvest on the East Side cut sites was a partial cut yielding a 6-12-m spacing.

Riparian Harvest —The riparian zones of the 6 RMZ sites were harvested in strict accordance with the Washington State Forest Guidelines for buffer width and number of leave trees. The riparian zones of the 5 Modified RMZ sites were harvested according to a harvest prescription that we designed after examination of the initial years' data and in consultation with the TFW Wildlife Steering Committee and landowners. The intent of this harvest was to incorporate a site-specific approach to riparian management. We identified habitat features of importance to wildlife - snags, seeps, deciduous trees and shrubs - and provided for the protection of these elements when present.

Timeframe—All cut sites were harvested between fall 1993 (after sampling) and summer 1994. Vertebrate population sampling took place during spring-early summer of 1992-1996. Vegetation sampling took place before and after timber harvest.

Riparian and Adjacent Upland Habitat Characteristics

Kathryn A. Kelsey and Stephen D. West

We documented characteristics of riparian and adjacent upland habitats to better understand habitat changes following timber harvest and vertebrate responses to these changes.

Methods-- Sampling quadrats were placed along riparian and upland transects relative to avian point count stations on both sides of the stream (Figure 1). At each survey area, four 8x10 m quadrats were delineated. Quadrats paralleled the stream for 10 m and ran 8 m perpendicular to the stream. Twelve sampling stations were located on each riparian transect and ten were located on each upland transect. We measured ground cover characters using 1x1 m and 2x2 m nested plots. Downed wood, shrub, snag, and tree measures were taken in the four quadrats.

Riparian vs. upland habitats-- Riparian areas are characterized by significantly greater numbers of red alder trees *(Alnus rubra),* berry-producing and other deciduous shrubs, herbs, ferns, bare soil, and rock than upland habitats (Table 1). Upland habitats had significantly greater numbers of western hemlock trees *(Tsuga heterophylla),* snags, litter cover and depth, and higher canopy cover.

Treatment effects-- Following timber harvest, riparian areas remained dominated by red alder. The width of the buffer strip was significantly greater at modified sites (mean 30.5 m, sd 9.87) than state sites (mean 13.7 m, sd 5.93; Table 2). Likewise, riparian canopy cover differed significantly among treatment types (Table 2). Control sites provided 90-100% canopy cover within riparian areas while state buffer sites provided less than 50% cover. Modified buffers ranged from 40-90% cover. Percent cover of ferns, moss, and bare soil decreased significantly while litter cover and berry producing shrubs increased within riparian areas at treatment sites.

Table 1: Habitat measures that differed significantly among riparian and upland transects. Ground cover was measured as percent cover except for litter depth. Snags were grouped according to diameter at breast height (DBH) and decay class (dc1: structurally sound; dc2: losing limbs and showing reduced structural integrity, dc3: about to fall down due to minimal structural integrity). Trees were classified by species (ALRU: *Alnus rubra;* PSME: *Pseudotsuga menziessei;* TSHE: *Tsuga heterophylla)* and diameter class.

Habitat Category	Parameter Measured	R vs. U	*P*-value
Ground Cover	herbs	R > U	<0.001
	soil	R > U	0.031
	rock	R > U	0.009
	ferns	R > U	0.056
	berry-producing shrubs	R > U	<0.01
	other deciduous shrubs	R > U	<0.05
	litter	R < U	<0.001
	litter depth	R < U	0.064
Snags	<10 cm DBH, dc2	R < U	0.038
	10-50 cm DBH, dc3	R < U	0.026
	>50 cm DBH, dc3	R < U	0.001
	>50 cm DBH, dc3	R < U	0.01
	<10 cm DBH, dc1	R < U	0.09
	10-50 cm DBH, dc2	R < U	0.069
	<10 cm DBH, dc2	R < U	0.081
	<10 cm DBH, dc1	R < U	0.059
	10-50 cm DBH, dc1	R < U	0.01
	10-50 cm DBH, dc1	R < U	0.001
	10-50 cm DBH, dc2	R < U	0.012
	10-50 cm DBH, dc1	R < U	0.009
	10-50 cm DBH, dc2	R < U	0.019
Tree Counts	ALRU, 10-50 cm DBH	R > U	0.002
	PSME, 50-100 cm DBH	R < U	0.002
	TSHE, 10-50 cm DBH	R < U	0.001
	PSME, 10-50 cm DBH	R < U	0.098
	TSHE, <10 cm DBH	R < U	0.071
	TSHE, 50-100 cm DBH	R < U	0.06
	% canopy cover	R < U	0.016

Table 2: Mean difference of habitat measures that differed significantly among treatment types (ANOVA, Tukey's HSD-test, $P < 0.10$). Values are standardized by pre-harvest year. Means of one habitat type (i.e., riparian, upland) sharing the same letters do not differ. Riparian shrubs, snags, trees, and downed wood were measured within 8 m of the stream (Streamside) and 8-16 m from the stream (Transition Zone). Snags and downed wood were grouped according to diameter and decay class (dc1: structurally sound; dc2: losing limbs and showing reduced structural integrity, dc3: limbless with minimal structural integrity). Trees were classified by species (ALRU: *Alnus rubra;* ACCI: *Acer cercinatum;* TSHE: *Tsuga heterophylla)* and diameter class.

Habitat Category	Variable Measured	Riparian			Upland		
		Control	Mod.	State	Control	Mod.	State
	Canopy Cover	-2.28a	-33.12b	-61.13c	14.54a	-75.77b	-97.967b
	Buffer Width		15.50a	34.75b			
Ground Cover	Fern	3.82a	-10.81b	-14.56b	0.09a	-18.21b	-15.95b
	Moss	-2.559a	-10.30ab	-13.64b	-2.73a	-13.85ab	-19.15b
	Grass				-0.12a	1.12b	0.29ab
	Lichen				0.34ab	0.45a	-0.16b
	Litter	9.84a	27.70b	23.57ab			
	Soil	3.94a	-1.75b	-1.84b			
	Rock				0.76a	-0.26b	0.01ab
Tall Shrubs	Streamside, Berry-Producing	-21.76a	-3.10b	-3.98b			
Tree Regener.	ACCI, Transition Zone	0.67a	-0.79ab	-2.00b			
Downed Wood	10-30 cm, DC1, Transition zone	0.08a	0.31a	3.37b			
	10-30 cm, DC3, Transition Zone				3.07a	-0.22b	-0.56b
	>30 cm, DC1, Transition Zone	0.08a	0.35ab	1.71b			
Snags (1.5-15 m)	10-50 cm DBH, DC2, Streamside	1.33a	1.67a	-2.60b			
	10-50 cm DBH, DC3, Streamside				2.83a	-2.00b	-3.20b
	>50 cm DBH, DC3, Streamside	2.33a	0.50a	-2.60b	2.17a	0.17ab	-2.60b
	10-50 cm DBH, DC2, Transition Zone	0.17a	2.50a	-4.40b	4.33a	-3.5b	-4.00b
	10-50 cm DBH, DC3, Transition Zone	0.50a	2.00a	-1.80b	2.50a	-1.17b	-1.80b
	>50 cm DBH, DC3, Transition Zone	1.50a	0.17a	-3.00b	3.67a	-0.17b	-3.80c
Snags (>15 m)	10-50 cm DBH, DC3, Transition Zone				0.67a	-1.17b	0ab
Tree Counts	TSHE, <10 cm, Streamside	3.33a	4.83a	33.80b			
	TSHE, 10-50 cm, Streamside	6.17a	1.33a	-9.60b			
	TSHE, 10-50 cm, Transition Zone	5.67a	-6.00ab	-20.00b			
	TSHE, 50-100 cm, Transition Zone	3.83a	-1.00b	-0.6b			
	ALRU, <10 cm, Transition Zone	0.50a	15.83b	-0.40a			

[1]Upland tree count statistics are not included because the treatment prescription was to clearcut upland areas.

The Habitat: Structure and Vegetation Response to Treatments–East Side

James G. Hallett and Margaret A. O'Connell

The differences between riparian and adjacent upland habitats are considered to be primary determinants of the patterns of vertebrate distribution and abundance in these areas. This study characterized structural and floristic habitat features on riparian and upland transects at 18 stream sites in northeastern Washington. Six sites were harvested under State guidelines for creation of riparian management zones (RMZs) and five were harvested under a modified prescription developed for this research; seven sites were unharvested controls. We compared conditions in riparian and upland habitats before and after harvest and between treatments.

Methods— To examine structural habitat characteristics, we established 16 × 20-m plots at 50-m intervals along riparian (8 m from the stream) and upland (100 m upslope) transects for a total of 15 riparian plots and 15 upland plots per site. Within the plots, we measured shrub dispersion, shrub height and area, and percentage of overstory and understory canopy cover. We tallied numbers of logs in four diameter and length classes and four decay classes, living and dead trees in four size classes, and regenerating conifers. To evaluate floristic diversity we established 30-m point-intercept transects between each of the vegetation plots for a total of 14 riparian and 14 upland transects per site. A point-intercept rod was lowered perpendicular to the transect at 0.5-m intervals and all vegetation (i.e., herbs, shrubs, ferns, grasses, and trees), woody debris, and substrate that the rod contacted was recorded by height class (1.5m, 1.0m, 0.5m, 0.25m, and 0 m). Litter depth was measured every 5 m on each transect. Vegetation measurements were conducted before and after harvest. After harvest on the Modified and State sites we measured the buffer width as the perpendicular distance from the stream to the edge of the riparian harvest unit. We measured the buffer width at 17 points spaced 50 m apart along the riparian transect. To characterize differences between riparian and upland habitats, we conducted analysis of variance (ANOVA) on the overall means of each habitat variable for each site and habitat type. We examined changes in habitat variables between pre- and post harvest, modified and state harvest, and riparian and upland habitats using factorial ANOVA. We used ANOVA to compare species richness between riparian and upland habitats and to examine changes in species richness due to harvest treatment.

Riparian vs. Upland Habitats—Relatively few structural differences were observed between the two habitats prior to harvest. Mean distance between shrubs was significantly greater in riparian than in upland habitats. Small diameter logs in decay class 2 were more common in the upland, whereas two classes of the largest diameter logs were more abundant in the riparian (Table 1). Natural stumps in advanced decay were more common in riparian areas. Overstory canopy cover was significantly greater in the riparian, but the magnitude of the difference was small. Deciduous trees < 25 cm DBH were more abundant in riparian than upland habitats, as were large conifers. Numbers of snags did not differ between upland and riparian except for the greater number of large (> 50 cm DBH) condition 2 trees in the riparian. Of the six taxa of deciduous trees, only alder and willow were broadly distributed across the 18 sites. Most of the 10 species of coniferous trees occurred across most sites, but stocking densities were quite variable. The principal exceptions were ponderosa pine and western white pine (Table 2A), which had limited distributions. Most of the 26 taxa of shrubs occurred on both riparian and upland transects. Mean species richness did not differ between the two habitats, but local species richness was greater on upland transects. The relative abundance of 11 of 17 (64.7%) of the more common shrubs was greater in upland than in riparian; whereas only 3 species were more abundant in the riparian. Of ca. 115 taxa of herbaceous plants, few were observed exclusively along riparian or upland transects. Both site and local species richness was greater on riparian than on upland transects. Additionally, 48.6% of all taxa were more abundant in the riparian, and only 18.9% of the taxa were more abundant in the upland habitat. Litter depth was similar between riparian and upland habitats when compared across all sites. The mean number of point intercepts of litter was greater in the upland than riparian habitat when compared across all sites.

Treatment Effects—The Modified harvest sites had wider, but considerably more variable RMZs than did State harvest sites. Otherwise, forest harvest had largely predictable changes on structural characteristics of the habitat. The removal of trees in the upland opened both understory and overstory canopies, and reduced the mean height of trees and snags. Harvesting activities also decreased the shrub layer, regenerating stems, and deciduous trees. Snags were lost in both habitats, but to a greater extent in the upland. These changes accentuated differences between upland and riparian habitats. Fresh down wood and stumps increased, especially in the upland. However, down wood in the older decay classes was generally reduced and remained higher in riparian areas. The numbers of cut stumps increased, particularly in the upland, but natural stumps in older decay classes were lost. Bare ground also increased in the upland.

There were few differences in habitat structure between State and Modified cut sites. Floristically, there were greater changes on the State harvest sites than on Modified or Control sites. These differences included reductions in the abundance of several shrub species in both upland and riparian habitats of State sites, which were not observed on Modified or Control sites. Additionally, most herbaceous species in the riparian zones of State sites were more abundant prior to harvest. Several weedy species increased in abundance or appeared for the first time after harvest.

Responses of Larval Stream Amphibians to Riparian Management Zones

Kathryn A. Kelsey

This research attempts to evaluate the effectiveness of riparian buffer strips along Type 3 streams in western Washington in protecting stream amphibians and in-stream habitat from any detrimental effects of clearcut logging. The work was undertaken because of the uniqueness of the stream amphibian community and the apparent vulnerability of larval stream amphibians to changes in stream habitat associated with clearcut logging.

Methods-- We surveyed stream amphibians and in-stream habitat at 12 sites in 1992, 18 sites in 1993 and 1995, and 17 sites in 1996. Stream amphibians were captured within two, 10 m stream reaches that were randomly selected each year. The 10 m reaches were characterized according to water width and depth, dominant substrate, and pool-riffle ratio. We placed 1/8th inch hardware cloth screens at the downstream end of the reach and roughly 3 m and 7 m from the downstream end. Within the 10 m reach, we removed all rock and pieces of wood. All amphibians observed within the 10m reach were captured, identified, weighed, and measured. The survey was judged complete once a final sweep of the entire 10 m by all surveyors revealed no new individuals. We replaced all rock and wood that had been removed and then released all animals captured. Stream habitat was measured five times at 100 m intervals within the study site. The following variables were measured: stream and bank slope gradients, volume and position of wood greater than 20 cm diameter, substrate composition, substrate embeddedness, bankfull width and depth, water width, undercut bank, bankslope failures, stream bank integrity, and water temperature.

Treatment effects-- Tailed frog *(Ascaphus truei)* and Pacific giant salamander *(Dicamptodon tenebrosus)* larvae accounted for more than 95% of amphibians found during stream surveys. We captured a total of 788 tailed frog tadpoles and 608 Pacific giant salamander larvae between 1992 and 1996. We found tailed frog tadpoles at 9 of 18 study streams: 5 of 7 control sites, 3 of 6 modified sites, and 1 of 5 state cut sites. Pacific giant salamander larvae were found at 13 of 18 study streams: 6 of 7 control sites, 4 of 6 modified buffer sites, and 3 of 5 state buffer sites. Tailed frog tadpole and Pacific giant salamander density did not differ significantly among treatment types (Figure 1). Habitat characters also showed no significant differences among treatment types following timber harvest.

Management implications-- Results suggest that both configurations of riparian buffer strips provide adequate habitat for tailed frog and Pacific giant salamander larvae and protect instream habitat conditions. However, tadpole density in treated streams decreased from 1995 to 1996. Because tailed frog tadpole densities in previous studies have declined following clearcut logging, we must view the results from this study cautiously and continue monitoring larval stream amphibian density for the next 5 to 15 years.

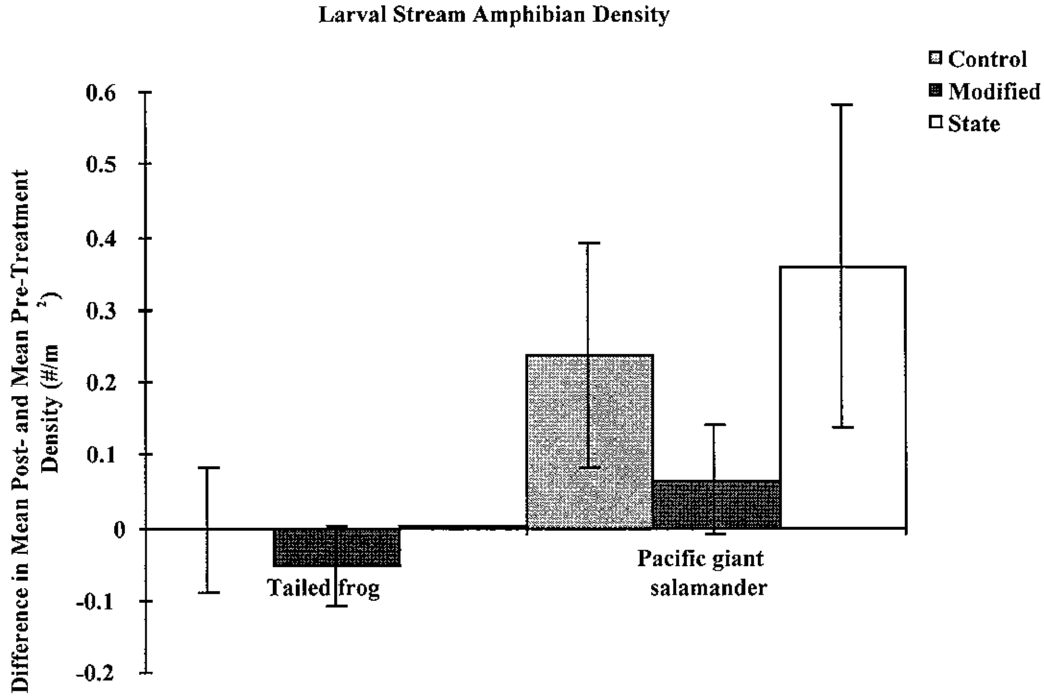

Figure 1: Mean (SE) density of larval tailed frogs and Pacific giant salamanders in streams with no treatment (control), modified cut (modified), or cut according to state forest practices regulations (state). Values are standardized by the pre-harvest year (the pre-harvest year is subtracted from the mean of the two post-harvest years). Positive values indicate an increase in density post-harvest and negative values indicate a decrease in density. Differences among treatment types were not significant ($P > 0.10$)

Use of Riparian and Adjacent Upland Habitat by Terrestrial Amphibians

Kathryn A. Kelsey

Terrestrial amphibians were included in this study to increase our understanding of amphibian 1) distribution in riparian and adjacent upland areas; 2) responses to two riparian buffer strip configurations; and 3) associations with habitat characteristics.

Methods-- To capture amphibians, we installed pitfall traps at study sites in transects that ran parallel to the stream at 5 m from the stream, riparian transects, and upland transects. Eighteen traps were placed within 5 m from the stream at 15 m intervals at 100 m from the stream (upland transect). All traps were placed at 15 m intervals and remained open for 28 days following the onset of fall rains. During the trapping period, field crews collected amphibians from traps once a week, identified, weighed, and measured total length and snout-vent length (from tip of snout to anterior tip of vent) on all amphibians. Live amphibians were released at the capture site when traps were closed. Dead amphibians were either preserved for the Burke Museum or the University of Washington Wildlife Sciences Program teaching collection or discarded. Thirteen sites were surveyed in 1992, 18 sites were surveyed in 1993 and 1995, and 17 sites were surveyed in 1996.

Riparian vs. upland habitats-- A total of 607 amphibians of 12 species were captured during pre-treatment sampling years. Amphibian species richness did not differ betweeen riparian and upland habitats prior to timber harvest (Figure 1). Pacific giant salamanders and red-legged frogs appeared to be more abundant in riparian areas when compared to uplands, although differences were not statistically significant. We captured significantly greater numbers of *Ensatina (Ensatina eschscholtzii)* salamanders and tailed frogs *(Ascaphus truei)* on upland transects.

Treatment effects-- A total of 868 amphibians of 13 species were captured during post-treatment sampling years. Mean amphibian species richness in riparian buffer strips and adjacent upland areas did not change significantly following timber harvest (Figure 1). State buffers had fewer total amphibian species (6 species) on riparian transects than modified buffers (8 species) or controls (9 species). Clearcut upland transects of both treatment types had fewer species of amphibians (modified-6, state-7) than at control sites (10). Captures of *Ensatina* salamanders on both riparian and upland transects were significantly greater on state and control sites when compared to modified buffer sites (Table 1). Riparian captures of red-legged frogs increased in modified buffer strips (Table 1). Upland captures of tailed frogs, red-legged frogs, and northwestern salamanders decreased following timber harvest at both treatment types, while western redback salamander captures increased (Table 1). Differences were not significant.

Management implications-- 1) amphibian responses may not become evident within two years of timber harvest because of limited adult movement and their ability to endure periods of unsuitable conditions; 2) riparian buffer strips appear to provide adequate habitat for terrestrial amphibians; 3) clearcut areas do not provide suitable habitat for tailed frogs and red-legged frogs.

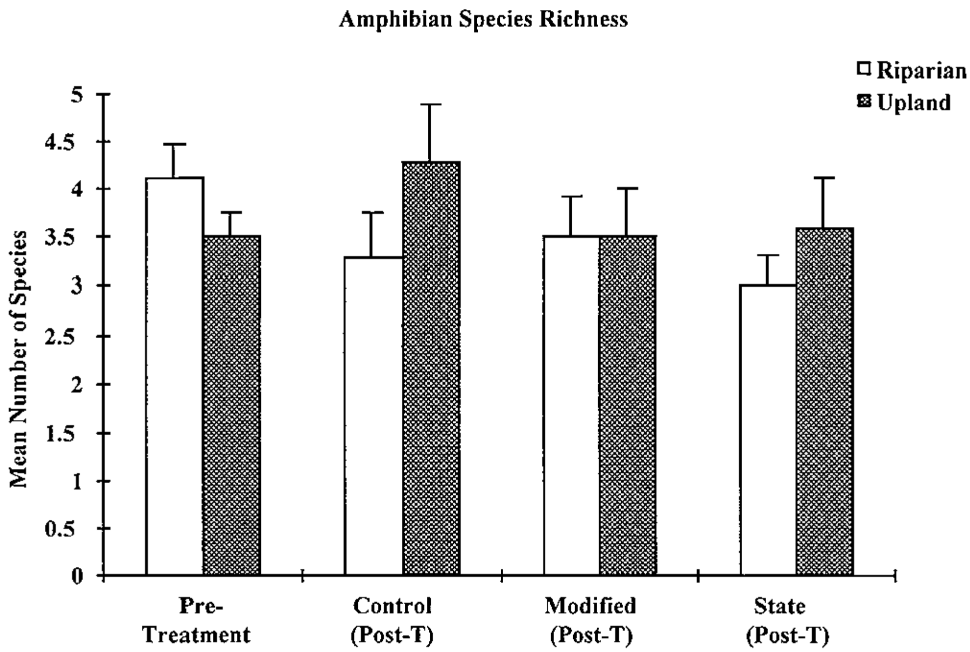

Figure 1: Mean (SE) number of amphibian species captured in riparian and upland habitats at all 18 sites prior to timber harvest (Pre-Treatment) and at 7 sites with no treatment (Control, Post-T), at 6 sites with modified cut (Modified, Post-T), and at 5 sites cut according to Washington state forest practices regulations (State, Post-T).

Table 1: Mean (SE) numbers of captures (abundance) of amphibians in riparian and upland habitats with no treatment (control), modified cut (modified), or cut according to state forest practices regulations (state). Values are standarrdized by pre-harvest year mean captures (mean pre-harvest captures is subtracted from mean post-harvest captures). Positive values indicate an increase in abundance post-harvest and negative values indicate a decrease. Only *Ensatina* salamanders showed statistically significant differences in mean captures.

Species	Riparian			Upland		
	Control	Modified	State	Control	Modified	State
Ensatina Sal.[1]	0.04(0.610)a	-0.16(0.070)b	0.10(0.054)a	-0.16(0.141)a	-0.41(0.270)a	0.51(0.241)b
Western Redback	0.40(0.158)	0.31(0.218)	0.80(0.179)	0.32(0.286)	1.12(0.936)	1.91(0.572)
Pacific Giant Sal.	0.00(0.057)	-0.03(0.028)	-0.06(0.138)	-0.03(0.034)	-0.07(0.042)	0.00(0.031)
Northwestern Sal.	-0.05(0.065)	-0.07(0.071)	-0.04(0.051)	0.00(0.021)	-0.20(0.134)	-0.10(0.126)
Tail Frog	-0.09(0.069)	0.00(0.026)	-0.002(0.055)	0.19(0.191)	-0.11(0.073)	-0.10(0.063)
Red-legged Frog	-0.05(0.057)	0.04(0.093)	-0.08(0.037)	0.14(0.075)	-0.05(0.134)	-0.22(0.135)

[1]Statistically significant differences in mean captures (ANOVA, Tukey test, $P < 0.05$), means sharing the same letters do not differ

Amphibians and Reptiles - East Side

Margaret A. O'Connell and James G. Hallett

The objectives of this study were to 1) to examine the species richness and abundance of amphibians and reptiles in riparian and upland habitats of managed forests in northeastern Washington and 2) compare species richness and abundance before and after different timber harvest treatments of the riparian forests.

Methods— Amphibians and reptile populations were sampled by pitfall trapping and time-constrained searches. Eighteen pitfall traps were placed at 15-m intervals on the riparian and the upland transect for a total of 36 pitfall traps per site. Amphibian and reptile populations were sampled by pitfall trapping for two weeks per site during June/July 1992-1996. Traps were checked every two days. This sampling effort yielded 9,072 trap nights per year and 45,360 trap nights for the duration of the study. Time-constrained searches were conducted during late May-mid June in 1992-1996. At 6 predetermined starting points along each transect an observer searched for 20 min for a total search time of 120 min per transect and 240 min per site per year.Abundance is presented as the number of animals per site per sample year. Given the low sample size, we provide only descriptive statistics.

Riparian vs. Upland Habitats—The abundance of amphibians and reptiles was very low. We captured a total of 131 amphibians of four species, the long-toed salamander (*Ambystoma macrodactylum*), the western toad (*Bufo boreas*), and the Pacific tree frog (*Hyla regilla*), and the spotted frog (*Rana luteiventris*). We captured 30 reptiles of seven species: western skink (*Eumeces skiltonianus*), northern alligator lizard (*Elgaria coerulea*), rubber boa (*Charina bottae*), racer (*Coluber constrictor*), bull snake (*Pituophus catenifer*), common garter snake (*Thamnophis elegans*), and western terrestrial garter snake (*Thamnophis sirtalis*). Before harvest, the species richness of amphibians was three times greater in the riparian ($\bar{X}$=2.6±0.86) than the upland ($\bar{X}$= 0.7±0.50) habitats. The abundance of the four amphibian species during the years before timber harvest was three times greater in the riparian ($\bar{X}$ = 1.5±0.87) than in the upland ($\bar{X}$ = 0.66±0.38) habitats. Three of the four amphibian species, *A. macrodactylum, B. boreas* and *H. regilla*, were found in both riparian and upland habitats. *R. luteiventris* was found only in the riparain habitat in streams and side pools. The abundance of the seven reptile species during the years before timber harvest was three times greater in the upland ($\bar{X}$ = 0.39±0.22) than in the riparian ($\bar{X}$ = 0.11±0.06) habitats. Only two of these species, *E. skiltonianus* and *T. elegans*, were captured in the riparian habitat. Most species were found at only one or very few sites. Three of these species, *C. bottae*, *C. constrictor*, and *E. corulea* were found only in the upland habitat at a single control site, Chewelah Creek. *E. skiltonianus* and *P.catenifer* were captured at two sites, *T. sirtalis* was captured at three sites and observed at an additional five sites. Although *T. sirtalis* was captured only on the upland transects, the observations at the five additional sites were in riparian habitat. *T. elegans*, found at ten sites and observed on one additional site, was the most widely encountered reptile.

Treatment Effects—Species richness of amphibians decreased from 2.3 (±0.75) preharvest to 1.2 (±0.48) postharvest on the State sites. Species richness of amphibians remained similar on the Control (pre: 1.3±0.42; post: 1.0±0.38) and Modified (pre and post: 0.8±0.37) sites. The most pronounced changes in abundance of the amphibian species were observed on the riparian habitats of the State sites (Fig. 2). The decrease was attributable to a decrease in captures of *Rana luteiventris* (1.08 to 0.06 captures per site per year) and of *Bufo boreas* (1.0 to 0.23 captures per site per year). Declines in *B. boreas* on the upland habitats of the State sites (0.59 to 0.05 captures per site per year) and on the riparian habitats of the Modified sites (0.54 to 0.17 captures per site per year) explain the decrease in amphibian abundance observed on these sites. In comparison, captures of *B. boreas* remained similar in both the riparian (0.28 to 0.24 captures per site per year) and upland (0.28 to 0.40 captures per site per year) habitats of the Control sites and in the upland habitats (0.15 to 0.16 captures per site per year) of the Modified sites. The abundance of the reptiles was lower across all treatments during the years after harvest. Four species that had been captured during the preharvest years in the uplands of one Control site were never captured during the years postharvest, explaining the pronounced overall decline in the upland habitats of Control Sites.

Management Implications—Although we observed most of the amphibian and reptile species potentially present in these forests, the species richness at most and abundance at all sties were very low. Amphibian abundance was greater in the riparian habitat and reptile abundance was greater in the upland habitat. Decreases in abundance of *Rana luteiventris* and *Bufo boreas* following timber harvest on especially the State sites indicate that focused studies in areas supporting higher abundance would be of merit.

The Importance of Riparian Habitats to Birds

Scott F. Pearson and David A. Manuwal

The goal of this research was to 1) compare species richness, diversity and abundance between riparian habitats and the adjacent upland habitats; 2) examine the effects of buffer width on species richness, diversity and abundance by comparing the currently required buffer strips to modified buffer strips and controls; and 3) examine the habitat correlates that may provide insights into the observed patterns of species richness, diversity and abundance.

Methods--We used modified point counts for surveying bird populations. We established ten point count stations along the edge of each stream (riparian stations) with five stations spaced evenly on both sides of the stream. Each station was located 15 m from the stream edge and 100 m from other stations. Ten additional point count stations were located parallel to the riparian stations in the adjacent uplands (upland stations). During the bird survey period, each observer recorded the birds heard or seen within a 15-m radius of each station for a period of 6 minutes. For the riparian stations, birds detected within the 8-m riparian management zone were also noted separately. Each of the 18 stands was visited 5 or 6 times between mid-April and late-June in 1993, 1995 and 1996. All stands were surveyed for one year pre-harvest (1993) and two years post-harvest (1995 & 1996).

Riparian vs. upland habitats-- Although there were slightly more species detected in the uplands, species richness did not differ significantly between riparian and upland habitats. Likewise, the diversity of species in riparian and upland habitats was very similar. Of nine common species, four were more abundant in riparian habitats when compared to the adjacent uplands. American robin, black-throated gray warbler, Pacific-slope flycatcher, and winter wren. No individual species was significantly more abundant in upland habitats when compared to riparian habitats. Although not statistically significant, the brown creeper and golden-crowned kinglet were more abundant in the upland (Table 1).

Treatment effects-- Species richness varied significantly post-harvest in the uplands, with more species found in control sites when compared to state cut sites (Figure 1). Sites with modified buffers were intermediate in species richness but not significantly different from control or state cut sites. Species diversity also varied significantly post-harvest in the uplands with higher species diversity on control sites when compared to state cut sites. Again, modified sites were intermediate in species diversity but not significantly different from control and state cut sites. Of the 12 common species compared, species abundance was not significantly different among treatments for golden-crowned kinglet, rufous hummingbird, song sparrow, and Wilson's warbler. Dark-eyed junco increased post-harvest on both treatments (Table 1). The rufous-sided towhee and white-crowned sparrow increased on both types of treatments but only significantly on state cut sites (Table 1). The hermit/Townsend's warbler, Pacific-slope flycatcher, and winter wren decreased significantly on both types of cuts (Table 1). The brown-creeper decreased on both types of harvest stands but only significantly on modified stands (Table 1). Both the golden-crowned kinglet and the chestnut-backed chickadee virtually disappeared from the uplands post harvest, but did not demonstrate significant declines on state and modified riparian buffers. Both species demonstrate dramatic declines on control sites in the two years post-harvest when compared to the pre-harvest year.

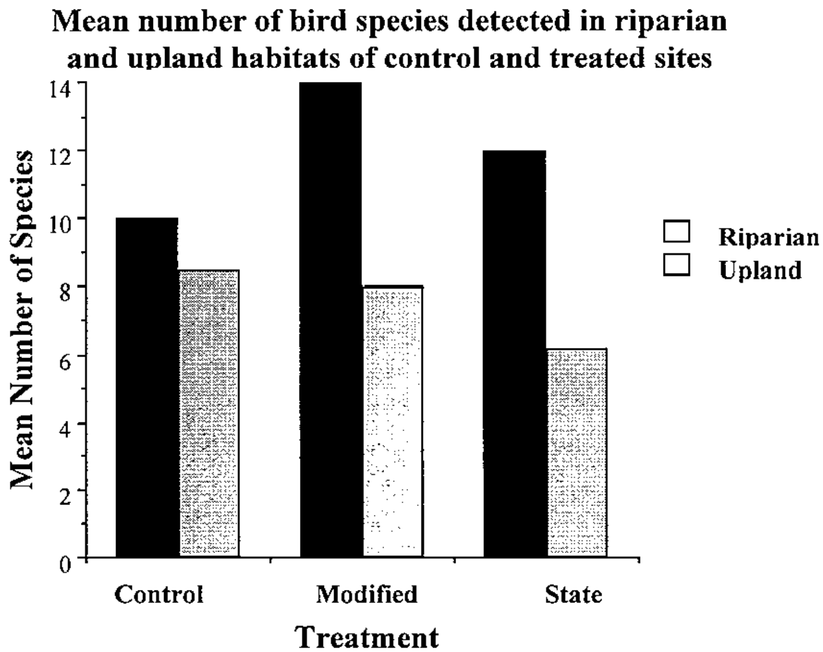

Table 1. Mean[1] (SE) numbers of detections (abundance) of common birds (>25 total detections in a year) in upland habitats with no treatment (control), modified cut (modified), or cut according to state forest practices regulations (state). Values are standardized by the pre-harvest year (the pre-harvest year is subtracted from the mean of the two post-harvest years). Positive values indicate an increase in abundance post-harvest and negative values indicate a decrease.

Species	Treatment[2]		
	Control	Modified	State
Dark-eyed junco	0.14 (0.07)a	1.50 (0.29)b	1.03 (0.18)b
Hermit/Townsend's warbler	0.14 (0.04)a	-0.17 (0.03)b	-0.09 (0.06)b
Pacific-slope flycatcher	0.19 (0.15)a	-1.40 (0.37)b	-1.57 (0.19)b
Winter wren	-0.22 (0.13)a	-1.10 (0.28)b	-1.17 (0.32)b
Brown creeper	0.05 (0.05)a	-0.27 (0.12)b	-0.22 (0.10)ab
Chestnut-backed chickadee	-1.74 (0.62)a	-3.74 (0.40)b	-2.77 (0.26)ab
Rufous-sided towhee	0.00 (0.00)a	0.29 (0.13)ab	0.35 (0.14)b
White-crowned sparrow	0.00 (0.00)a	0.41 (0.17)ab	0.58 (0.18)b
Golden-crowned kinglet	-0.31 (0.43)a	-1.38 (0.44)a	-1.18 (0.31)a
Rufous hummingbird	0.00 (0.03)a	0.16 (0.10)a	0.18 (0.09)a
Song sparrow	0.02 (0.02)a	0.50 (0.21)a	0.65 (0.33)a
Wilson's warbler	-0.47 (0.29)a	-0.30 (0.17)a	-0.23 (0.19)a

[1]No differences (*P's > 0.10*) were detected in abundance of each species between years. Thus, abundance was pooled between the two post-harvest years.
[2]Means sharing the same letters do not differ (ANOVA, Tukey's HSD-test, *P > 0.10*).

Management implications– 1) wide buffers are preferable to narrow ones; 2) riparian corridors with leave areas at least as large as our modified cuts may be adequate to maintain most songbird populations, assuming populations one and two years post-harvest are similar to those 4 or 5 years after harvest. This, however, should be determined by further study.

Birds–East Side

Margaret A. O'Connell and James G. Hallett

We examined the effects of riparian buffer zones on avian populations through an experimental approach, comparing bird populations in riparian and adjacent upland habitats before and after a partial timber harvest in forests on the east side of the Cascade Crest in Washington State. Our goals were 1) to compare avian species richness, diversity, and abundance between riparian and upland habitats, 2) examine how different harvest practices in the riparian zone affect avian species richness, diversity, and abundance, and 3) to examine the habitat correlates that might provide insight into the observed patterns of species richness, diversity, and abundance.

Methods— Bird surveys were conducted during spring 1992-1996 using a modified belt transect design. All 18 sites were visited 6 times per year during this period. Two 800-m transects were established, one was 8 m from the stream and the other 100 m upslope. The focal survey areas on the riparian transect were the 8 m between the transect and the stream and the 22 m on the upland side of the transect for a total belt width of 30 m. On the upland transect, one 30-m wide belt, 15 m on each side of the transect, was the focal survey area. We compared species richness, turnover rates, diversity and evenness, and relative abundance between riparian and upland habitats using two-way ANOVA. We examined treatment effects on the same metrics using ANOVA with a repeated measure for time. To examine the relationship between the habitat variables and the abundance of individual species with > 75 detections/species, we used a stepwise multiple regression that also incorporated four additional dummy variables in the regression model. The first dummy variable represented the habitat zone, the second represented sampling time, the third represented the State harvest treatment, and the fourth dummy variable represented the Modified harvest treatment. During 1992 and 1995 we conducted experimental studies to examine the rates of nest predation on artificial nests in the riparian and upland habitats.

Riparian vs. Upland Habitats: Pre Harvest— We based our analyses on 11,745 observations of 78 bird species. There was significant inter-year variation in the number of detections in both the riparian and upland habitats. The mean number of species per site was similar between the riparian and the upland habitat. Most species were observed in both riparian and upland habitats and relatively few were exclusively found in the riparian habitat. The proportion of species turnover between years averaged > 50% across all sites and habitats with no differences between riparian and upland habitats. Across all years, diversity values were consistently higher in the upland than in the riparian habitats. Overall evenness values averaged > 0.80 and were higher in the upland than riparian habitat. Before harvest, the mean detection rate for all species combined was 11 birds/visit with no differences between the riparian and upland habitats. Of the 22 common species, three species were more abundant in the riparian than upland habitat and seven species were more abundant in the upland habitat (Table 1). Rates of nest predation were similar between riparian and upland habitats before timber harvest.

Riparian vs. Upland Habitats: Post Harvest—Similar to pre harvest conditions, there were no differences in mean number of species per site in the riparian habitat of the Control and the Modified RMZ sites but there were more species in the upland habitat of the State RMZ sites. After harvest on the Modified and State RMZ sites, turnover rates remained > 50% with no differences between the riparian and upland habitats. Avian diversity was greater in the upland habitats across all treatments. After harvest, the mean detection rate for all species combined was

12 birds/visit with no differences between the riparian and upland habitats. Across all sites, the three species that had been more abundant in the riparian than upland habitat before harvest remained more abundant in the riparian habitat after harvest and five of the eight species that had been more abundant in the upland habitat before harvest remained more abundant in the upland after harvest. Four additional species, that had been equally distributed between the upland and riparian habitats before harvest, were more abundant in the upland habitat after harvest. Swainson's thrush became more abundant in the riparian habitat on the State RMZ sites but remained equally distributed between habitats on the other sites. There were no differences in mean rates of nest predation between riparian and upland habitats following timber harvest.

Treatment effects—There were no differences due to treatment effects of species richness, turnover rates, diversity, evenness, or overall abundance in the riparian habitats. Of the 22 common species, only four species exhibited a change in abundance in the riparian habitat due to the effects of the harvest treatment. More species of birds were observed during the post harvest years in the upland habitats across all sites and the increase was more pronounced on the Modified and State RMZ sites compared to the Control sites. Species turnover rates were similar between the pre harvest and post harvest years on the Control, increased on the Modified RMZ, and decreased on the State RMZ sites. Diversity values increased more on the State RMZ than on the Control or Modified RMZ sites. In contrast, evenness values decreased on the State RMZ sites in response to harvest treatment, but did not change on either the Control or Modified RMZ sites. The upland abundance of all species combined was greater post harvest a across all treatments and was not due to treatment effects. Mean rates of nest predation were greater on the State RMZ sites than on the Control or Modified RMZ sites.

***Species Habitat Associations*—**All 27 species analyzed were significantly associated with at least one habitat variable, but R^2 values were low. Six upland-associated species were negatively associated with overstory cover and positively associated with shrubs and the State harvest. In contrast, five riparian-associated species were negatively associated with the State harvest and positively so with the Modified harvest. These species were either associated with early succession riparian features such as shrubs and deciduous trees or with more mature forest features such as dispersed shrubs and taller trees.

***Management Implications*—** Our results indicate 1) avian species richness, abundance, and diversity were either equal or greater in upland habitats as compared to riparian habitats, 2) given the association of certain species with riparian habitat and the relatively restricted area of riparian as compared to upland habitat, protection of riparian habitats remains important, 3) although the east-side State Riparian Management Zones and our Modified Riparian Management Zones retained comparable overall avian diversity and abundance following a selective harvest in the adjacent upland, the abundance of individual riparian species was better retained and more positively associated with the Modified RMZ. The intent of the Modified RMZ was to incorporate a more site-specific approach to riparian management by providing for protection of habitat features of importance to wildlife such as seeps and snags. The importance of upslope habitats in maintaining avian diversity in this region argues for a similar site-specific approach to upland habitat management.

Table 1. Comparison of mean abundance (± SE) of common bird species associated with riparian or upland habitats across all sites and on Control, Modified RMZ, and State RMZ sites before and after timber harvest on the Modified and State sites. Significantly larger means are in bold.

PRE HARVEST	Overall (df = 1,82)		Control (df = 1,32)		Modified (df = 1,24)		State (df = 1,22)	
Species	Riparian	Upland	Riparian	Upland	Riparian	Upland	Riparian	Upland
Chestnut-backed chickadee	0.15±0.41	**0.40**±0.65	0.25±0.09	0.44±0.09	0.08±0.03	**0.37**±0.13	0.10±0.04	0.36±0.13
Chipping sparrow	0.004±0.003	**0.06**±0.02	0	0	0	0.03±0.03	0.01±0.01	**0.17**±0.07
Dark-eyed junco	0.22±0.07	**0.57**±0.10	0.28±0.12	0.40±0.14	0.13±0.09	0.53±0.18	0.24±0.12	**0.85**±0.17
Golden-crowned kinglet	**3.15**±0.24	2.42±0.20	2.74±0.24	3.10±0.38	**3.45**±0.18	2.32±0.20	**3.43**±0.76	1.67±0.29
Gray jay	0.02±0.01	**0.30**±0.06	0.02±0.02	**0.23**±0.08	0.01±0.01	**0.38**±0.09	0.04±0.03	**0.31**±0.12
Hammond's flycatcher	**0.37**±0.11	0.12±0.04	0.25±0.09	0.08±0.04	**0.78**±0.30	0.06±0.03	0.08±0.03	0.22±0.11
Nashville warbler	0.07±0.02	**0.25**±0.45	0.06±0.02	**0.25**±0.08	0.051±0.02	**0.32**±0.08	0.11±0.18	0.18±0.07
Red-breasted nuthatch	0.16±0.03	**0.56**±0.07	0.19±0.05	**0.66**±0.16	0.14±0.06	**0.45**±0.07	0.15±0.05	**0.56**±0.10
Winter wren	**1.69**±0.15	0.22±0.05	**1.32**±0.18	0.137±0.06	**2.19**±0.309	0.44±0.124	**1.67**±0.28	0.11±0.04
Yellow-rumped warbler	0.083±0.03	**0.27**±0.07	0.06±0.03	0.32±0.14	0.15±0.064	0.31±0.13	0.08±0.05	0.15±0.07
POST HARVEST	Overall (df = 1,94)		Control (df = 1,34)		Modified (df = 1,22)		State (df = 1,34)	
Brown creeper	0.57±0.09	**0.94**±0.14	0.63±0.12	**1.34**±0.27	0.35±0.11	**0.86**±0.23	0.66±0.20	0.602±0.19
Chestnut-backed chickadee	0.17±0.03	**0.38**±0.06	0.24±0.05	**0.55**±0.11	0.18±0.08	0.35±0.15	0.10±0.04	0.22±0.05
Chipping sparrow	0.03±0.01	**0.22**±0.05	0	0.056±0.04	0	0.07±0.04	0.09±0.03	**0.49**±0.11
Dark-eyed junco	0.69±0.12	**1.81**±0.22	0.38±0.17	0.85±0.20	0.24±0.66	**1.15**±0.19	1.31±0.21	**3.19**±0.34
Golden-crowned kinglet	**2.51**±0.21	1.77±0.18	2.92±0.25	2.61±0.27	2.13±0.36	1.35±0.33	**2.35**±0.42	1.21±0.20
Gray jay	0.06±0.02	0.09±0.03	0.03±0.02	0.13±0.05	0.03±0.03	0.01±0.01	0.10±0.05	0.10±0.05
Hammond's flycatcher	**0.39**±0.08	0.17±0.05	**0.19**±0.55	0.009±0.01	0.63±0.15	0.32±0.88	0.44±0.15	0.23±0.10
Mountain chickadee	0.06±0.02	**0.13**±0.03	0.08±0.36	0.07±0.39	0.06±0.03	0.07±0.03	0.04±0.02	**0.23**±0.06
Red-breasted nuthatch	0.23±0.05	**0.93**±0.10	0.21±0.08	**0.80**±0.17	0.21±0.06	0.82±0.20	0.26±0.09	**1.13**±0.15
Red-naped sapsucker	0.045±0.02	**0.18**±0.03	0.03±0.03	0.83±0.02	0.069±0.03	**0.26**±0.09	0.05±0.02	**0.22**±0.05
Solitary vireo	0.10±0.03	**0.28**±0.06	0.06±0.03	0.167±0.08	0.15±0.06	0.49±0.16	0.11±0.05	0.269±0.08
Swainson's thrush	0.65±0.07	0.63±0.07	0.49±0.07	0.68±0.09	0.47±0.09	0.71±0.16	**0.94**±0.15	0.51±0.10
Townsend's warbler	1.58±0.16	1.48±0.18	1.55±0.22	2.07±0.28	1.44±0.28	1.21±0.27	1.70±0.33	1.06±0.29
Winter wren	**2.11**±0.15	0.55±0.08	**1.90**±0.24	0.49±0.13	2.54±0.24	0.85±0.20	**2.05**±0.27	0.42±0.11
Yellow-rumped warbler	0.260±0.05	**0.68**±0.11	0.14±0.05	**0.62**±0.22	0.31±0.13	0.39±0.10	0.35±0.10	**0.94**±0.15

Terrestrial Small Mammals—West Side

Stephen D. West

The primary focus of this study was to assess the usefulness of riparian management zones (RMZ) in maintaining populations of small mammals after timber harvest. We assessed the habitat occupancy patterns and relative abundance of small mammals within the riparian zone and the associated upland on unharvested control sites, on sites harvested under minimal State guidelines for RMZ creation (state guidelines), and on sites harvested under guidelines designed as part of this study (modified guidelines).

Methods—We sampled using snap and pitfall traps. For snap traps we sampled with two paired traplines on each side of the stream, one trapline within the riparian zone, and the other well outside the zone about 100m from the stream. Each trapline consisted of 36 stations set 10m apart (350m total length) with two Museum Special traps per station. Traplines were centered on the 500-m stream study sites. Traps were baited with peanut butter and whole oats and operated for four consecutive days and nights (4 trap nights). Pitfall traps (double deep, two #10 cans) were operated for two continuous weeks. Traps were checked weekly. Eighteen traps were placed at 15-m intervals on the central portion of each snap trapping transect. The snap and pitfall trapping occurred simultaneously. Trapping totals for each technique were summed to give an overall catch per unit effort index, which was used in statistical testing. To assess the effect of different RMZs on capture rates between riparian and upland transects, we used the difference between the pre- and post-harvest mean capture rates as test data ($\bar{x}_{Post} - \bar{x}_{Pre}$), and analyzed for treatment effects using a 1-way ANOVA followed by Tukey's HSD test for multiple comparisons.

Riparian vs. Upland Habitats—Over the 4 years of sampling 8,731 individuals of 18 species of small mammals were captured. Species richness before harvest was higher within the riparian zones (10.3±.45 species) than in the adjacent uplands (8.5 ±.39 species; $P=0.003$). Species evenness and overall abundance were not different. Species composition was similar between riparian zones and uplands. The montane shrew, the marsh shrew, the Pacific jumping mouse, and the long-tailed vole were caught at greater rates on riparian transects, while the southern red-backed vole was caught more often on the upland transects. Two other species showed trends in their abundance patterns. The vagrant shrew favored riparian transects ($P=0.102$), while the deer mouse tended to be found more often in the uplands ($P=.099$).

Treatment Effects—On riparian transects species richness and evenness did not differ significantly among treatments. Species composition of the riparian transects between harvest treatments was very similar. No species showed a statistically significant change in capture rate with respect to treatment on the riparian transects. The strongest trend toward a statistical difference between treatments on riparian transects was shown by the southern red-backed vole ($P=0.081$). On upland transects species richness and evenness did not differ significantly. A change in species composition reflected losses of Insectivores and gains by the deer mouse and the creeping vole. Capture rates declined significantly for the marsh shrew, the shrew-mole, and the forest deer mouse. Capture rates increased for the creeping vole.

Management Implications—Over the first two post-harvest years both RMZ treatments provided habitats intermediate in quality for species associated with closed canopy forest. One measure of success for a particular RMZ design is whether riparian obligate species and forest associated fauna will persist within the RMZ between the time of harvest and canopy closure. Of the two RMZ designs, the modified design appeared to provide the better chance for persistence.

Declines on these sites were less precipitous than the state sites and the species composition of the modified sites more closely reflected that of control sites. This study has provided a very good baseline from which to evaluate the performance of these RMZ designs. An adequate assessment, however, requires future sampling. Several species showed declines over the 2-year period. Knowing whether they will persist on these sites during the pre-canopy period requires additional sampling.

Table 1. Differences by treatment in mean (se) capture rates (number caught per 100 trap nights) before and after harvest. Tabled values are $\bar{x}_{Post} - \bar{x}_{Pre}$. Indices combine pitfall and corrected snap trap data. Superscripts indicate significant differences among treatments at $P=0.05$. Indices without superscripts or with shared superscripts are not significantly different.

Species	Control	Modified	State
Vagrant shrew			
Riparian	-.476 (.290)	-.323 (.157)	.245 (.242)
Upland	-.166 (.269)	.543 (.252)	.144 (.142)
Montane shrew			
Riparian	-.229 (.288)	-.649 (.271)	-.405 (.403)
Upland	-.146 (.272)	-.284 (.163)	-.041 (.257)
Marsh shrew			
Riparian	.076 (.173)	-.164 (.071)	-.093 (.081)
Upland	.076 (.047)[a]	-.279 (.047)[b]	-.099 (.074)[ab]
Trowbridge's shrew			
Riparian	.778 (.406)	-.167 (.518)	-.150 (.354)
Upland	.366 (.752)	-1.141 (.495)	-.0830 (.345)
Shrew-mole			
Riparian	-.037 (.128)	.202 (.557)	-.184 (.172)
Upland	.366 (.752)[a]	-1.141 (.495)[ab]	-.830 (.345)[b]
Pacific jumping mouse			
Riparian	.035 (.175)	.277 (.152)	.971 (.573)
Upland	.197 (-)	.201 (.175)	.267 (.140)
Deer mouse			
Riparian	.109 (.176)	.045 (.534)	.672 (.301)
Upland	.430 (.369)	.803 (.336)	1.540 (.598)
Forest deer mouse			
Riparian	.267 (.334)	-1.616 (1.067)	-1.211 (1.360)
Upland	1.060 (1.288)[a]	-2.829 (.743)[b]	-2.298 (.857)[ab]
Southern red-backed vole			
Riparian	.174 (.157)	-.035 (.067)	-.168 (.028)
Upland	.082 (.142)	-.681 (.455)	-.720 (.330)
Creeping vole			
Riparian	-.034 (.133)	1.286 (.802)	2.455 (1.295)
Upland	-.278 (.253)[a]	3.878 (1.130)[b]	3.731 (1.625)[b]
Long-tailed vole			
Riparian	.259 (.063)	.474 (.347)	.201 (.248)
Upland	.480 (.678)	.216 (.067)	.289 (.108)

Terrestrial Small Mammals—East Side

James G. Hallett and Margaret A. O'Connell

The primary focus of this study was to assess the usefulness of riparian management zones (RMZ) in maintaining populations of small mammals after timber harvest. We assessed the habitat occupancy patterns and relative abundance of small mammals within the riparian zone and the associated upland on unharvested control sites, on sites harvested under minimal State guidelines for RMZ creation (state guidelines), and on sites harvested under guidelines designed as part of this study (modified guidelines).

Methods— At each of the 18 study sites we established an 800-m riparian transect at 8-m distance from the stream and another 800-m upland transect 100-m upslope from the riparian transect. We conducted pitfall and snap-trapping in May-June from 1992 to 1996. The 1992-1993 samples represent preharvest conditions, and the 1995-1996 samples represent postharvest conditions. Pitfall (9,072 trap nights/year) and snap-traps (20,736 trap nights/year) were used to sample small-mammal populations on the 18 riparian and adjacent upland sites. Two parallel transects 720 m in length, were placed 8 m from the stream and 100 m upslope. A total of 72 snap-trapping stations was spaced at 10-m intervals along each transect. Two snap-traps were placed at each station and checked for 4 consecutive days. Eighteen pitfall traps were placed at 15-m intervals. Pitfall traps were checked every other day for 2 weeks. Specimens were later autopsied to determine reproductive condition. Reproductive data collected for females included size of nipples, number and size of embryos, and number of placental scars and corpora lutea. Females were considered reproductive if embryos or placental scars were present. Determination of male reproductive condition was based on size of testes and epididymis. Species identification was based on dental characteristics, relative body measurements, and pelage.

Riparian vs. Upland Habitats—Pitfall and snap-trapping yielded 13,081 specimens of 19 species. About 91.5% of all captures consisted of just four species: southern red-backed vole (32.5%), vagrant shrew (24.1%), deer mouse (20.0%), and masked shrew (14.9%). These species also had the broadest distributions. In all years, there was a greater number of individuals captured in the riparian zone than in adjacent upland habitat. In the two preharvest years (1992-1993), there were no differences in species diversity, evenness, or species richness between upland and riparian habitats. However, abundance was greater in the riparian than in the upland ($P < 0.0001$). The red-backed vole, vagrant shrew, western jumping mouse, water shrew, and bog lemming were all significantly associated with the riparian zone, whereas masked shrew, montane shrew, and chipmunk were all upland associates. The water shrew, bog lemming, and water vole were only observed in the riparian zone.

Treatment Effects—Most sites were harvested by spring 1994, which coincided with a sharp increase in abundance of most small mammal species. Population numbers declined by 1995 and remained relatively constant in 1996, near their pre-harvest level. Species diversity after harvest did not differ with habitat, but was significantly greater on State and Modified sites. Evenness was greater in the upland and increased between 1994 and 1996. Species richness peaked in 1994 with the pulse in abundance and decreased by 1995. Species richness was greater for State and Modified sites and for riparian habitat. Abundance after harvest was again greater in the riparian, and was significantly greater on the Modified sites with no differences between Control and State sites.

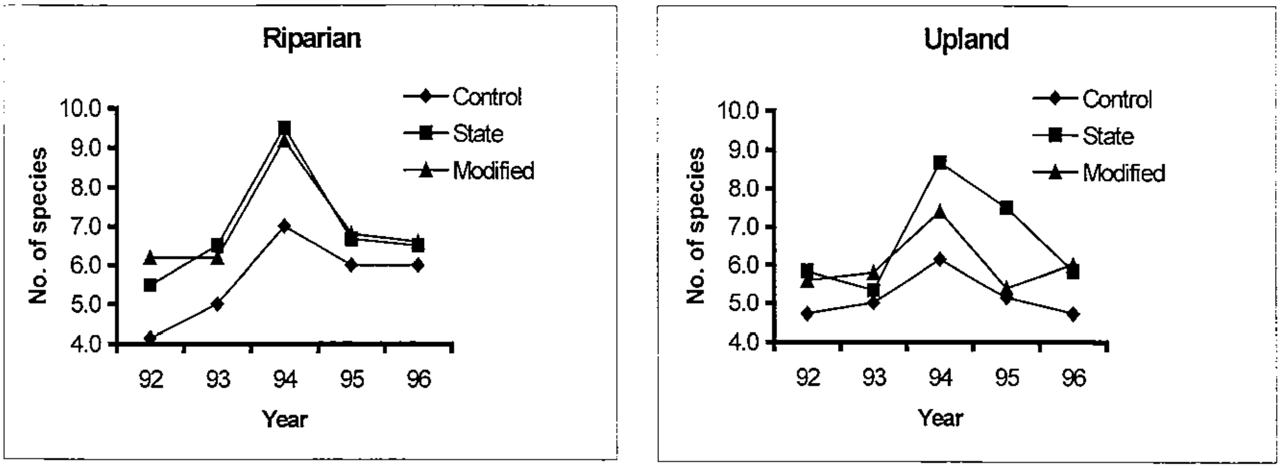

Figure 1. Species richness observed in riparian and upland habitats for the three treatment types.

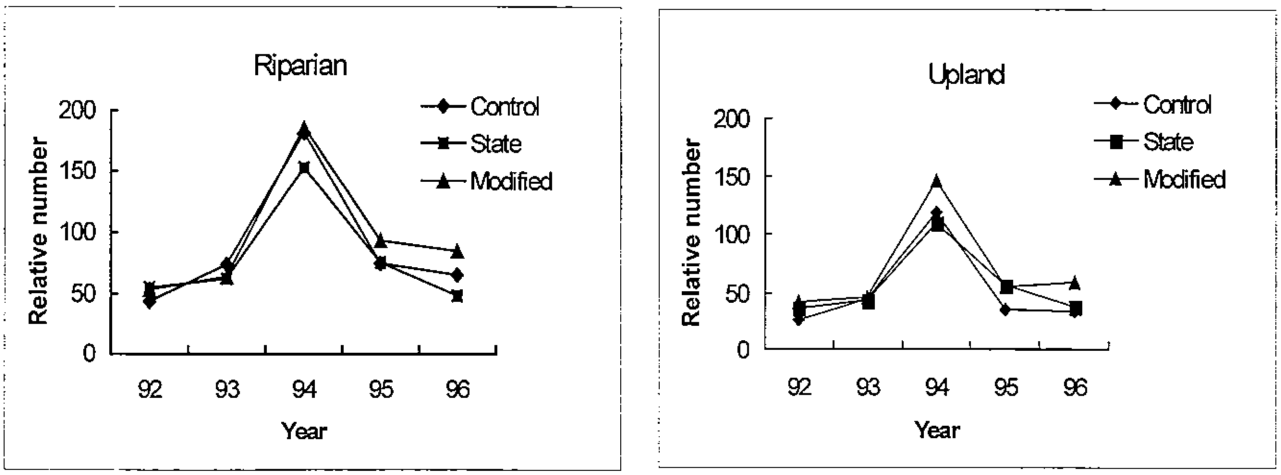

Figure 2. Relative abundance of all species in riparian and upland habitats for the three treatment types.

Management Implications—Pulses in abundance of small mammals as we observed in 1994 may be of great importance for recolonization of vacant habitats. Riparian buffer strips may act as corridors or may be source habitats for dispersers. Maintenance of the riparian area also will help to retain species that have specific requirements for elements found only in the riparian (e.g., water shrew). The Modified sites appear to have a greater potential for species persistence based on the greater population sizes in the riparian zone.

Bats - East Side

Margaret A. O'Connell and James G. Hallett

We examined the response of bats to timber management in riparian habitats of northeastern Washington. Our specific objectives were to 1) identify the species inhabiting riparian and adjacent upland forests and 2) to compare bat activity before and after different timber harvest treatments of riparian forests.

Methods—Bats were captured using mist nets and harp traps set across slow moving areas of streams and across shallow ponds (9 sites) and across narrow roads (10 sites) during summer 1992 and 1993. Bat activity at the 18 RMZ sites was measured using ultrasonic detectors. Bat detectors were placed along the riparian transect at each site for two consecutive nights in August 1993, 2 consecutive nights per month during June-August 1994-1995 and along the riparian and upland transects for two consecutive nights per month during June-August 1996. Tapes were reviewed for calls and "feeding buzzes". Each detection was reviewed for maximum and minimum frequency, duration, pulse shape, number of pulses, and occurrence of feeding buzzes. Calls with ≤ 3 pulses in the sonogram were not included in the analyses. Designation of calls to species or species groups was based on comparison with calls recorded from free flying bats of known identity and with call libraries. Relative bat activity was measured as either the mean number of calls per site-night or the mean number of calls per 30-min interval. To examine inter-site variation, habitat associations of the species, and treatment effects the mean number of bat calls per sample night were analyzed using the Kruskal Wallis analysis of variance. Temporal patterns of bat activity were examined using the mean number of calls per 30-min interval.

Results— We captured 114 bats representing eight species: *Myotis californicus*, *M. ciliolabrum*, *M. evotis*, *M. lucifugus*, *M. yumanensis*, *Eptesicus fuscus*, *Lasionycteris noctivagans*, and *Lasiurus cinereus*. All eight species were captured over water, but *M. californicus* and *M. ciliolabrum* were more commonly captured at the road sites. A total of 451 sample nights (=night/site) were monitored for bat activity between August 1993 and August 1996 yielding 6,402 calls. Four species and one species group were detected. Three of these species, *E. fuscus*, . *noctavagans*, *L. cinereus*, had been captured. Bat sampling elsewhere in the region confirmed the presence of *Corynorhinus townsendii*. All *Myotis* species were grouped. There was significant variation in bat activity both between and within sites. At all sites there was ≥ 1 sample night with no bat activity recorded and the proportion of sample nights with no calls varied from 9-60%. The number of sites with a high proportion of no call sample nights (>50%) and the number of sites with a low proportion of no call sample nights (< 25%) were equally distributed between the control and treatment sites.

Riparian vs. Upland Habitats—Use of riparian versus upland habitats was based on the 1996 data. The mean number of calls per sample night did not differ between riparian and upland habitats on Control Sites for *L. noctavagans* or *E. fuscus*. In contrast, the mean number of calls per sample night was greater in riparian than upland habitats on Control Sites for *Myotis*. The mean number of feeding buzzes per sample night was greater for *Myotis* in riparian as compared to upland habitats. Although the mean number of feeding buzzes for *E. fuscus* was greater in upland ($x = 0.23 \pm 0.02$) than riparian habitats ($x=0.02 \pm 0.02$), sample size was low and the differences not significant. Similar to the Control Sites, the mean number of calls per sample night did not differ between riparian and upland habitats on the cut sites for *L. noctavagans* and

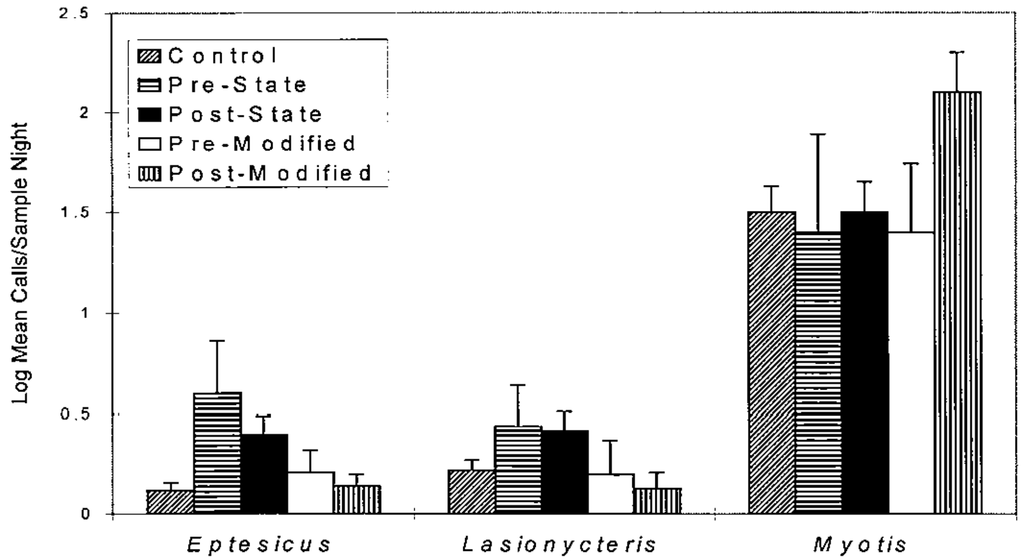

Figure 1. Log of mean calls/sample night for three bat species before and after timber harvest.

the mean number of calls per sample night was greater in the riparian than upland habitats for *Myotis*. In contrast, *E. fuscus* was detected more often in the upland habitats of the cut sites. Temporal patterns of total bat activity were generally similar between the riparian and upland habitats and in both habitats was greatest in the first part of the night (17:30-22:30). The mean calls per sample night was greater in the upland riparian habitat during only 2 time periods, early in the evening (18:30) and at dawn.

Treatment effects—The mean number of bat calls per sample night did not differ between Control, State, or Modified RMZ. Although the mean number of total bat calls per sample night decreased between the pre-harvest (x = 24.6±13.4) and post-harvest (x = 19.7±4.8) on the State sites and increased between the pre-harvest (x = 18.3±5.8) and post-harvest (x = 28.4±7.4) on the Modified RMZ sites, the variances were great and the differences not significant. However, there were significant differences observed between sites for individual species. Activity of both *E. fuscus* and *L. noctivagans* was greater on the State sites as compared to Control and Modified sites. The mean number of bat calls for *E. fuscus* per sample night decreased between pre- and post-harvest on the State RMZ sites. In contrast, the mean number of calls per sample night for *Myotis* was greater after harvest on the Modified sites (Fig. 1).

Management Implications—Riparian habitats are important habitat for Myotis bats. The site-specific protection of snags on the Modified sites might explain the increased activity of the *Myotis* group after harvest on these sites. At least two species are known to roost near water when suitable roosts are present, and a shorter distance between suitable roost trees and low canopy closure influences roost selection in other *Myotis* species. Some evidence suggests that bat activity is greater in partial cut as compared to clearcut or closed-canopy forests. Therefore, retention of snags in the riparian habitats on the Modified sites after harvest might have led to increased activity. Relative abundance of bat species in riparian versus upland habitats reflected both the feeding activities, as well as the roosting activities of bats in these habitats. For species that utilize trees for roosting, the availability of suitable roost trees, especially snags, might dictate relative use of riparian and upland habitats. These bat species are known to travel several kilometers between roosting and foraging sites and some appear to select upland roosting sites. The importance of upland habitats for the bats of this region also must be stressed and a management approach that ensures adequate roosting habitat in the uplands is an essential complement to riparian habitat management.

Management Implications

Stephen D. West and Margaret A. O'Connell

Pre-harvest Comparisons

Unlike studies conducted in arid regions, overall contrast between riparian and upland habitats in this region was not great. From the perspective of wildlife habitat many vegetation characteristics were shared between habitats and habitat elements often differed in degree rather than kind.

Habitat West side—Riparian zones had more red alder trees, berry-producing and other deciduous shrubs, herbs, ferns, bare soil, and rock than upland habitats. Upland habitats had significantly greater numbers of western hemlock trees, snags, litter cover and depth, and higher canopy cover.

Habitat East side—Vegetation differed in few, but significant respects between riparian and upland habitats. The riparian zone had greater dispersion of shrubs, more deciduous vegetation, and more trees and snags in the largest size classes. Although canopy cover was more closed in the riparian, a greater diversity of herbaceous plants was present. The riparian zone also had down wood of greater diameter and greater decay.

Birds West Side— Species richness and diversity were not significantly different between riparian zones and uplands. The American robin, black-throated gray warbler, Pacific-slope flycatcher, and winter wren favored the riparian zone. No species was significantly associated with the uplands, although there was a positive trend in abundance for the brown creeper and golden crowned kinglet. Deciduous trees were an important habitat component for birds.

Birds East Side—Species richness, turnover rates, and rates of nest predation were equal between riparian and upland habitats. Diversity was greater in upland as compared to riparian habitats. Although overall abundance was comparable between habitats, individual species exhibited differences. Four species were more abundant in the riparian habitat, responding to either the deciduous component or the larger trees that were present in these habitats. Nine species were more abundant in the upland habitats. Most of these species were associated with more open overstory and shrubs.

Bats East Side—Bat activity (primarily *Myotis* group) is greater in riparian habitat. There were no habitat differences observed for the big brown or silver-haired bats. Bats typically travel between roosting and foraging sites thus linking riparian and upland habitats.

Terrestrial Amphibians West Side—Differences in richness and abundance between riparian and upland transects were slight. About one-third of all captures were in the riparian zone with most captures of *Ensatina* in the uplands. Sampling during fall rains may lessen restriction to the riparian zone. Adult tailed frogs used the uplands extensively

Terrestrial Amphibians and Reptiles East Side—Amphibian abundance is very low in these forests, but was greater in riparian habitats. These species require slower moving water for breeding than was common on these sites. Reptile abundance (albeit very low) was either equal to or greater in upland as compared to riparian habitats.

Small Mammals West Side—Species richness before harvest was higher within the riparian zones than in the adjacent uplands. Species evenness and overall abundance were not different. Species composition was similar between riparian zones and uplands. The montane shrew, the marsh shrew, the Pacific jumping mouse, and the long-tailed vole were caught at greater rates on riparian transects, while the southern red-backed vole was caught more often on the upland transects.

Small Mammals East Side—Small mammal abundance was highest in the riparian zone, as was species richness. Species diversity was similar between habitats.

Management implications of Pre-harvest Conditions

The vertebrate communities of these small riparian zones and adjacent uplands are largely a shared fauna. There are differences in the relative abundance of some species, with about equal numbers favoring either riparian or upland habitat. Other species use both habitats to fulfill different and critical life functions, such as some stream-breeding amphibians and several bats. Given such a close connection between these habitats, management consideration of both habitats should be a goal. A greatly simplified upland habitat, for example, would no doubt seriously degrade the habitat value of an RMZ. Conversely, if uplands are managed with structural diversity and attention to habitat features of importance to wildlife in mind, RMZs may not require extensive area.

Post-harvest Comparisons

Habitat West Side—Following timber harvest, riparian areas remained dominated by red alder. The width of the buffer strip was about twice as large on Modified sites than on State sites. Riparian canopy cover differed significantly among treatment types Control sites provided 90-100% canopy cover within riparian areas while state buffer sites provided less than 50% cover. Modified buffers ranged from 40-90% cover. Percent cover of ferns, moss, and bare soil decreased significantly while litter cover and berry-producing shrubs increased within riparian areas at treatment sites.

Habitat East Side—Modified sites had wider, but considerably more variable RMZs than did State harvest sites. Changes after harvest accentuated differences between riparian and upland habitats with predictable reductions in canopy cover, shrub layer, regenerating stems, deciduous trees, and decayed down wood. State harvest sites had greater floristic changes than Modified or Control sites including reductions in the abundance of shrub species in both upland and riparian and herbaceous species in the riparian. Several weedy species increased in abundance or appeared for the first time after harvest.

Birds West Side—Upland habitats on harvested sites showed significantly lower species richness and diversity, due to the loss of closed-canopy forest species. About one-half of the common species showed significant treatment effects. Species richness and diversity were significantly greater in the Modified RMZs, compared to Control sites. State sites were intermediate, but not significantly different from either.

Birds East Side—The general patterns of riparian and upland associations remained the same after harvest, but there were differences in the associations of individual species. The pre- vs. postharvest associations of the riparian species were more consistent that those of the upland species. Within the upland habitats, the changes in species richness and diversity were most pronounced on the State RMZs. Within the riparian habitats, there were no differences between pre- and postharvest with respect to species richness, turnover rates, diversity, or overall abundance. At the species level, there was a decline in several riparian-associated species and increase in the upland-associated species in the State RMZs. Rates of nest predation were greater on the State RMZs. State RMZs maintained similar species composition as the Control and Modified RMZs.

Bats East Side—The mean number of all bat calls did not differ between Control, State, or Modified RMZs. Activity of big brown bats and silver-haired bats was greater on the cut sites than Control sites. Activity of the big brown bat decreased between pre- and post-harvest on the

State RMZ sites. In contrast, activity for *Myotis* was greater after harvest on Modified sites.

Stream Amphibians West Side— No differences were found in stream habitat pre- and post-harvest. Irregular geographical distributions made statistical tests weak. No differences in abundance post-harvest although larvae of Pacific giant salamanders tended to increase. Tailed frog tadpoles showed no change.

Terrestrial Amphibians West Side—Only Ensatina showed significant difference in abundance. About one-third of all captures were in RMZs with most captures in the uplands of the western red-backed salamander. Low captures of all species except for Ensatina and the western red-backed salamander resulted in low statistical power. Upland captures of tailed frogs, red-legged frogs, and northwestern salamanders showed a decreasing trend following timber harvest on both RMZ types.

Terrestrial Amphibians and Reptiles East Side—State RMZs and Modified RMZs retained comparable overall species richness. The abundance of amphibians declined on the State RMZs.

Small Mammals West Side—On riparian transects species richness and evenness did not differ significantly among treatments. Species composition of the riparian transects between harvest treatments was very similar. No species showed a statistically significant change in capture rate with respect to treatment on the riparian transects. On upland transects species richness and evenness did not differ significantly among treatments. A change in species composition reflected losses of Insectivores and gains by the deer mouse and the creeping vole. Capture rates on the uplands declined significantly for the marsh shrew, the shrew-mole, and the forest deer mouse. Capture rates increased for the creeping vole.

Small Mammals East Side—Habitat associations remained generally constant over time. Species richness on State cuts increased temporarily in the upland after harvest and was greater than in Modified or Control sites until declining. Modified cuts had greater abundances of small mammals in both the riparian and upland. Rare species were more likely to be found in the riparian zone and may use these areas as corridors.

Effectiveness of State and Modified RMZs

Immediately following timber harvest, a primary role for an RMZ is to provide a patch suitable for occupancy by species associated with the riparian zone and closed canopy forest. Depending upon the rate of forest growth the RMZ will be the primary habitat for two or three decades until the canopy closes in the adjacent upland. We seek an RMZ configuration that will promote the persistence of these species during this post-harvest period. After canopy closure we expect local conditions to improve greatly for these species.

Two years after harvest both RMZ configurations retained a large proportion of species associated with riparian zones and closed canopy forest. Judging from the trends in abundance for individual species, the Modified RMZ appeared to hold the greatest promise of species persistence during the early post-harvest years. Most likely this was due to its greater area and structural diversity.

The intent of our Modified RMZ was to incorporate a more site-specific approach to riparian management by identifying and protecting habitat features of importance to wildlife. The importance of upslope habitats for PNW vertebrates argues for incorporation of such a site-specific approach to both riparian and upland habitats.

By design, our results focus on the years immediately following harvest. We have provided a baseline from which future changes within the RMZs and adjacent uplands can be compared. Studies of wildlife response to different buffer harvests in other regions have indicated changes in composition and abundance between the immediate post-harvest years and later years. From some trends in this study and our experience with the habitat patterns shown by vertebrates in the TFW Landscape Study, we expect several such changes in the next few years.

To document these changes these sites must be resurveyed at regular intervals. We suggest returning about five years post-harvest and again at about 10 years post-harvest. The first decade should encompass the most active period for decline in species associated with riparian and closed canopy forest. Without additional sampling the effectiveness of these RMZ designs cannot be assessed.