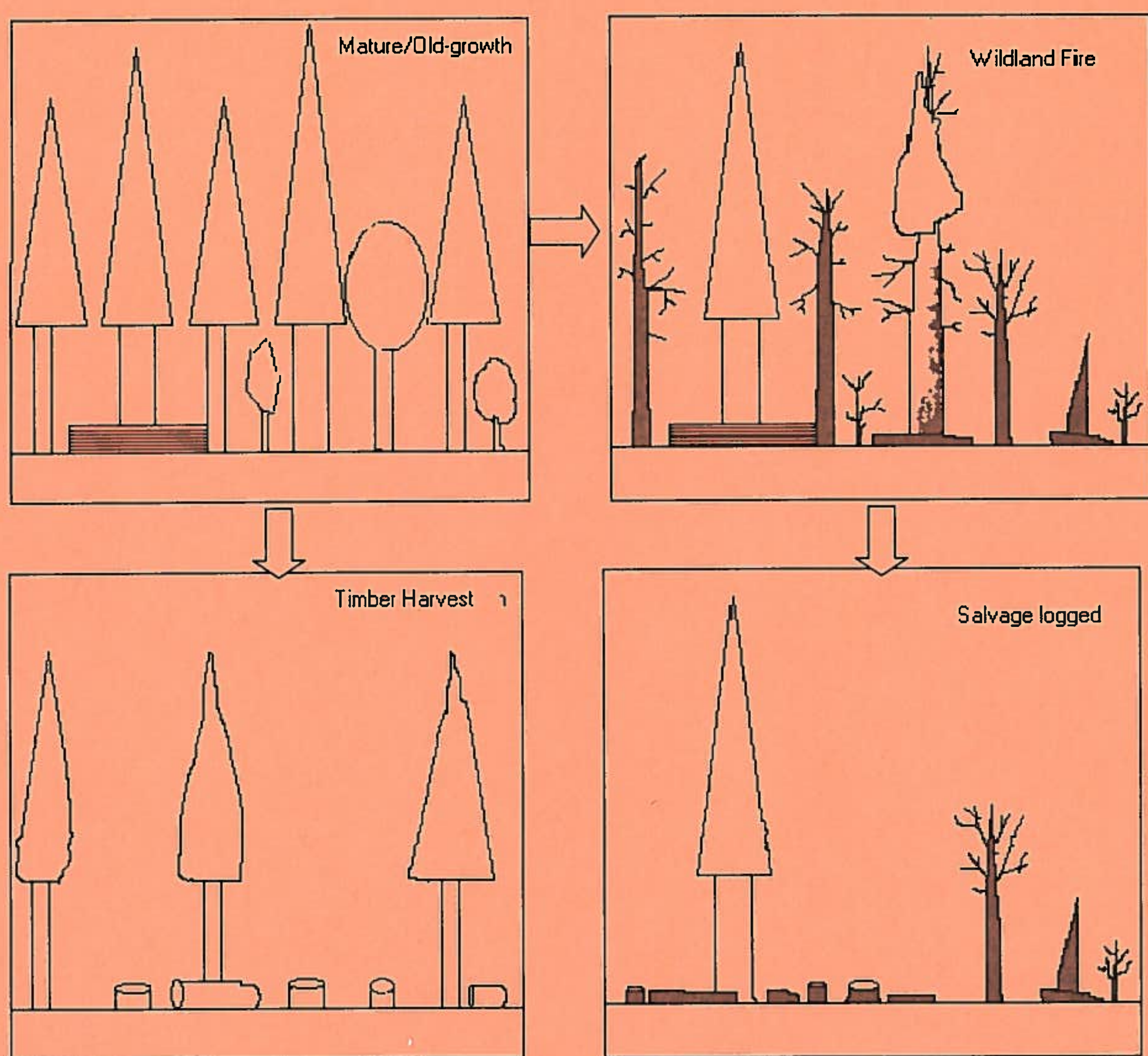
Joint Fire Science Program

Fuels Management and Wildlife Habitat: Quantity and Quality Relationships

INTERIM REPORT

Principal Investigator:
R. Bruce Bury
USGS Forest and Rangeland Ecosystem Science Center
3200 SW Jefferson Way, Corvallis, Oregon 97331

14 September 2004
176 pp.



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* Also available online

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Part 1: Executive Summary and Problem Analysis

Introduction

Our objectives were to determine the responses of forest-floor material (coarse woody debris, duff/leaf litter) and associated herpetofauna to fire in forest stands. Most of our studies were on wildland fires in northern California and southern Oregon. We also examined effects of some prescribed fires in western North Carolina and northern California. These constitute the most comprehensive study of forest-floor fuels and associated wildlife responses in Pacific Northwest forests to date. Our research results suggests several new or important points about forests 1-5 years post-fire (listed on next page).

Today, we have rudimentary knowledge of how fire and management impact wildlife in western forests. A major national program is needed to study the responses of wildlife to fire, and how to restore or improve wildlife habitat and resources in post-fire situations. Further, we must address how fuel reduction efforts (thinning, prescribed fire, mechanical mulching) effect wildlife species and associated habitat and how we can make management decisions compatible with the needs of our native biodiversity.

Key Findings

- Wildland fire reduced woody fuels on the forest floor by about one-third (35%) but prescribed fire resulted in twice the loss (ca. 60%).
- Wild or prescribed fire reduced forest-floor material (duff/leaf litter/twigs) by about half (48-55%).
- Reptiles likely had minimal or no mortality, and fire usually opens up stands so improves their habitat.
- Wildland or prescribed fire did not reduce the numbers of terrestrial amphibians within the sampling framework (1-5 yrs post-burn).
- Terrestrial salamanders on burned plots had more injuries than individuals found in unburned stands, perhaps due to increased attacks by predators or interspecific aggression (some of the species are territorial and will bite each other).
- Wildfire usually occurs in summer (hot, dry period in the West) and, thus, may have little or no direct effect on amphibians because these species are underground.
- Loss of woody objects and leaf litter may concentrate amphibians in or under the reduced amounts of cover objects post-fire. This could lead to a sampling bias between burned and unburned plots.
- These studies only examined responses of mature/old-growth to wild- and prescribed fire.
- Additional studies are needed to address gaps in our knowledge about responses of forest-floor material and wildlife, particularly for:
    - ▶ Forest Thinning (harvest of unburned forests)
    - ▶ Salvage Logging (harvest of burned forests)
    - ▶ Mechanical Reduction of Fuels
- We suggest initiation of a national program to study the responses of wildlife to fire.
- We recommend new research and management efforts to determine how to restore and maintain wildlife habitat and resources in post-fire situations.

Synopsis

Heterogeneity Rules

Western forests are highly variable with surface activity of salamanders in distinct seasons, dependent on storm events with different amounts of precipitation from late fall to early spring. Cold periods usually occur in winter. These environmental variables compress surface activity of terrestrial salamanders into relatively narrow windows. Still, terrestrial salamanders alone may be locally abundant, exceeding the numbers of small mammals or birds. Many amphibians west of the Cascade Mountain crest are associated with coarse woody material on the forest floor.

Timber Harvest Legacy

Concurrent to fire concerns, the imprint or legacy of timber harvest must be recognized in the Pacific Northwest, because logging has occurred on 50-80% of the mature and old-growth forests of the region. Fire frequency varies in these forests with more fires in drier, more southern locales. Major events include the Biscuit Fire—the largest in North America in 2002. In its north portion, severe fire occurred on >50% of young, managed trees but only about 25-33% of old-growth stands. This suggests that the legacy of timber harvest produce fire-prone stands, but warrants further study.

Management Needs

National calls for extensive use of prescribed fire and thinning to reduce fuel loads will remove large amounts of coarse woody material from forests. This will reduce cover for amphibians and other wildlife, and alter nutrient inputs to streams. The challenge is to maintain biodiversity in western forests in the face of intense socio-economic pressures designed to "prevent" catastrophic fires. We need a dedicated research effort to understanding how fire affects biota, and to proactively investigate outcomes of fuel reduction management on wildlife in western forests.

Productivity of Project (Abbreviated Version)

This project resulted in many products and public outreach efforts. We provide a short list here and a longer version (Appendix to this Section):

1. Two major publications on fire and wildlife:

    - Review chapter in a *General Tech Report* (US Forest Service) that has a target of managers and field biologists
    - Invited article in *Conservation Biology:* Special Section on Forest Fires in the West

2. We also have two related articles in journals:

    - Edge effects on amphibians in Pacific Northwest forests: *Northwest Science*
    - Review of responses of herpetofauna to fire in aquatic, riparian and terrestrial ecosystems. *Forest Ecology and Management*. Special Section on Aquatic Ecosystems and Fire. (Parts on uplands habitat).

3. Support permitted research leading to a PhD dissertation and three research publications are expected from that work:

    Major, D.J. 2004. Effects of Fire Disturbance on Terrestrial Salamanders in Mixed-Coniferous Forests of the Klamath/Siskiyou Region on the Pacific Northwest. Utah State University. (Draft Final to Committee Sept 2004).

4. Three other research papers intended for scientific journals are in preparation and all are a direct result of JFSP funding:

    - Prescribed fire effects on terrestrial salamanders in western North Carolina
    - Wildfire effects on woody debris and salamanders in so. Oregon (Spring Fire),
    - Detection probabilities of western salamanders in burned and unburned forests, no. Calif. (may spin off another paper comparing count indices to population estimates)

5. We provided many presentations, workshops and other information services:

    - Regional/national Workshop on "Fuels Reduction and Wildlife" (Ellensberg, WA)
    - 11 presentations to scientific meetings and agency workshops
    - Invited talk at a national meeting (Nashville, TN)
    - Several public information venues (2 annotated bibliographies available on line, news releases, etc.).

Problem Analysis

Background (Setting the Stage)

Wildfire is a natural, recurring disturbance in western forests, but aggressive fire-fighting efforts suppressed most wildfires in the last 50 years (Pyne 1982; Agee 1993). Effective fire suppression beginning over much of the last century reduced fire frequency and severity. One unintended result was large accumulations of fuel loads (Agee 1988; Backer et al. 2004). Further, timber harvest has converted vast acreage to young managed stands that are prone to fire (Azuma et al. 2004, Bury 2004). Today, we face larger or more frequency fires than in the past.

To reduce fuel loads and threat of fire, there are several national initiatives to reduce fuels by forest thinning and prescribed burns, including the National Fire Plan (USDA 2000) and the Healthy Forest Initiative (see USDA 2003). These new programs are the drivers for our studies on how forest-floor fuels (leaf litter, small wood, coarse large wood, etc.) and associated amphibians respond to projected changes in land-use and forest structure.

Our objective was to synthesize and assess our current knowledge of fire on forest-floor cover (especially coarse woody material) and associated amphibians. We also are interested in the legacies of past logging that affect reptiles and amphibians, and a means to better protect resident wildlife in the face of restoring fire to habitats in western forests.

Responses to Type of Fire and Management: What Do We Know?

We compared the differences between forest-floor habitat and terrestrial salamanders in unburned stands compared to: wildland fire and prescribed fire. Our unburned stands were predominately naturally regenerated and represented mature/old-growth conditions (Fig. 1.1). Although these represent a major component of fire-induced changes in the West, we also need to examine wildlife responses to other land-use treatments and different fire regimes (Table 1). Young managed stands (Fig. 1-2) are important because they may constitute 40-60% of the landscape. Of major concern are new management activities of salvage logging of already burned stands as well as thinning and mechanical reductions of fuels in natural stands.

There are at least 8 different treatments that could affect an existing Mature/Old-growth stand from just wildland fire (Table 1). This number increases to 10 treatments with prescribed fire as wildland fire could and does occur after prescribed fire (often just burns ground wood material and understory vegetation). Further, a stand may burn multiple times by wildland fire within a short period of time (1-5 yrs) after the first fire.

This study is one of the first to examine the responses of forest-floor habitat (wildlife cover) and amphibians to either wild fire or prescribed fir in the Pacific Northwest. We focused on Mature/Old-growth stands to both wildland and prescribed fire (Table 1; boxed). However, there are many other treatment types and permutations awaiting investigation in the Pacific Northwest, especially thinning and salvage logging.

Our understanding of fire and management on western forests is minimal, or to date restricted to a relative few of scenarios (Fig. 1.1). There are national initiatives to increase implementation of thinning and prescribed fire to curtail effects of catastrophic wild fires. Also, other quarters are asking for increased salvage logging of burned stands. How all these activities impact resident wildlife is unclear and will likely be complicated and difficult to understand. Moreover, these scenarios may result in different results across the varied western landscapes (i.e., what we find out in one area is often not applicable to another area).

One important point to keep in mind is that forested landscapes are mosaics of prior fire histories and variable legacies of timber harvest (with large acreage in young managed stands, many of which are fire prone). All this occurs over a highly diverse landscape (e.g., riparian zones and steep valleys often burn less often than nearby ridges). No single prescription will work in this diverse mix of natural and managed forest.

We have little information on how fire and management affect forest-floor habitat and associated wildlife such as terrestrial salamanders. Moreover, we have little evidence on responses of wildlife to even one forest type let alone the great diversity of forests in the West (e.g., from coastal dense Sitka spruce, through Douglas fir, then mixed conifer-hardwood stands, to Ponderosa pine).

Salvage logging and thinning will likely occur in many of these forest types, and result in different effects across the varied western landscapes. Today, we have rudimentary knowledge of how fire and management impact wildlife in western forests. A major program is needed to guide the study of wildlife responses to fire, and how to restore or enhance wildlife habitat and resources in post-fire situations.

References

Agee, J. A. 1988. Wildfire in the Pacific West: A brief history and implications for the future. Pages 11-16 in N. H. Berg, editor. Proceedings of Symposium on Fire and Watershed Management. General technical report PSW-GTR-109. U.S. Forest Service, Berkeley, California.

Agee, J. K. 1993. Fire ecology of Pacific Northwest forests. Island Press. Washington D.C

Azuma, D.L., J. Donegan, and D. Gedney. 2004. Southwest Oregon Biscuit Fire: An analysis of forest resources and fire severity. USDA Forest Service. Research Paper PNW-RP-560. U.S. Forest Service, Portland, Oregon. 32 pp.

Backer, D. M., S. E. Jensen, and G. R. McPherson. 2004. Impacts of fire suppression activities on natural communities. Conservation Biology 18:937-946.

Bury, R.B. 2004. Wildfire, fuel reduction, and herpetofauna across diverse landscape mosaics in northwestern forests. Conservation Biology 18:968-975.

Pyne, S. J. 1982. Fire in America: a cultural history of wildland and rural fire. Princeton University Press, Princeton, New Jersey.

USDA. 2000. National Fire Plan: managing the impact of wildfires on the communities and the environment. U.S. Department of Agriculture, Forest Service, Washington, D.C. Available at http://www.fireplan.gov.

USDA. 2003. National Fire Plan: Research and development. 2002 business summary. U.S. Department of Agriculture, Forest Service, Washington, D.C. Also see http://www.whitehouse.gov/infoucs/healthyforest/Healthy_Forests

Table 1. Comparison of major forest stand conditions in the Pacific Northwest related to fire and timber harvest history.

Mature/Old-growth	⇒	**Wildland Fire**	+ Salvage Logging
⇓			
Timber Harvest	⇒	Wildland Fire	+ Salvage Logging (if old enough)
⇓			
Thinned Stand	⇒	Wildland Fire	+ Salvage Logging (if old enough)
Mature/Old-growth	⇒	**Prescribed Burn**	+ Salvage Logging
⇓			
Timber Harvest	⇒	Prescribed Fire	+ Wildland Fire + Salvage Logging ?
⇓			
Thinned Stand	⇒	Prescribed Fire	+ Wildland Fire + Salvage Logging ?

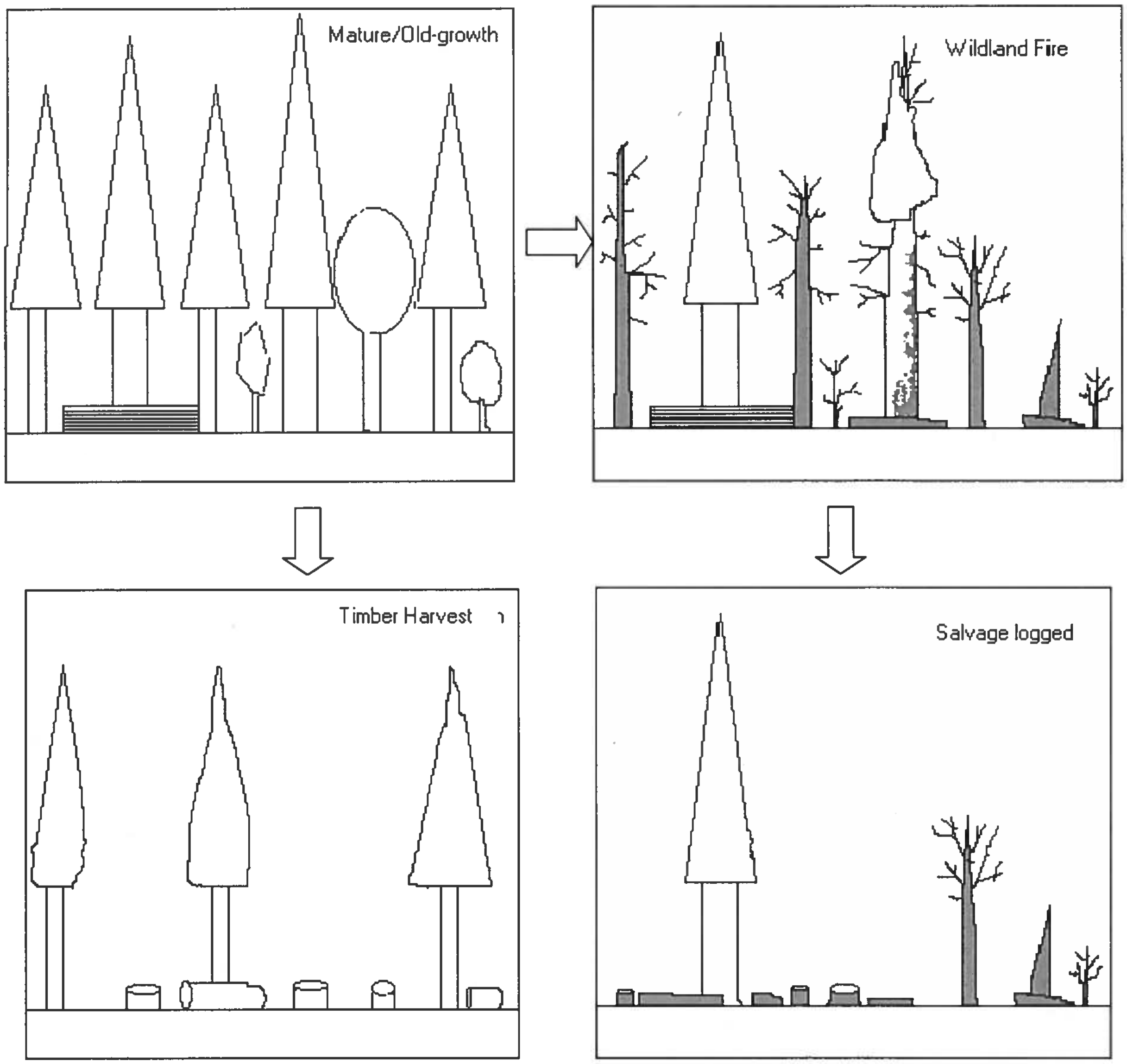


Fig. 1-1. Representative conditions in western forests (clockwise from upper left): Mature/Old-growth stands have relatively few but very large trees and much forest-floor material; Wildland Fire results in loss of trees and downed material; Salvage Logging of Wildland Fire areas further reduces standing tree trunks (future snags) but may leave more woody material on forest floor; and Timber Harvest may remove the largest trees and leave smaller trees to mature in the forest.

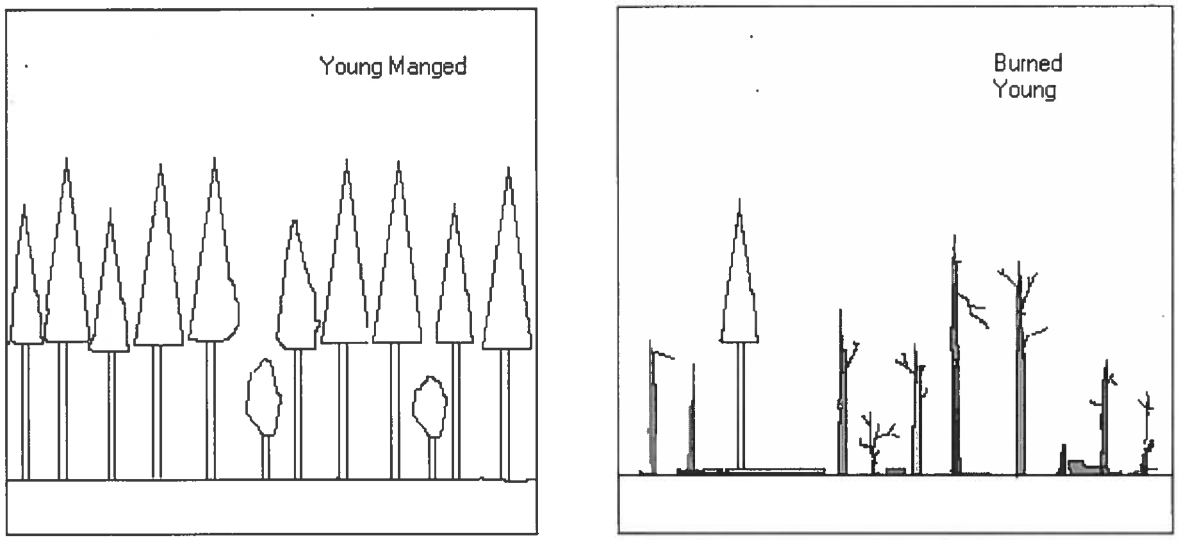


Fig. 1-2. Representative conditions in western forests showing a young managed stand (planted trees with some hardwood invasion) and same stand after a wildfire. Some of these young stands burn almost completely as their lower branches touch or are in close proximity, permitting fire to jump from one tree to the next.

Management and Wildlife Habitat: Quantity and Quality Relationships

Synthesis of Deliverables and Products

This is a summary of what we produced and plan to provide from this JFSP sponsored project. We show key results and products tied to the original three objectives (in **BOLD**).

1. **SYNTHESIZE AVAILABLE INFORMATION ON HABITAT REQUIREMENTS AND EFFECTS OF FIRE ON RESIDENT WILDLIFE SPECIES.**

- We have two products available online:

Major, D.J., and R.B. Bury. 2000. Annotated bibliography: Fire effects on wildlife (amphibians, reptiles and small mammals). http://zippy.fsl.orst.edu/Fuels/annotated_bibliography.htm – Server Time out error

Hyde, E., R.B. Bury, and D.J. Major. 2003. Fire bibliography. 313 entries. http://fresc.usgs.gov/products/fire/firebiblio.html

- Invited contributor to a Special Section of Conservation Biology on "Wildfire and Conservation in the Western United States."

Bury, R.B. 2004. Wildfire, fuel reduction, and herpetofaunas across diverse landscape mosaics in Northwestern forests. Conservation Biology 18(4):969-975. (pdf is available)

- Support allowed work on a related forest issue in the region of interest and a major review, which are now two publications:

Biek, R., L.S. Mills, and R.B. Bury. 2002. Terrestrial and stream amphibians across clearcut - forest interfaces in the Siskiyou Mountains, Oregon. Northwest Science 76:129-140.

[Related study on edge effects conducted in region; at the time, R. Biek was a visiting student from Germany; now a PhD cand., U. Montana).

Pilliod, D., R.B. Bury, E.J. Hyde, C.A. Pearl, and P.S. Corn. 2003. Fire and amphibians in North America. Special Issue: Fire and Aquatic Ecosystems. Forest Ecology and Management 178:163-181.

[JFSP: This is mostly a product of our more recent project on "Fire Effects on Aquatics…" but linked some to "Fuel Mgt…" project as the land and water are interlinked in ecological function].

2. National Workshop on Habitat Structure: Fire Fuels Loads and Wildlife Use.

- Invited attendee and presenter of a key paper at a.Special Workshop of The Wildlife Society annual meeting, Nashville, TN. Sept. 2000. Published results were:

Bury, R.B., D.J. Major, and D.S. Pilliod. 2002. Responses of amphibians to fire disturbance in Pacific Northwest forests: A review. Pp. 34-42. In Ford, W.M., K.R. Russell, C.E. Moorman (eds.). The role of fire in nongame wildlife management and community restoration: traditional uses and new directions. USDA, Genl. Tech. Report, NE-288. 145 pp.

Note: This is a fairly large file but available online at:

http://www.fs.fed.us/ne/newtown_square/publications/technical_reports/pdfs/2002/gtrne288.pdf

- Presented paper at International Meeting:

Major, D.J., T.C. Edwards, Jr., and R.B. Bury. 2003. Effects of Fire on Terrestrial Salamanders in the Klamath-Siskiyou Region, Pacific Northwest. International Association of Fire Ecologists / International Wildland Fire Congress / International Association of Meteorologists. Orlando, FL.

- Regional workshops and sessions:

Pilliod, D.S., and R. B. Bury. (Co-Organizers). 2004. Fire and Fuel Reduction Effects on Wildlife. Northwestern Scientific Association and Society for Northwestern Vertebrate Biologists, Ellensburg, WA. March 2004.

Bury, R. B., and D.S. Pilliod (Co-Organizers). 2005. Responses of Wildlife to Fire and Fuel Reduction Effects. Combined meeting of The Wildlife Society – Oregon Chapter and the Society for Northwestern Vertebrate Biologists, Corvallis, OR. February 2005.

[Note: Topics cover both aquatic and terrestrial ecosystems].

3. Protoype Project: Develop Sampling Protocols for Fuels and Wildlife Habitat for Forest-dwelling Herpetofauna of the Pacific Northwest and Southeast (Regional).

Most of these results are provided in a PhD Dissertation supported by JFSP:

Major, D.J. 2004. The Effects of Fire Disturbance on Terrestrial Salamanders in Mixed-conifer Forests of the Klamath/Siskiyou Region of the Pacific Northwet. Unpubl. PhD Dissertation, Utah State University.

[Note: The final defense for this work is scheduled for Sept. 10, 2004.]

Besides an introductory section to set the stage and a conclusion to the dissertation, there are three major chapters and all are intended to be submitted for publication:

- The role of fire disturbance in stand dynamics of dry Douglas-fir/tanoak forest systems: implications to a potential fire refugia.
- Fire exclusion legacy in mixed-conifer forests: implications for fuel dynamics and future ecosystem resilience.
- Classification-tree modeling of Del Norte salamander habitats across fire severity levels in dry Douglas-fir/tanoak forests.

Additonal manuscripts in preparation:

Hyde, E.J., and R. B. Bury. Response of terrestrial herpetofauna to prescribed fire in the southern Applachian Mountains. [Wildlife Society Bulletin].

Bury, R.B., E.J. Hyde, and D.J. Major. Effects of wildlland fire on downed wood and associated herpetofauna in the Spring Fire, Umpqua River basin, Oregon. [Northwest Science].

Major,D.J., and R.B. Bury. Effects of fire disturbance on woody cover and detectability of herpetofauna in northern California. [J. Wildlife Management].

Major, D.J. Fire, fuels management, and forest-floor fauna: A case study evaluating fire effects on terrestrial salamanders in Douglas-fir / tanoak forest systems. *Invited paper*. Ecological Restoration

Presentations and Posters

Major, D.J., and T.C. Edwards, Jr. 2001. Effects of Fire Disturbance on Terrestrial Salamanders in Coniferous and mixed-coniferous forests, Klamath-Siskiyou Region, Pacific Northwest. Regional Meeting of Utah Cooperative Wildlife Research Station, Logan, UT. (Poster)

Hyde, E.J., and R.B. Bury. 2002. Inventory and Monitoring Needs: Herpetofauna and Wildfire in the Klamath Province. National Park Service, Klamath Network Science Meeting, Ashland, Oregon. Nov 2002. (Invited Paper)

Hyde, E.J., D. Major, and R.B. Bury. 2002. Fire, Fuels, and Terrestrial Salamanders. Society for Northwestern Vertebrate Biologists. Hood River, OR. (Paper)

Hyde, E.J., and R.B. Bury. 2003. Amphibian Responses to Fire in the Pacific Northwest. Northwest Section and Oregon Chapter, Wildlife Society. Eugene, Oregon. Feb. 2003. (Invited Paper)

Bury, R B. and E.J. Hyde. 2003. Amphibian Responses to Fire in the Pacific Northwest: Complex Answers to Simple Questions. Dept. Fisheries and Wildlife, Oregon State University, Corvallis. March 2003. (Invited Departmental Seminar).

Gibson, J. and R.B. Bury. 2003. The Challenges of Managing for Fire and Species Diversity within the Wildland-urban Interface. Society for Northwestern Vertebrate Biologists, Humboldt State University, Arcata, California. March 2003. (Invited Paper)

Bury, R.B. 2003. *RAPP Session* (Research and Products/Projects on Wildlife and Fire Studies in the Pacific Northwest. Coordination Meeting, Oregon/Washington BLM State Office and USGS Research, Corvallis, Oregon. May 2003.

Bury, R B. and E.J. Hyde. 2003. Wildfire and Fuels Reduction in Northwest Forests: Responses of Amphibians and Reptiles. Fire Ecology and Resource Management Workshop, The Wildlife Society - Western Section. Arcata, California. Nov 2003. (Invited Paper).

Bury, R.B., D.S. Pilliod, and E. Bull. 2004. Fire and hazardous fuel reduction in the West: perspectives and challenges. Joint Meeting of the Society for Northwestern Vertebrate Biology and Northwestern Scientific Association, Ellensburg, WA, March 2004.

Bury, R.B., E.J. Hyde, and C.A. Pearl. 2004. Southern Oregon 04 Rendezous: Review of Results and Needs Wildlife and Fire Studies. Coordination Meeting. BLM Medford and Roseburg Dist. Offices, Siskiyou and Umpqua Natl Forsts, USFWS Roseburg Office, and OR Dept. Fish and Wildlife. Roseburg, Oregon. Nov 2004 (tent.).

Field Trips

Major, D.J. (presenter) and R.B. Bury. 1999. "Ecology and Management of Small Vertebrates on DOI Lands." BLM - Oregon State Office, BLM District Offices, and FRESC Coordination Meeting. Answered questions on Field Trip. Roseburg and Klamath Falls, Oregon. 1999.

Hyde, E.J., and R.B. Bury. "Restoring Ecosystems: Fire Ecology, Planning and Application in Western Oregon" Conference, Eugene, OR. Central Cascades Adaptive Management Area, Little River Adaptive Management Area, and the NW Oregon Ecology Group. Invited experts and assisted with field trip to the Spring Fire, Umpqua National Forest, so. Oregon. Federal and State agencies. May 2002.

Fire Research: Rapid Information Exchange

We provided a review of research and field work on visits to Field Offices of agencies:
2002 Klamath National Forest – Regional Office. Yreka, CA; Medford BLM, OR.
2003 Klamath National Forest – Happy Camp District, CA

Annual reports and progress to the Joint Fire Science Program (funding source):
Fuels Management and Wildlife Habitat: Quantity and Quality Relationships– 2001. View at: http://jfsp.nifc.gov/98proj.htm

We helped develop a USGS press release "A New Look at Fire and Fuels Reduction Effects: Frogs and Fish" on June 23, 2003. On July 1, Bury received a call from Dan Berman, *Land Letter* (part of *Greenwire*) and on June 23 he was contacted by Don Thompson, reporter for the *Associated Press* in Sacramento. In both cases, Bury provided background about the issue and provided basic information for a possible story on fire effects. The news release can be viewed on the web at: http://fresc.usgs.gov/news/newsreleases.asp?NRID=6

We participated in a special issue of *Forest Ecology and Management* (Vol. 178, Issues 1-2, Pages 1-229) on "The Effects of Wildland Fires on Aquatic Ecosystems of the Western USA." A news release regarding these articles by USGS scientists was released on Monday, June 9, 2003. View on the web at: (http://fresc.usgs.gov/news/news.asp).

Bury, R.B., and E.J. Hyde. 2003. Exploring Fire Effects of Amphibian Communities. See Web Page of Forest and Rangeland Ecosystem Science Center. Includes Project on Fire Effects of Stream Amphibians (10 p. Proposal, 31 p. Progress Report, and photo gallery of species), and "Bibliography – Fire Effects on Wildlife" (313 entries; citations with abstracts), and Meet the Herp Lab. Draft Version is available at: http://fresc.usgs.gov/products/fire/index.html

Appendix

Fire and Fuel Reduction Effects on Wildlife (Special Session)
NW Scientific Association and Soc. for NW Vertebrate Biology, Ellensburg, WA.
26 March 2004. Organizers: David S. Pilliod, USFS; R. Bruce Bury, USGS, FRESC

INTRODUCTION: David S. Pilliod, USFS Rocky Mountain Research Station, Missoula, MT

FIRE AND HAZARDOUS FUEL REDUCTION IN THE WEST: PERSPECTIVES AND CHALLENGES
R. Bruce Bury, USGS Forest and Rangeland Ecosystem Science Center, OR
David Pilliod, USFS Rocky Mountain Research Station, Missoula, MT
Evelyn Bull, USFS Pacific Northwest Research Station, LaGrande, OR

FIRE EFFECTS ON PLANTS, ANTS, AND RODENTS IN THE MOJAVE DESERT
Todd Esque, USGS Western Ecosystem Science Center, Las Vegas, NV, & others

CHANGES IN FOREST RODENT COMMUNITIES AFTER FIRE: IMPLICATIONS FOR DISPERSAL AND REGENERATION OF PINE
Jennifer S. Briggs, Biological Res. Research Ctr., Univ. Nevada, Reno.
Stephen B. Vander Wall, Ecology, Evolution & Conserv. Biol, Univ. Nevada,Reno

USING TAXA-BASED CONSERVATIONS PLANS TO EVALUATE ECOLOGICAL EFFECTS OF FIRE MANAGEMENT: INSIGHTS FROM BIRD MONITORING IN OAK WOODLANDS
Nathaniel E. Seavy, Klamath Bird Observatory, Ashland, OR, and Dept. Zoology, Univ. Florida, Gainesville, FL
John D. Alexander, Klamath Bird Observatory, Ashland, OR
Paul E. Hosten, BLM, Ashland Field Office, Medford District, Ashland, OR

RESPONSES OF POND-BREEDING AMPHIBIANS TO WILDFIRE IN GLACIER NATIONAL PARK
Blake R. Hossack and P. Stephen Corn, USGS Northern Rocky Mountain Science Center, Missoula, MT

EFFECTS OF WILDLIFE FIRES ON STREAM AMPHIBIAN POPULATIONS IN THE GREATER NORTHWEST
David S. Pilliod, USFS Rocky Mountain Research Station, Missoula, MT
R. Bruce Bury and Erin Hyde, USGS Forest and Rangeland Ecosystem Science.
P. Stephen Corn, USGS Northern Rocky Mountain Science Center, Missoula, MT

DISCUSSION: How can we get wildlife resources better supported and protected?
R. Bruce Bury and David S. Pilliod.

1. What are the greatest risks to wildlife habitat from current and future fire management practices on federal lands?
2. What are the key research needs for protecting and managing habitat for sensutive wildlife in landscapes managed with prescribed fire, stand thinning or mechanical alteration (mastication)?
3. What are the challenges ahead for wildlife management and how might they be met more efficiently and effectively?

Joint Fire Science Program

Fuels Management and Wildlife Habitat: Quantity and Quality Relationships

Interim Report

R. Bruce Bury

Part 2: Summaries and Reviews

Overview and Interpretation of Current Knowledge

Following are excerpts from two of our reviews (Bury et al. 2002, Bury 2004) and other sources that lay out the general premise and status of our information.

Wildfire in the West

Wildfire is a natural, recurring disturbance in western forests, but aggressive fire-fighting efforts suppressed most wildfires in the last 50 years (Pyne 1982; Agee 1993). Fire prevention and suppression were past priorities to protect timber resources as well as property and lives. However, an unintended result was accumulations of fuel loads that have resulted in catastrophic or more frequent wildland fires in the West.

Many amphibian species have declined across their ranges in the West (Bury et al. 1980; Corn 2000; Semlitsch, 2000). Also, amphibians are of high conservation concern because many species have restricted geographical ranges, are listed as threatened or endangered, or only occur in specialized habitats.

Little evidence exists on the responses of amphibians and their habitats to fire and fuels management practices in the West. The few studies on the effects of fire on stream or terrestrial amphibians in western forests were part of other studies examining forests 30 or more years post-fire (e.g., Cole et al. 1997). There is no study of populations pre- and post-fire in the West. However, we have a body of knowledge available on the relationship of the herpetofauna to late-successional forests compared to mature and young >30 yr-old stands (see Smith et al. 1998, Ruggerio et al 1991).

Responses of Forest Stands and Cover

Current evidence suggests that wildland fires burn at different intensities, which leaves a mosaic of habitat post-burn. Some stands burn entirely, but generally there are patches with little or no fire as well as areas with high severity.

We found that young managed stands (<40 yrs age) tended to burn more severely than old-growth in the massive 2002 Biscuit Fire in southwestern Oregon. Within the northern portion managed by the Bureau of Land Management, severe burn occurred on ca. 75% of young managed stands but only ca. 25–33% of old-growth stands. Similar results were noted in the nearby 1987 Silver Fire where intense fire burned >75% of shrubs and hardwoods (e.g., oak, madrone, tanbark oak) but only ca.22% of the old-growth stands (T. Atzet, pers. comm.). Early seral stages and young managed stands resulting from timber harvest appear to be more prone to fire than late-successional forests (see Azuma et al. 2004). The legacy of extensive timber harvest (50-80% of the area) in the region likely has a major imprint on fire behavior today, but this relationship needs further study.

Responses of Reptiles

With a few exceptions, reptiles flourish in interior locations or slopes with hot, xeric conditions such as grassland, chaparral, or oak woodlands. Prescribed fire had no negative effects on reptiles in oak woodlands of central California (Vreeland and Tietje 2002). To my knowledge, no studies have addressed how reptiles in the Pacific Northwest forests respond to fire. However, opening of closed forest canopies or dense shrub by fire or timber harvest likely benefits most species of reptiles.

Responses of Amphibians to Habitat Changes

More individuals of terrestrial salamanders occur in older forests than in young, natural stands in northern California (Welsh 1990). There are more species and numbers of individuals of terrestrial salamanders in natural forests (>40 yrs old) compared to logged stands (Welsh 1990; Bury 1994; Welsh and Lind 1995). Similar results occur in logged stands in deciduous forests in the eastern U.S. (see Petranka et al. 1993; deMaynadier and Hunter 1995).

Our results at two study areas in southern Oregon and northern California (see Bury et al. 2002) indicate no reduced numbers of terrestrial amphibians in areas subjected to wildfire compared to adjacent unburned sites. However, leaf litter and downed woody material were reduced 50-70% in areas subjected to fire, which reduces available cover for salamanders. However, the number of animals found post-fire was consistently higher than in unburned stands.

Management

The direct and indirect effects of fire on amphibian communities are based on few studies, mostly for species in Southeastern pine plantations (Means & Campbell 1980; Russell et al. 1999; Schurbon and Faith 2003). To date, the studies in the West have focused on comparison of burned versus unburned stands (see Major and Bury 2000; Pilliod et al. 2003).

There is a need to promote more experimental designs and studies on prescribed fires to elucidate herpetological responses of this fairly new prescription in the West. Future studies of effects of wildfire or prescribed fire on amphibians should include the diversity of habitat conditions, including stream, riparian and terrestrial habitats in northwestern forests. We need better assessments of how thinning and prescribed fire affect the biota, processes and functions of western ecosystems. Thus, we face several complex challenges of how to:

(1) reduce risk of catastrophic fires, especially in the urban-wildland interface;
(2) determine the type, quantity and quality of leaf litter and downed wood used by resident wildlife; and
(3) predict the short- and long-term effects of fuels management practices on the diversity and abundance of wildlife and their required habitat features.

New studies need to examine the relationships between the legacy of logging and fire intervals, and fire effects on herpetofaunas, in the Pacific Northwest. We need to address these serious challenges because fuels treatments are underway or planned for millions of acres of forest and rangeland in the West. Further, how can biologists and managers better understand and protect the biodiversity, endemic species, and abundance of biota in western forests under several new or proposed management regimes, some of which may be applied before detailed studies can be conducted?

Amphibians are a diverse group and, in turn, responses to fire and associated habitat alteration are expected to vary widely from the microhabitat to the watershed scale. Available data suggest that amphibian responses are complex, incompletely understood and vary among species, habitats, and regions. Much of the limited research addresses only the short-term (1-3 yr) effects of prescribed fire on terrestrial life stages of amphibians. We encourage studies to address not just relative abundance of animals but population-level responses of amphibians to fire by examining how different life stages are affected.

Fuels Reduction Practices

Prescription burning is often used to reduce hazardous fuels in the United States, but the effects of these practices on amphibians and their habitats are poorly understood. No studies have directly examined the effects of mechanical fuel reduction or thinning understory brush on western amphibians, although the effects of logging on amphibians are fairly well documented to be negative to populations.

Large pieces of downed wood are key habitat objects in forest stands and need to be maintained as cover for wildlife. Young managed stands tend to have greatly reduced amounts of downed wood, likely due to piling and burning of material after timber harvest. Further, trees are removed for timber and snags were earlier cut down (now increasingly retained in stands). Large wood should be left in place and not burned as it is a limited resource (i.e., large-sized standing trees and snags are not providing large pieces to the forest floor).

Thinning

We have a little information suggesting that thinning of young, dense managed stands increases diversity and numbers of wildlife such as bats, birds and some small mammals in Oregon forests (Hayes et al. 1997). No direct results were reported for amphibians. In western Washington, Grialou et al (2000) reported a significant difference in relative rate of capture of red-backed salamanders after thinning (7.9% decrease one year after thinning, and 15.2% less two year later). The thinning was light at an average of 16% basal area of stems. We have preliminary evidence (Bury and Major 1998 unpubl.) of marked decreases in salamander abundances in thinned stands compared to old-growth and unthinned plots in the Oregon Coast Range.

Overall, much remains unstudied or poorly known about the effects of thinning on terrestrial amphibian populations or aquatic systems. Thinning may appear to only temporarily decrease wildlife but we need more evidence.

Table 2. Comparison of the only two known studies on multiple treatments of stands in the greater Pacific Northwest. Pitfall trapping (Grialou et al. 2000), Time-constrained searches (Bury and Major 1998 unpubl.).

Method	Mean Number of Capture (with percent of Old growth)			
	Old growth	Unthinned	Thinned	Clearcut
Pitfall trapping				
Red-backed sal.	23-28			7-15 ***(46.4-69.6%)***
		33-38	28-34 **(7.9-15.2%)**	
Ensatina	13-14			5-14 ***(0-64.3%)***
Time-constrained searches	24.0	22.4 ***(93.5%)***	11.8 ***(49.1%)***	

Timber Harvest

Prior studies (Bury 1983, Welsh 1990, Corn and Bury 1991) suggest that clear cut harvest had negative effects on forest amphibians in the Pacific Northwest. Grialou et al. (2000) found significant decreases (46.4-69.6%) for red-backed salamanders 2-4 yr post-harvest in Washington clear cuts, but ensatina had no difference one sampling period and a significant decrease (64.3%) the next year. Diller and Wallace (1994) suggest that timber harvest is less detrimental to salamanders in coastal forests of northern California.

Salvage Logging

To my knowledge, there are no studies of the effects of salvage logging on wildlife in western forests. Based on our preliminary results, fire alone appears to have little effect on amphibians in the West, but the additive effects of thinning or salvage logging of stands remains a challenge to understand.

Post-Burn: Habitat Quantity and Quality

Forests and their responses to fire are highly variable in western North America. This marked heterogeneity is a given and we need to expect high variability as the usual situation rather than the exception in most western forests. Over this varied landscape, wildlife such as terrestrial salamanders use cover (coarse woody material, snags, etc.) during the rainy season.

Earlier (Bury and Corn 1991), we found that species of Northwestern terrestrial salamander on the surface use types of woody and other cover in different proportions. Clouded salamanders (*Aneides ferreus*) preferred age classes 1-2 (relatively intact or newer) downed wood compared to ensatina (*Ensatina eschsholtzi*) that were mostly in age classes 3-5 (moderately to fully rotted or aged material). The western red-backed salamanders (*Plethodon vehiculum*) occurred under downed wood but in reduced numbers; most were in nearby rocky substrate (under rocks).

In this example of three western plethodontids, one may need to determine separate detection probabilities related to amount or proportion of each type of cover found on a plot. Further, the types of cover dry out differently (e.g., age class 3-5 pieces of downed wood are like sponges and hold water a long time compared to rocky soil that drains and dries relatively fast).

A summary of recent data from northern California (Major 2004) indicates a major reduction in fuels and forest floor depth in burned habitat compared to nearby unburned forests. In brief, total amounts (mean values) were:

Table 3. Comparison of forest-floor materials in different fire regimes in northern California (from Major 2004).

		Fire	
	No Fire	Prescribed	Wildland
Woody fuels (tons/ha)	25.5	15.6 (**61.2%**)	9.0 (**35.3%**)
Forest floor depth (cm)	3.1	1.7 (**54.8%**)	1.5 (**48.4%**)

Prescribed burns had about 2/3rd of the woody fuels and 55% of fine fuels (litter/duff) of unburned stands. Wildland fire plots were 1/3rd of the woody fuels and ca. 48% of fine fuels compared to unburned stands. These are all major reductions in available surface cover for animals such as terrestrial salamanders.

The type of fire also differently effects the distribution of downed wood and forest floor post-burn. Prescribed burns tended to burn relatively evenly across a managed fire line that moves fairly rapidly across the landscape. Large pieces of downed wood are usually not allowed to burn. Wildland fire often has intense "hot spots" that may burn severely while other areas have moderate fire severity. Wildfire may burn little of some stands or patches, or have minimal effects. Wildland fire often leaves a mosaic of fire severity at the landscape level (e.g., one stand burns severely while most stands survive with mixed losses of trees) down to small patches in stands (e.g., one piece of large woody debris is consumed totally by fire while a nearby one does not burn).

Response of Herpetofauna to Habitat Changes

Most of the species we found were terrestrial plethodontid salamanders. The number and biomass of these salamanders is greater than that for small mammals or birds in forest ecosystems (Hairston 1987, Corn and Bury 1991). Plethodontid salamanders have been suggested as indicators of forest ecosystem integrity and models for monitoring because they are relatively long-lived, take several years to reach sexual maturity, and appear to have small home ranges. (Welsh and Droege 2001).

Animal Numbers Not Reduced in Burned Stands: Why is That?

There appeared to be no reduction in numbers of herpetofauna from wild- or prescribed fire in the few years post-burn that we studied. However, the majority of captures were terrestrial salamanders and two recent studies (Baliey et al. 2004; Major 2004, *in prep.*) suggest that detection probabilities of captures vary between vegetation types. It may be more likely to find salamanders after a fire because a large portion of cover objects and forest-floor habitat are consumed by fire. This concentrates remaining animals under moderate (> 5 cm diameter) or larger surface material—the objects that field biologists tend to check in disproportional numbers to small objects or duff/leaf litter (R.B. Bury, pers. obs.).

In the West, numbers of individuals may not be reduced in burned areas because most wildfires occur during hot, dry summers when terrestrial salamanders are deep underground for the season. Prescribed burns are set from fall to spring during the wet season, which is the period of surface activity for terrestrial salamanders and may result in some mortality. Salamanders in burned plots had more injuries than those in unburned stands (Major *in prep.*). However, we lack any published evidence of the direct effects of prescribed fire on herpetofauna in the West, but some work exists on loss of wildlife habitat (see Major 2004).

Our studies were relatively soon (1-5 yrs) post-burn. If there was reduction in reproductive success of amphibians, it may take a half decade or longer to express itself. Terrestrial salamanders require 2-5 years to reach sexual maturity. Loss of eggs or the first year cohort may not be noticed in the wild for a year or longer because nests of terrestrial salamanders and hatchling (1-yr olds) are rarely found in the wild. To my knowledge, we lack any method or technique to reliably sample these life stages.

It appears that detections of terrestrial salamanders differ between burned and unburned plots because of sampling bias. Fire engulfed much of the leaf litter and small pieces of coarse woody material on the forest floor. When salamanders are activity on the surface, they may be concentrated in fewer cover objects (Fig. 2-1). Large amounts of leaf litter and downed woody material occur in unburned stands, which make it much more difficult to detect salamanders during timed searches (e.g., 6 person-hrs of search in each plot).

Our studies and most others on responses of wildlife to forest harvest, burns or other treatments rely on count indices (relative abundance) of captured animals. The differences in the numbers of animals found on plots in control stands (e.g., unburned) compared to treatments (e.g., burned) can be due to:

(1) direct loss of individuals (e.g., due to fire);
(2) indirect changes due to habitat alterations from the treatment; or
(3) detection probability (the liklihood of finding an individual related to temporal, seasonal and habitat variables).

As shown earlier, burned stands have about half the duff/leaf litter and small pieces of coarse woody debris (CWD) than that of unburned forest. Regardless of direct losses, remaining animals on the surface would need to concentrate under the reduced number and amounts of cover that is available post-fire.

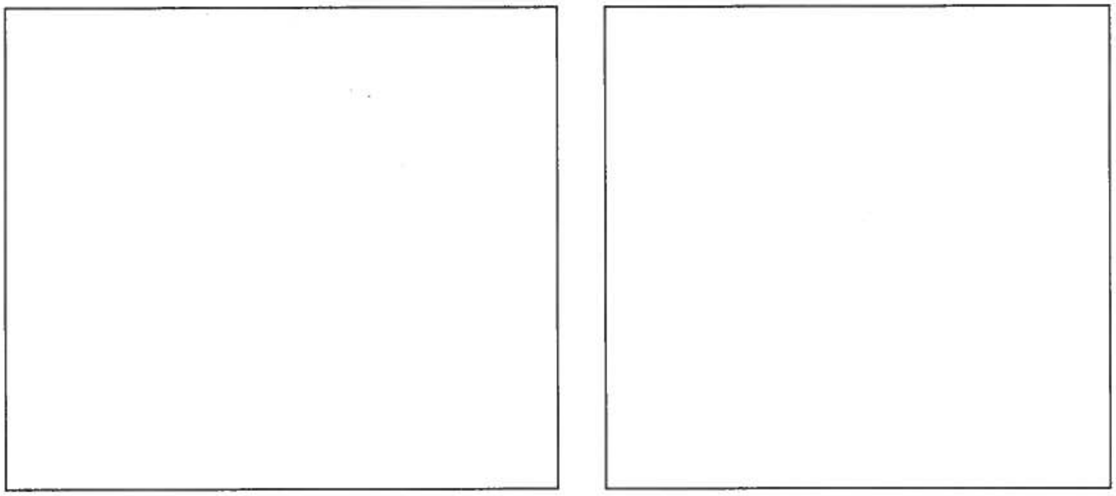
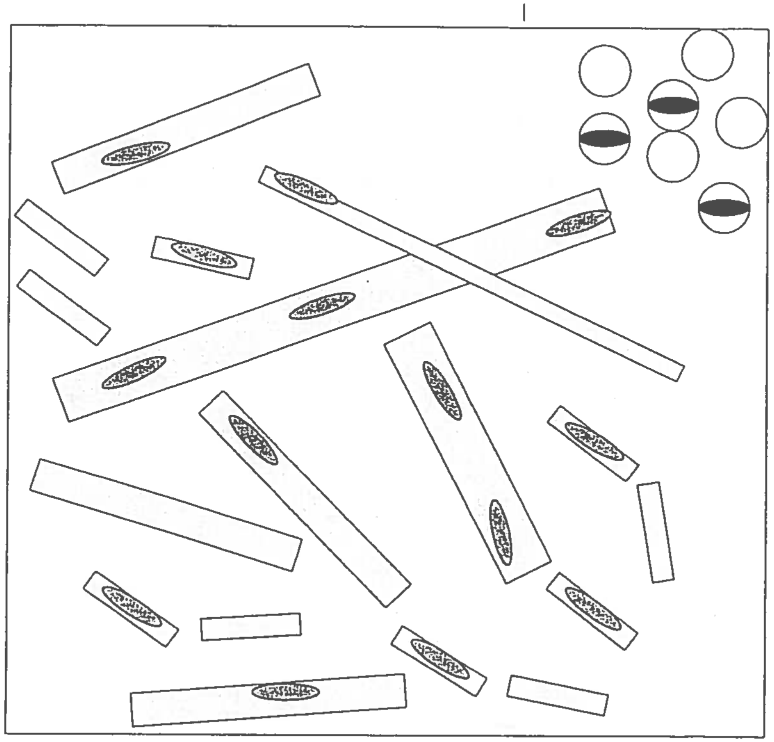


Fig. 2. Comparison of salamander distribution in an unburned plot (left) and burned site (right).



2-1

Fig. [illegible]. Distribution of terrestrial salamanders in downed woody material (rectangles) and pocket of rocky talus (open circles). There are 14 salamanders occupying 11 of 17 woody cover objects. Rocks/boulders (circles) have 3 salamanders (genus *Plethodon*).

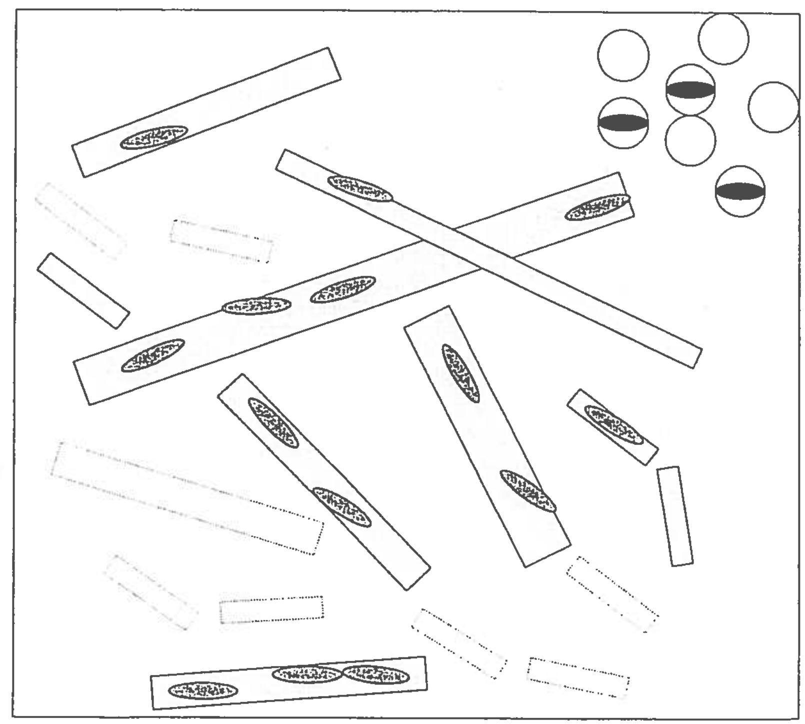


Fig. [illegible]. Same plot where wild fire has consumed over half of the downed woody material. Completely burned objects are now shown as faint gray (rectangles) while intact wood is solid (rectangle). Assuming no mortality salamander due to the fire, 14 salamanders now occur in 7 of 9 available woody cover objects. Number of salamanders (genus *Plethodon*) in rock/boulder remains unchanged.

Path Out of the Woods

We started this fire study late in 1998. Although sampling of terrestrial herpetofauna has been an active arena of research and monitoring efforts for decades (Bury 1983, Hairston 1987), design of studies is evolving rapidly in recent years. A few studies have determined the detection probabilities of salamanders (see Jung et al. 2000, Smith and Petranka 2000, Hyde and Simons 2001).

Recently, Bailey et al. (2004) promotes that count indices be tied to detection probability. This might require equal or more effort than search effort of many plots using count indices. Even a few population estimations (detection values) may be labor intensive. Although detection probabilities appear vital to determine, obtaining such data may cut coverage by half or more (as detection requires mark/recapture or other estimations of populations).

We suggest a need to balance the demands of statistical rigor (including detection probabilities) with the realities of field surveys in western forests that have high variation in habitats (see Bury 2004), including:

Forest type: closed canopy old forest; young; logged; burned or unburned
Ground cover
Season: Fall, Winter, Spring
Woody cover: Amount; type (decay class)
Substrate: Leaf litter/duff; rocky (type)
Slope/Aspect
Geographic location

Detection of salamanders could vary with each of these variables. For example, some salamanders are more resistant to desiccation than other species. They may be on the surface in greater proportion with the first fall rains or remain on surface longer in the spring than those species that are less tolerant of desiccation. Some species prefer hard wood (decay class 1-2) while others are in more rotten wood (decay class 4-5). Detection of salamanders in each is unknown at present. There also was a major difference between salamanders that tend to occur in or associated with woody cover (e.g., Ensatina, clouded salamanders) or rocky talus (e.g., most woodland salamanders of genus *Plethodon*). Detection probabilities may be needed for each group or each species.

This is not meant as a rejection of the value of detection probabilities for salamanders. Such effort is needed to improve our estimates of populations. Bailey et al (2004) may be correct in stating "We believe that using unadjusted count indices to compare populations over time and space without estimating detection probability is unjustified."

To me, this might be more of a goal than an effort to discard existing field techniques or designs. First, detection probabilities need to be better developed or proven for many variables across complex western landscapes. Moreover, we currently have no detection probabilities for any western plethodontid salamanders. We suggest study on this topic to refine its usefulness but, for now, retain known effective techniques and counts of populations.

How to Merge Extensive Surveys with Need for Intensive Detection Studies?

For some time, we have been aware of the influence or effects of seasonality and cover availability on detection of salamanders in western forests. One reason that investigators (see table 1) employ a "paired plots" (control:treatment) to compare terrestrial salamanders in the Pacific Northwest is the marked seasonality of surface environmental conditions. Sampling of control and treatment plots needs to be done close together in time and space (e.g., in adjacent or nearby stands). In most areas of the Northwest, there are relatively narrow windows of opportunity to find terrestrial salamanders on the surface.

Unlike the Appalachian Mountains or other regions of eastern North America, the West has little precipitation from May (sometimes earlier) to October. Rains start in the Fall and increase in intensity with appreciable rain predictable from November to April. While all this is occurring, there is reduced day length in winter (Dec-Feb) and temperatures decrease. Freezing nights occur except on coastal slopes, and snow may fall and remain on the ground for weeks or longer. Salamanders generally are underground in periods of drought (May-Oct) or cold (parts of late Dec-early Feb).

In Spring, the ground is often saturated and salamanders are active on the surface until the dry-hot season starts over. Even within these general patterns, there can be periods of little precipitation or cold snaps during any part of the rainy season (late October to April).

The amount of cover available appears to effect capture effectiveness and count indices. For example, Corn and Bury (1990) reported fewer plethodontid salamanders per amount (N/m^3) of cover searched in old growth stands compared to younger stands. This seemed odd as most biologists would predict that stable, most old-growth stands have the most terrestrial salamanders. However, old growth forests had vastly more downed wood (= cover) than young managed forests where not only are trees remove for timber but, in the past, snags were felled and downed wood piled up and burned as slash. The estimated number of animals per stand (area) is calculated as:

$$\text{Salamanders/m}^3 \text{ of wood} \times \text{Amount of cover in m}^3\text{/ha} = \text{total count}$$

Another way to view this is that there is so much cover in an old growth stand (e.g., >400 m^3 of downed wood/ha) that hand search literally only scratches only the surface of the available cover. Many more objects and duff/leaf litter need to be turned or dug through to find salamanders in these cover-rich habitats. This will get us closer to population estimates for salamanders using downed wood. However, we still lack knowledge of their use of leaf litter or fine woody debris, or rocky substrate.

Corn and Bury (1990) found that the density of salamanders (number/ha) is downed logs (coarse woody debris) is inversely related to the amount of downed wood present in the study area. Also, salamanders appeared to be less clumped as greater amounts of habitat are available. They provided a formula to calculate the predicted densities (e.g., per ha) to densities of salamanders to each category of coarse woody debris (3-5 types, depending on level of differentiation) multiplied by volume of wood/ha in that category. Thus, estimates can get complex.

Thus, reduced amounts of available cover in younger or managed forest stands may concentrate animals. Field effort in these stands results in searches of more preferred cover (e.g., pieces of wood large enough to hide under) than in stands such as old-growth with large amounts of cover. We do not claim this is always the case, but much of our experience suggests there are marked differences in amount and quality of cover between stands of different ages (e.g., young vs. old-growth) and treatments (e.g., old-growth vs. logged or burned stands).

All of these variables can make calculations increasingly complicated, but all are important to accurate, reliable population estimation. Currently, there is no model or practical equation/approach to include all these variables into one formula to estimate population densities of western plethodontid salamanders. This is a need and goal for the future.

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Joint Fire Science Program

Fuels Management and Wildlife Habitat: Quantity and Quality Relationships

INTERIM REPORT

R. Bruce Bury

Part 3: ASSESSMENT OF HERPETOFAUNAL RESPONSES IN WESTERN FORESTS: TRADEOFFS OF RELATIVE ABUNDANCE AND DETECTION PROBABILITIES (COUNTS VERSUS MARK/RECAPTURE STUDIES)

INTRODUCTION

Amphibians are a major portion of the forest-floor fauna in Pacific Northwest forests and play important ecological roles (see Bury et al. 2002). Rigorous, effective sampling protocols are essential to understanding the response of amphibians and associated habitat to perturbations such as fire and timber harvest. Designs and field techniques also must be able to cover sufficient area and samples to ensure adequate replication over as the range of variation in habitat and species assemblages over the landscape. Welsh and Droege (2001) stated that use of salamanders as bioindicators requires appropriate and cost-effective counting techniques that are precise and replicable (i.e., exhibit low count variances) and accurate (i.e., unbiased).

The objectives of this paper are to summarize and evaluate an apparent conflict or difference in use of relative abundance (count indices) and estimations of densities (mark and recapture). This is an effort toward a goal of union of emerging technologies (field measurements) and statistical rigor into an effective system to best compare how treatments (e.g., fire, thinning) affect populations.

Comparison of Sampling Designs and Approaches

Relative Abundance

In our study and many prior ones in western forests (see Corn and Bury 1989; de Maynadier and Hunter 1995; Welsh and Droege 2001), relative abundance (or count indices) of terrestrial salamanders were a main measure of wildlife compared between controls and treatment plots (Table 1). These did not assume these were an accurate population estimate but a measure of animals active on the surface when comparing different habitat types (i.e., reduced numbers on a treatment compared to a natural forest could suggest an affect is occurring due to the treatment). However, count-based studies are problematic because differences in detection probability can confound inferences about the treatment of interest (e.g., fire), especially if detection probability differs among treatments (burned and unburned sites).

Detection Probability

Bailey et al (2004a) recommend a double-sampling design for large-scale studies when estimating detection probability at every sampling location is not feasible. A large number of sites are selected in a variety of habitats and use of count indices or "proportion of area" occupied as state variables. Capture-recapture studies are conducted on a subset of reference sties to estimate detection probabilities and calibrate counts for the more extensive sampling effort. Although the new approach (Bailey et al 2004) has merit and great promise, there were few or no practical guidelines provided.

In concert, Bailey et al (2004b) found that vegetation type and elevation were correlated with detection probabilities, and surface population size. They stated that investigators should be cautious about drawing inferences based on count indices unless detection probabilities are estimated. There evidence indicated spatial and temporal variation in salamander detection probability parameters for populations.

Table 1. Techniques and methods used to determine relative abundance (count indices) of terrestrial herpetofaunas in Pacific Northwest forests.

Technique	Location	Reference
Pitfall trapping	Washington Coast Range Washington Cascades	Grialou et al. (2000) Gilbert and Allwine (1991) Bury and Corn (1987) Aubry (1991, 2000)
	Oregon Cascades	Bury and Corn (1987) Butts and McComb (2000) Maguire (2002)
	Oregon Coast Range	Corn and Bury (1991) McComb et al. (1993) Gomez and Anthony (1996) Cole et al. (1997) Martin and McComb (2003)
	Oregon Siskiyou Mtns	Biek et al. (2002)
	Northern California	Raphael (1988) Welsh and Lind (1988)
Quadrats (e.g., 1.m^2)	British Columbia	Dupuis et al. (1995), Dupuis (1997) Davis (1996, 1998)
Area-constrained	No. California (25×50 m) (7×7 m) (ca. 20 m^2)	Bury (1983) Welsh and Lind (1995) Diller and Wallace (1994)
	Oregon Siskiyous (30×50 m)	Biek at eal. (2002)
Transects or Belts	Oregon Coast Range Oregon Cascades Oregon Siskiyou Mtns.	Olson (in prep.) Butts and McComb (2002) Major (2004)
Coarse Woody Debris	Oregon Coast Range	Corn et al. (1991)
Cover boards	British Columbia	Davis (1997, 1998)
	No. California	Fellers and Drost (1994)
Time-constrained	Washington Cascades	Aubry et al. (1998)
	Oregon Cascades	Bury and Corn (1988)
	Northern California	Raphael (1988) Welsh and Lind (1988)

Sampling Forest Amphibians: An Example of Landscape Variation

A common design to assess responses of animals employs paired plots replicated over the landscape. These could be three paired plots (3 unburned: 3 burned sites) across a forested gradient (Fig. 1). Although all of these are in relatively close proximity, the sites on a gentle slope (A) will tend to have a more extensive duff/leaf letter compared to a steeper slope (C) that often is drier (better drainage) and, in turn, greater amounts of exposed rocky substrate. Aspect and slope may even vary between each pair, but are assumed fairly similar here. Plant communities vary widely in western forests related to a complex interaction of these factors (aspect, slope, substrate) as well as prior fire and timber harvest legacy. Each pair and, possibly, each plot may require its own study of detection probability. To us, these variables need to be better defined, tested and established before establishing a double-sampling regime (count indices plus detection probabilities).

Downside to Detection Probability Sampling

Mark-recapture sampling requires intensive effort and, in turn, often restricts effort to relatively small plots. Bailey et al (2004a, b) show the value of detection probability using mark/recapture techniques, but these tests were on small plots (15 × 15-m). The outer boundary was construed of silt fence buried into the ground. Emigration and immigration in these plots were prevented by a silt fence but no sampling was done to test this assumption (e.g., sampling outside the enclosure). Such fences, even if they were 100% effective, are difficult to install under natural field conditions when larger areas need to be sampled. Bailey et al. (2004a) installed 900 m of fence (15 plots with 60-m fencing each). Although extensive, we (Bury et al. 1991) installed more drift fence (6 arms each 5-m long = 30 m/site × 147 stands = 4410 m) in the Pacific Northwest. We found this highly effective to capture animals (in pitfall traps) but also is costly in terms of expenses (fencing) and time.

These methods are statistically more rigorous than other techniques (Table 1) but estimation of population size are costly to perform. Bailey et al (2004a) used small plot sizes (225 m^2). Over 44 of these would be needed to encompass what is happening in 1 ha. Not only are there differences between stands (Fig. 3-1), our preliminary studies in western Oregon (Bury and Major, pers. obs.) indicate that there are differences in catch of species within a stand. Heterogeneity of vegetation, substrate and cover is great in western forests so it seems prudent to employ several multiple plots (e.g., 15 × 15-m or other sizes) inside each stand. Currently, there are no guidelines on how many of these are optimal or necessary to embrace the range of variability within forest stands.

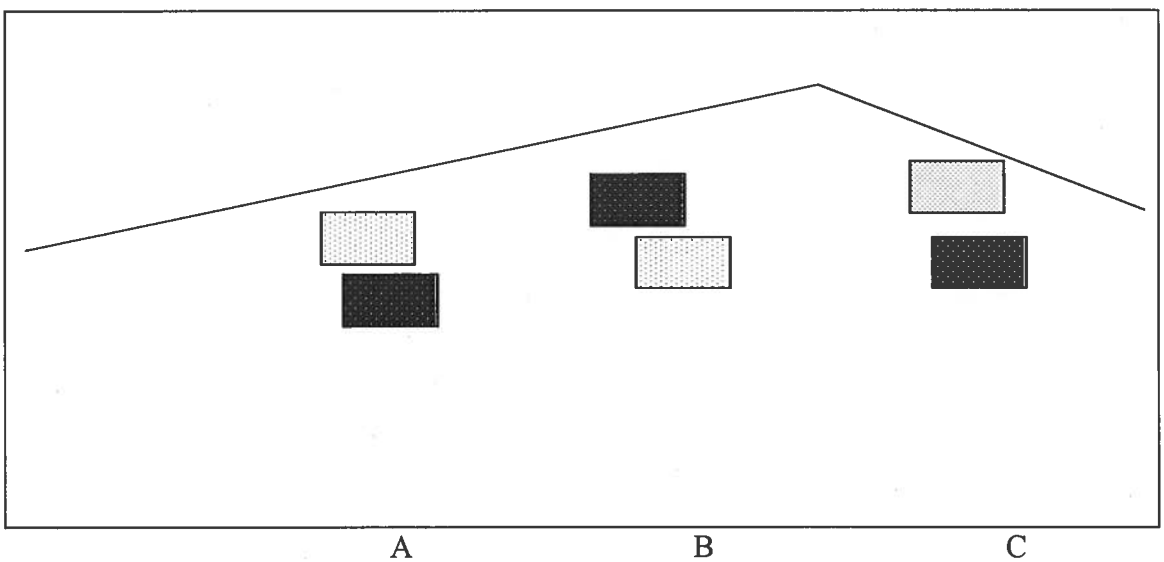

Fig. 3-1. Representative spatial distribution of three paired plots (dark = burned; light = unburned) across a western landscape.

In the Pacific Northwest, variation is more the norm than the exception. It needs to be established that terrestrial amphibians are uniformly distributed across stands before one can assume detection probability works at all. Such tests do not exist at this time. This is not to discount the value of probability detections but to encourage further examination over diverse landscape (which is suggested by Bailey et al. 2004b).

Tradeoffs

Scale of Sampling

Davis (1997) reported that the absolute density of terrestrial salamanders is problematic and should not be attempted if relative abundance is all that is actually needed. Further, he stated that usually investigators are content with reporting maximum surface density as an index of absolute abundance. On the other hand, Bailey et al (2004a) stated using unadjusted count indices to compare populations over time and space without estimating detection probability is unjustified. They suggest a double-sampling scheme (extensive and intensive).

However, field sampling of western plethodontids and other herpetofauna is labor intensive. These species generally are only found by turning over objects, which is a slow process. It is even more demanding to rake through duff/leaf litter and, to me, this has received almost no attention to date to address key issues: visibility (most salamanders are small-sized and cryptically colored), observer bias (each crew member may have varying success rates in locating salamanders).

The magnitude of field sampling must be addressed. In an earlier study (Bury 1983), we searched all surface objects and raked through large amounts of leaf litter in moderate-sized plots (25 × 50 m = 0.125 ha/plot) in redwood forest. It required over three times as much time (person-hr per plot) to sample old-growth (mean = 32.75 h; range 19.5-44 h) as in clearcut plots (mean = 10.13 h; range 7.5-16.5). We spent 171 person-h searching 1 ha. Further, there was so much leaf litter and downed wood (some >1 m diameter) that search was likely only a fraction of the available cover (R.B. Bury, pers. obs.).

Needed Effort, Tradition and Efficiency

Context, level of knowledge and even tradition influence measurements of salamander populations. For example, there has been almost no use of mark and recapture techniques to estimate of population densities (let alone detection probability) for western salamanders compared to those in eastern North America (see Hairston 1987; Petranka 1998; Welsh and Droege 2001).

To our knowledge, there are no published estimates of population size (based on mark-and-recapture techniques) for any terrestrial salamander community or species of plethodtontid salamander in the Pacific Northwest (Oregon, Washington). Two studies use mark/recapture to estimate densities of salamanders in northwestern California. Welsh and Lind (1992) report a density of Del Norte salamanders (*Plethodon elongatus*) at 0.78±0.50 salamanders/m^2. Lowe (2002 unpubl.) found densities of Ensatina (*Ensatina eschscholtzi*) at 0.28 salamanders/m^2 and Del Norte (*P. elongatus*) at 0.16/m^2 and, together, at 0.44/m^2.

On Vancouver Island, British Columbia, Ovaska and Gregory (1989) reported mean densities of red-backed salamanders (*Plethodon vehiculum*) on the surface ranging from 0.35-1.16 individuals/m^2 with peak values of 1.04-1.40 during March-May. In the same area, Davis (1998) reported values as high as 1.8 individuals/m^2 but overall the density of *P. vehiculum* was relatively low (ca. 0.1/m^2) except for occasional areas of higher densities.

There have been >30 field studies using relative abundances to compare responses of amphibians to treatments in western forests. Although seldom stated or proven (by any technique), these studies assume that there is equal likelihood (i.e., detection probability) of salamanders on treatment(s) and control plots during the period of sampling. Sampling is usually attempted conducted in a relatively short window or equivalent environmental conditions (e.g., an unburned stand is sampled immediately after a burned stand) because weather greatly influences surface activity of western terrestrial salamanders. Also, it is important to have many plots to cover the range of environmental conditions and for replication because of high variation in habitat (e.g., forest composition, substrate type) in western forests,

Other investigations (e.g., Welsh 1990, Welsh and Lind 1992) show a positive relationship between numbers of salamanders found on timed-searches versus the age of forest stands (with more salamanders in older forests). Along such a continuum, it would seem prudent to determine detection probabilities at low, medium and high count indices. For statistical rigor, three detection tests at each level (high, medium, low) are needed to determine the range of variation and, thus, 9 tests are needed. This shows how a need for detection probability can quickly increase to a major undertaking. Conducting one mark-recapture study could be inaccurate itself as there are many assumptions (no emigration or immigration, equal chance of catch, etc.); we need to verify the consistency of mark-recapture results over varying landscape conditions.

Conclusion

We lack any major program to study the responses of wildlife resources to fire, and how to restore or enhance wildlife resources in post-fire situations. Also, we need to improve the reliability and accuracy of population estimates and relative abundance counts to asses how many terrestrial salamanders occur on control and treatment sites. We suggest increased attention to determination of population sizes by more rigorous, intensive techniques (e.g., mark/recapture studies) while relating these results to broader sampling for relative abundance to ensure coverage of the range of variation in western forests. A call for such work was made by Bailey et al. (2004a) but, today, we have no or minimal efforts to calculate estimates of populations (mark/recapture) in western forests. Accurate, timely information to determine the responses of wildlife to fire is urgently needed. Further, we also need to develop management tools that provide cover for wildlife in post-burn scenarios.

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PART 4

SECTION 1

Prescribed Fire Effects on Terrestrial Salamanders in western North Carolina

Prescribed Fire in Appalachian Mtns.

We studied responses of forest-floor habitat and terrestrial amphibians at 4 different prescribed burns in western North Carolina. All were relatively small fires that concentrated on clearing out underbrush and buildup of ground fuels.

Two of the sites lacked enough animals for analysis (Bark Mtn. & Leatherwood), but more animals were found in these controls. The other two sites had more amphibians found on the burned than the unburned plots (Fig. X.X). This was unexpected because other treatments like timber harvest results in reduced numbers of animals (see Petranka et al. 1993).

At the same time, visibility and detection of terrestrial salamanders is likely greater on the burned plots because of reduced amounts of surface cover in post-burn situations. We cannot explain the marked differences at this time because that requires tests of detectoin probability (mark and recapture studies), which are costly to perform.

In any case, there appears to be no reduction in terrestrial amphibians following prescribed fire in eastern deciduous forests that we examined 1 year or less post-burn. Longer term effects were not measured in this study.

SE FIRE	Burn captures	Control captures
7MILE	86	75
FLAT	125	94
LEATHER	1	9
BARK	1	4

Appendix A: Forest-floor habitat characteristics, fuels measurements, and amphibian capture numbers for four prescribed fires in the Appalachian Mountains in western North Carolina.

Stand ID	Array ID	FirstOfBurn	Σ(0-1/4)	Σ(1/4-1)	Σ(1-3)	Σ(STEM_CNT)	Σ(LOG_CNT)	Σ(LITTER(cm))	Σ(DUFF(cm))	Amphibs. capt.	Spp. Rich.
7MILEB1	7MILEB1SP1	BURN	52	3	5	283	3	0.333333	0.670833	24	4
7MILEB1	7MILEB1SP2	BURN	26	19	4	307	2	0.275000	0.912500	28	5
7MILEB1	7MILEB1SP3	BURN	61	7	6	345	3	0.704167	1.520833	34	5
7MILEC1	7MILEC1SP1	CONTROL	60	7	4	127	1	0.979167	0.966667	31	2
7MILEC1	7MILEC1SP2	CONTROL	38	5	4	113	6	1.850000	2.295833	20	4
7MILEC1	7MILEC1SP3	CONTROL	25	2	1	2	3	0.845833	0.845833	24	3
FLATB1	FLATB1SP1	BURN	90	12	3	190	1	0.433333	0.250000	36	4
FLATB1	FLATB1SP2	BURN	59	5	3	65	10	1.475000	2.370833	35	7
FLATB1	FLATB1SP3	BURN	240	45	17	274	5	0.491667	1.695833	54	7
FLATC1	FLATC1SP1	CONTROL	47	12	7	100	5	1.454167	1.250000	30	3
FLATC1	FLATC1SP2	CONTROL	49	9	13	161	4	1.283333	1.095833	36	6
FLATC1	FLATC1SP3	CONTROL	48	11	5	143	4	1.033333	0.691667	28	4
LEATHERB1	LEATHERB1SP1	BURN	51	4	6	120	3	0.529167	0.233333	1	1
LEATHERB1	LEATHERB1SP2	BURN	22	1	2	95	2	0.806250	0.683333	0	0
LEATHERB1	LEATHERB1SP3	BURN	67	13	4	58	4	0.741667	0.583333	0	0
LEATHERC1	LEATHERC1SP1	CONTROL	78	10	3	30	2	1.608333	2.712500	1	1
LEATHERC1	LEATHERC1SP2	CONTROL	26	7	3	6	0	1.212500	2.725000	6	3
LEATHERC1	LEATHERC1SP3	CONTROL	40	3	6	9	0	1.462500	2.366667	2	2
BARKB1	BARKB1SP1	BURN	45	8	5	6	3	0.708333	0.558333	0	0
BARKB1	BARKB1SP2	BURN	25	10	7	24	5	0.695833	0.795833	1	1
BARKB1	BARKB1SP3	BURN	60	9	6	27	6	0.620833	0.687500	0	0
BARKC1	BARKC1SP1	CONTROL	28	5	7	1	2	2.095833	1.358333	1	1
BARKC1	BARKC1SP2	CONTROL	29	13	6	13	3	2.429167	2.400000	1	1
BARKC1	BARKC1SP3	CONTROL	31	7	4	14	3	1.520833	1.104167	2	2

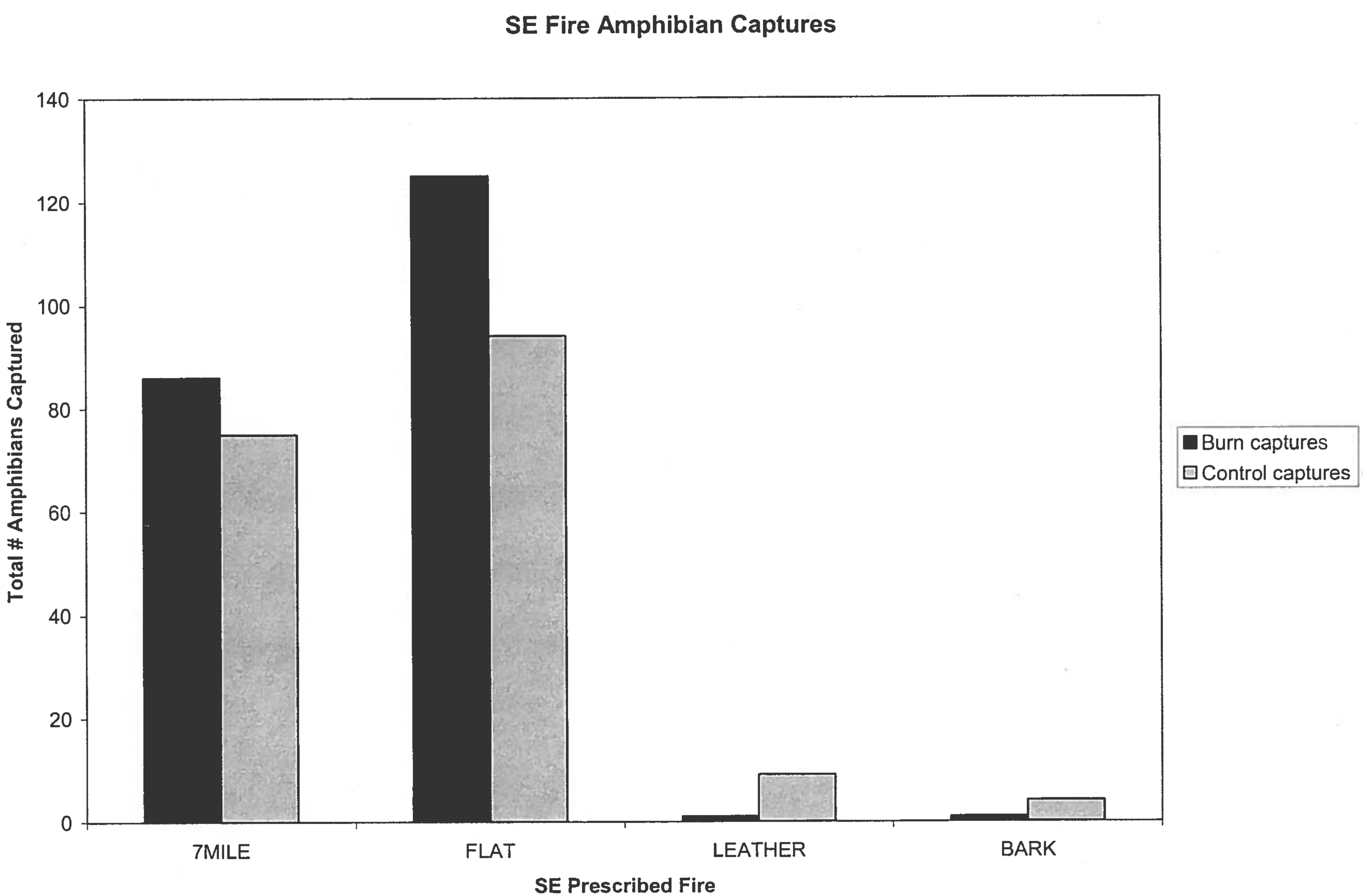


Figure X.x: Total amphibian capture histograms for western North Carolina (SE) prescribed fires. Burned plot captures represented by black bar and control plots represented by grey.

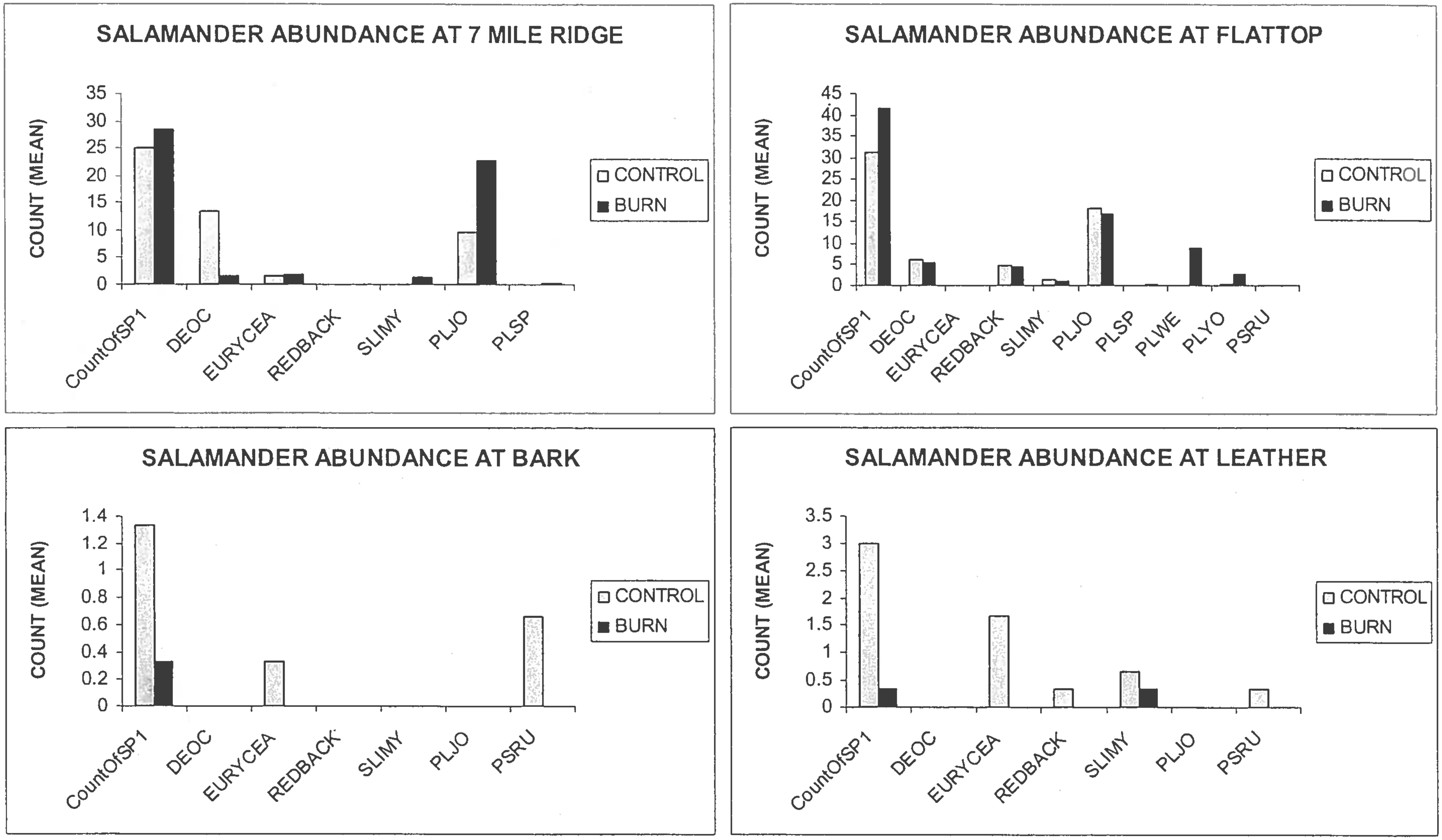


Figure x.x Relative abundance of dominant salamander species found in the each of SE prescribed fires. Relative abundance of salamanders in burn plots represented by black bars and control plots represented by grey bars.

Stand ID	Array ID	FirstOfBurn	Σ(0-1/4)	Σ(1/4-1)	Σ(1-3)	Σ(STEM_CNT)	Σ(LOG_CNT)	Σ(LITTER)	Σ(DUFF)	CountOfSP1	BUAM	BUWO	D_SP	DEOC	ENES	EUBI	EUWI	HYRE	PLCI	PLEE	PLGL	PLHY	PLJO	PLSE	PLSP	PLWE	PLYO	PSRU	RASY	UNK	Richness
7MILEB1	7MILEB1SP1	BURN	52	3	5	283	3	0.333333	0.670833	24	0	0	0	0	0	3	0	0	0	0	1	0	19	0	0	0	0	0	0	0	4
7MILEB1	7MILEB1SP2	BURN	26	19	4	307	2	0.275000	0.912500	28	0	0	0	2	0	1	0	0	0	0	2	0	22	0	1	0	0	0	0	0	5
7MILEB1	7MILEB1SP3	BURN	61	7	6	345	3	0.704167	1.520833	34	0	0	0	3	0	1	1	28	0	0	0	0	0	0	0	0	0	0	0	0	5
7MILEC1	7MILEC1SP1	CONTROL	60	7	4	127	1	0.979167	0.966667	31	0	0	0	22	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	2
7MILEC1	7MILEC1SP2	CONTROL	38	5	4	113	6	1.850000	2.295833	20	0	0	0	10	0	1	1	0	0	0	0	0	7	0	0	0	0	0	0	1	4
7MILEC1	7MILEC1SP3	CONTROL	25	2	1	2	3	0.845833	0.845833	24	0	0	0	8	0	0	3	0	0	0	0	0	13	0	0	0	0	0	0	0	3
BARKB1	BARKB1SP1	BURN	45	8	5	6	3	0.708333	0.558333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BARKB1	BARKB1SP2	BURN	25	10	7	24	5	0.695833	0.795833	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
BARKB1	BARKB1SP3	BURN	60	9	6	27	6	0.620833	0.687500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BARKC1	BARKC1SP1	CONTROL	28	5	7	1	2	2.095833	1.358333	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
BARKC1	BARKC1SP2	CONTROL	29	13	6	13	3	2.429167	2.400000	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
BARKC1	BARKC1SP3	CONTROL	31	7	4	14	3	1.520833	1.104167	2	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2
FLATB1	FLATB1SP1	BURN	90	12	3	190	1	0.433333	0.250000	36	0	0	0	7	0	0	0	0	5	0	1	0	23	0	0	0	0	0	0	0	4
FLATB1	FLATB1SP2	BURN	59	5	3	65	10	1.475000	2.370833	35	0	0	1	3	2	0	0	0	0	0	0	0	9	0	0	13	1	6	0	0	7
FLATB1	FLATB1SP3	BURN	240	45	17	274	5	0.491667	1.695833	54	0	0	0	6	0	0	0	0	6	0	2	0	18	0	1	14	7	0	0	0	7
FLATC1	FLATC1SP1	CONTROL	47	12	7	100	5	1.454167	1.250000	30	0	0	0	8	0	0	0	0	1	0	0	0	21	0	0	0	0	0	0	0	3
FLATC1	FLATC1SP2	CONTROL	49	9	13	161	4	1.283333	1.095833	36	0	0	0	9	0	0	0	0	5	0	3	0	17	0	0	0	1	0	1	0	6
FLATC1	FLATC1SP3	CONTROL	48	11	5	143	4	1.033333	0.691667	28	0	0	0	2	0	0	0	0	8	0	1	0	17	0	0	0	0	0	0	0	4
LEATHERB1	LEATHERB1SP1	BURN	51	4	6	120	3	0.529167	0.233333	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
LEATHERB1	LEATHERB1SP2	BURN	22	1	2	95	2	0.806250	0.683333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LEATHERB1	LEATHERB1SP3	BURN	67	13	4	58	4	0.741667	0.583333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LEATHERC1	LEATHERC1SP1	CONTROL	78	10	3	30	2	1.608333	2.712500	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
LEATHERC1	LEATHERC1SP2	CONTROL	26	7	3	6	0	1.212500	2.725000	6	0	0	0	0	0	4	0	0	0	0	0	1	0	0	0	0	0	1	0	0	3
LEATHERC1	LEATHERC1SP3	CONTROL	40	3	6	9	0	1.462500	2.366667	2	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2

Stony Knob- 7 mile ridge Control
77 critters

Desmognathus Ochrophaeus (mountain dusky)
P. jordani (Jordan's salamander)
Thamnophis sauritus (eastern garter snake)
E. wilderae (blueridge two lined salamander)

Stony Knob – 7 mile ridge Burn
86 critters

Plethodon Jordani (Jordan's salamander)
Eurycea Bislineata (Blueridge 2 line salamander)
P. glutinosus (Slimy Salamander)
Nothopthalmus viridescens (Red spotted newt)
Desmognathus Ochrophaeus (Mountain Dusky)
Plethodon serratus (E. Redback salamander

Grandfather Mountain- Bark Mountain Burn
1 critter
Bufo americanus

Grandfather Mountain – Bark Mountain Control
4 critters

Pseudotriton rubber (red salamander and blackchined red)
Eurycea wilderae (blueridge 2-line salamander)
Bufo americanus

Flattop Burn
124 critters

P. welleri (Weller's salamander)
P. yonahlossee (Yonahlossee salamander)
P. jordoni (Jordon's salamander)
D. ochrophaeus (Mountain Dusky)
P. cinereus (E. redback)
P. glutinosus (Slimy)

Flattop Control
94 critters
P. jordoni
D. ochrophaeus
P. cinereus
P. glutinosus
P. yonahlossee

Leatherwood Burn
3 critters

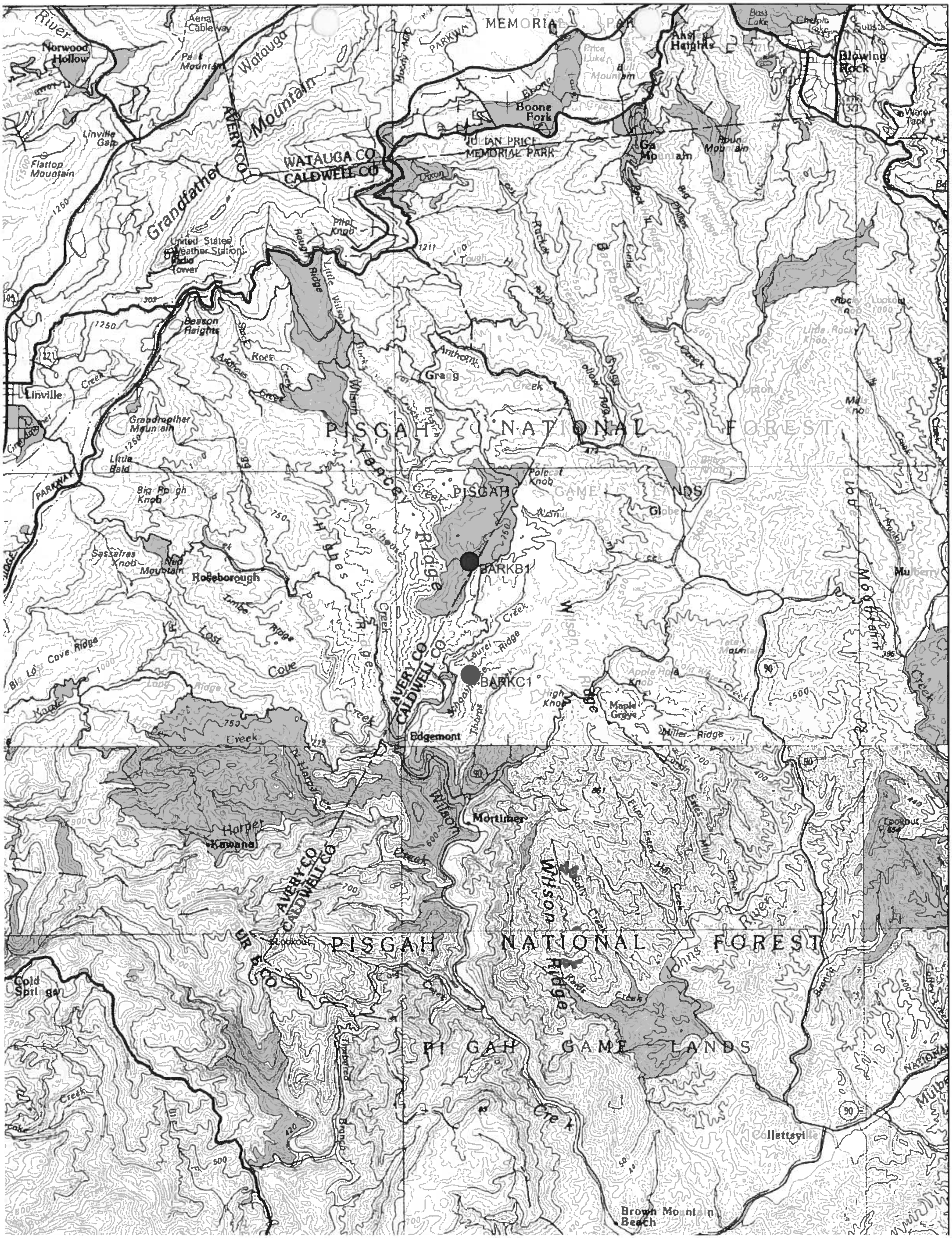
Diadophus punctatus (ringneck snake)
P. glutinosus (Slimy salamander)
Agkistrodon contortrix (copperhead)

Leatherwood Control
9 critters

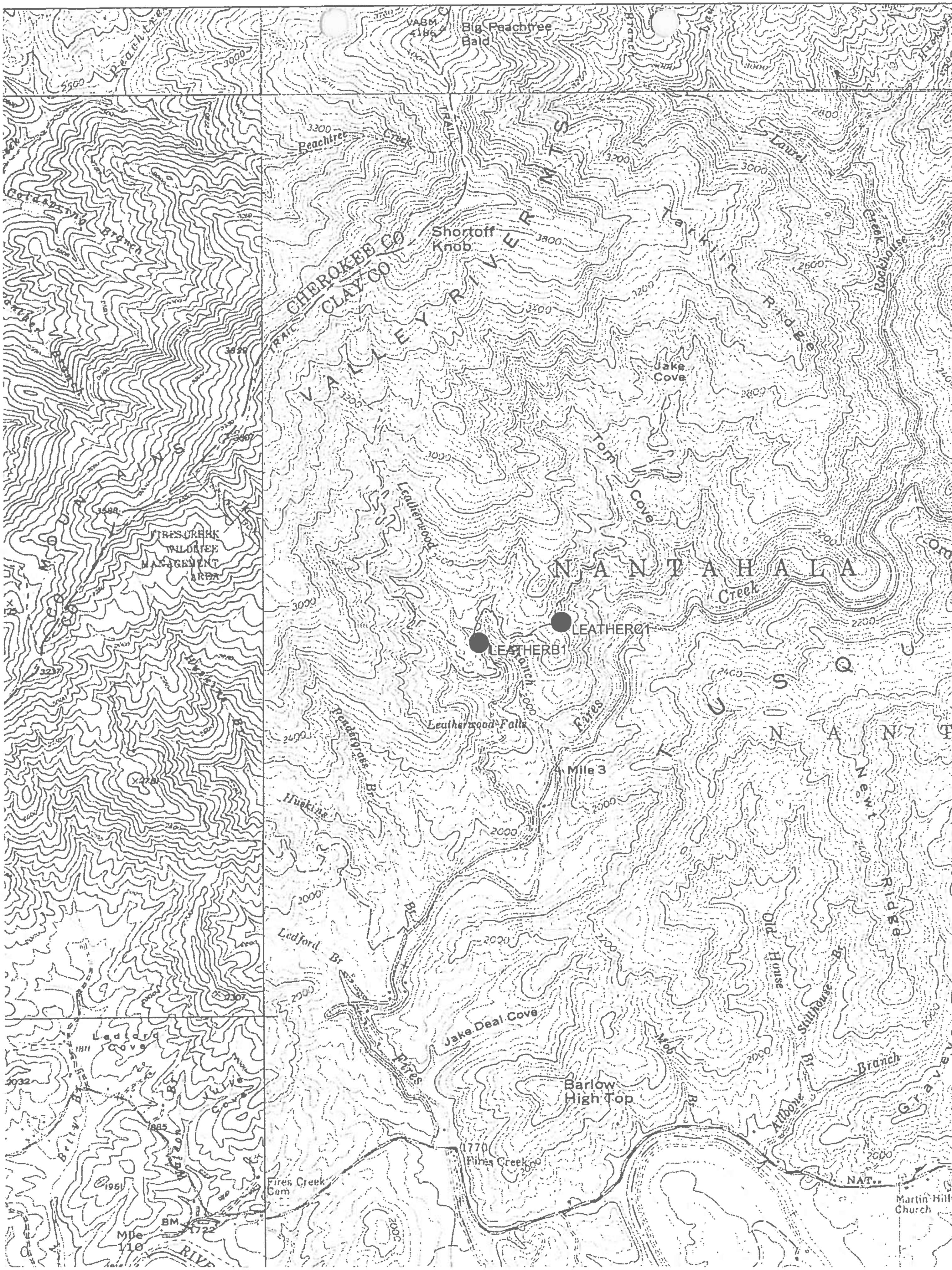
Plethodon serratus (Southern Redback)
E. bislineata (2 line salamander)
Pseudotriton rubber (Red)
Plethodon hybrid (glut/jordani)
P. glutinosus

Table X.X: Geographical data for all wildfire and prescribed fire stands. Treatment type, location, and geographical reference information presented.

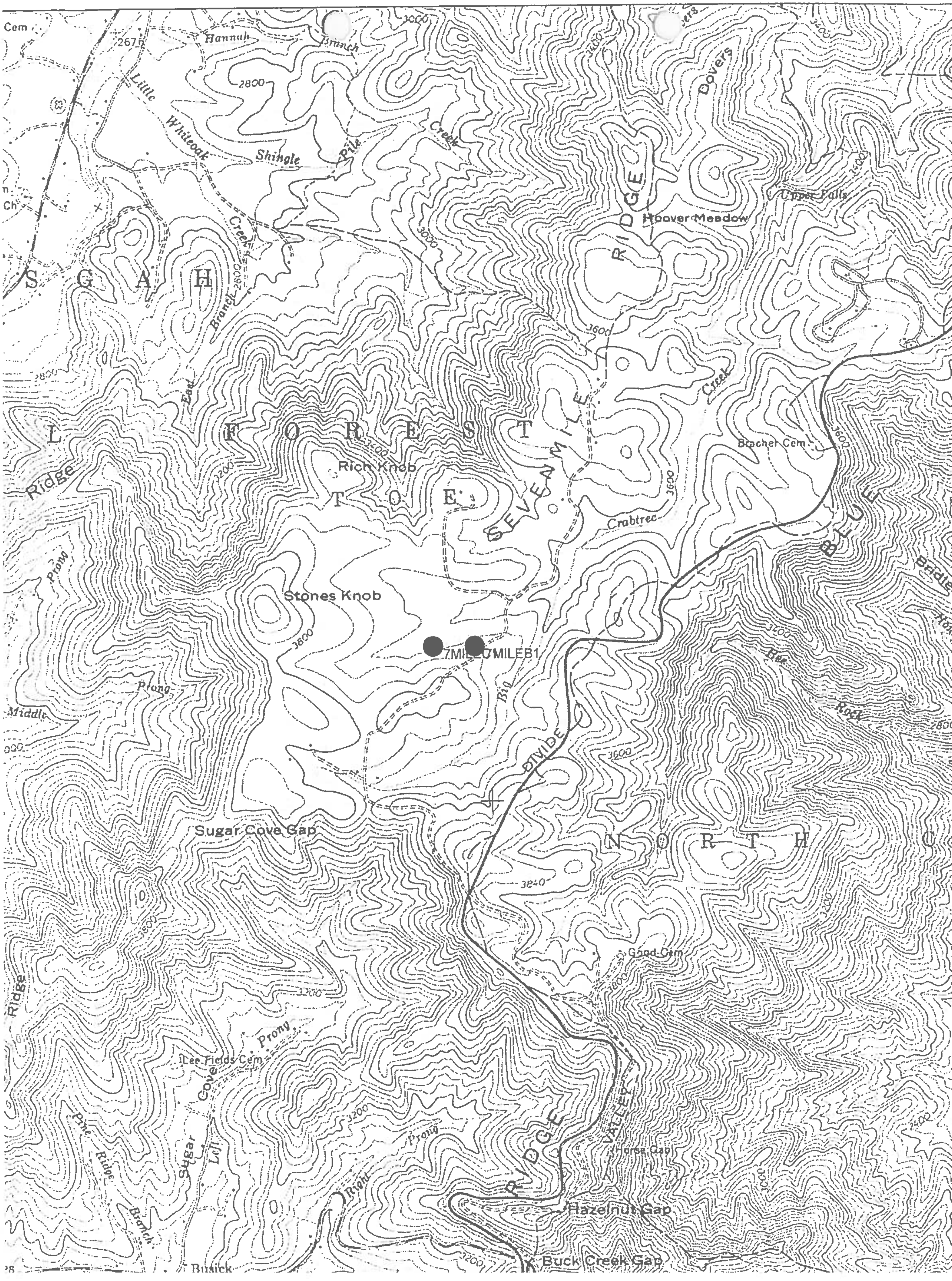
STANDS	BURN	FOREST	NAT. FOREST	DISTRICT	TOPO QUAD	PAIR	ARRAYID	UTMN	UTME
7MILEB1	BURN	SE	PISGAH	TOECANE/GRANDFATHER	CELO	7MILEC1	7MILEB1SPxx	17S 3962048	394512
7MILEC1	CONTROL	SE	PISGAH	TOECANE/GRANDFATHER	CELO	7MILEB1	7MILEC1SPxx	17S 3962053	394287
BARKB1	BURN	SE	PISGAH	GRANDFATHER	GRANDFATHER MTN.	BARKC1	BARKB1SPxx	17S 3987994	431618
BARKC1	CONTROL	SE	PISGAH	GRANDFATHER	GRANDFATHER MTN.	BARKB1	BARKC1SPxx	17S 3985531	431618
DILLON DA1	BURN	DILLON	KLAMATH	UKONOM	DILLON MTN.	DILLON DCA1	DA1SPxx	4601674	450050
DILLON DA3	BURN	DILLON	KLAMATH	HAPPY CAMP	BEAR PEAK	DILLON DCA3	DA3SPxx	4619245	456216
DILLON DC1	CONTROL	DILLON	KLAMATH	UKONOM	DILLON MTN.	DILLON DS1	DC1SPxx	4596888	451151
DILLON DC4	CONTROL	DILLON	KLAMATH	HAPPY CAMP	BEAR PEAK	DILLON DS4	DC4SPxx	4612032	455364
DILLON DCA1	CONTROL	DILLON	KLAMATH	UKONOM	DILLON MTN.	DILLON DA1	DCA1SPxx	4598526	450092
DILLON DCA3	CONTROL	DILLON	KLAMATH	HAPPY CAMP	BEAR PEAK	DILLON DA3	DCA3SPxx	4620009	453622
DILLON DS1	BURN	DILLON	KLAMATH	UKONOM	DILLON MTN.	DILLON DC1	DS1SPxx	4599065	453001
DILLON DS4	BURN	DILLON	KLAMATH	HAPPY CAMP	BEAR PEAK	DILLON DC4	DS4SPxx	4613155	451783
FLATB1	BURN	SE	PISGAH	TOECANE/GRANDFATHER	CHESTOA	FLATC1	FLATB1SPxx	17S 3989644	373969
FLATC1	CONTROL	SE	PISGAH	TOECANE/GRANDFATHER	CHESTOA	FLATB1	FLATC1SPxx	17S 3990462	375151
LEATHERB1	BURN	SE	NANTAHALA	TUSQUITEE	HAYESVILLE	LEATHERC1	LEATHERB1SPxx	17S 3887704	239038
LEATHERC1	CONTROL	SE	NANTAHALA	TUSQUITEE	HAYESVILLE	LEATHERB1	LEATHERC1SPxx	17S 3887793	239460
UMPQUA SB1	BURN	UMPQUA	UMPQUA	NORTH UMPQUA	ILAHEE ROCK	UMPQUA SC4	USB1SPxx	4796903	532540
UMPQUA SB2	BURN	UMPQUA	UMPQUA	NORTH UMPQUA	ILAHEE ROCK	UMPQUA SC1	USB2SPxx	4796721	532698
UMPQUA SB3	BURN	UMPQUA	UMPQUA	NORTH UMPQUA	ILAHEE ROCK	UMPQUA SC3	USB3SPxx	4797048	532354
UMPQUA SC1	CONTROL	UMPQUA	UMPQUA	NORTH UMPQUA	ILAHEE ROCK	UMPQUA SB2	USC1SPxx	4795839	531216
UMPQUA SC3	CONTROL	UMPQUA	UMPQUA	NORTH UMPQUA	STEAMBOAT	UMPQUA SB3	USC3SPxx	4795825	528482
UMPQUA SC4	CONTROL	UMPQUA	UMPQUA	NORTH UMPQUA	STEAMBOAT	UMPQUA SB1	USC4SPxx	4795746	528996



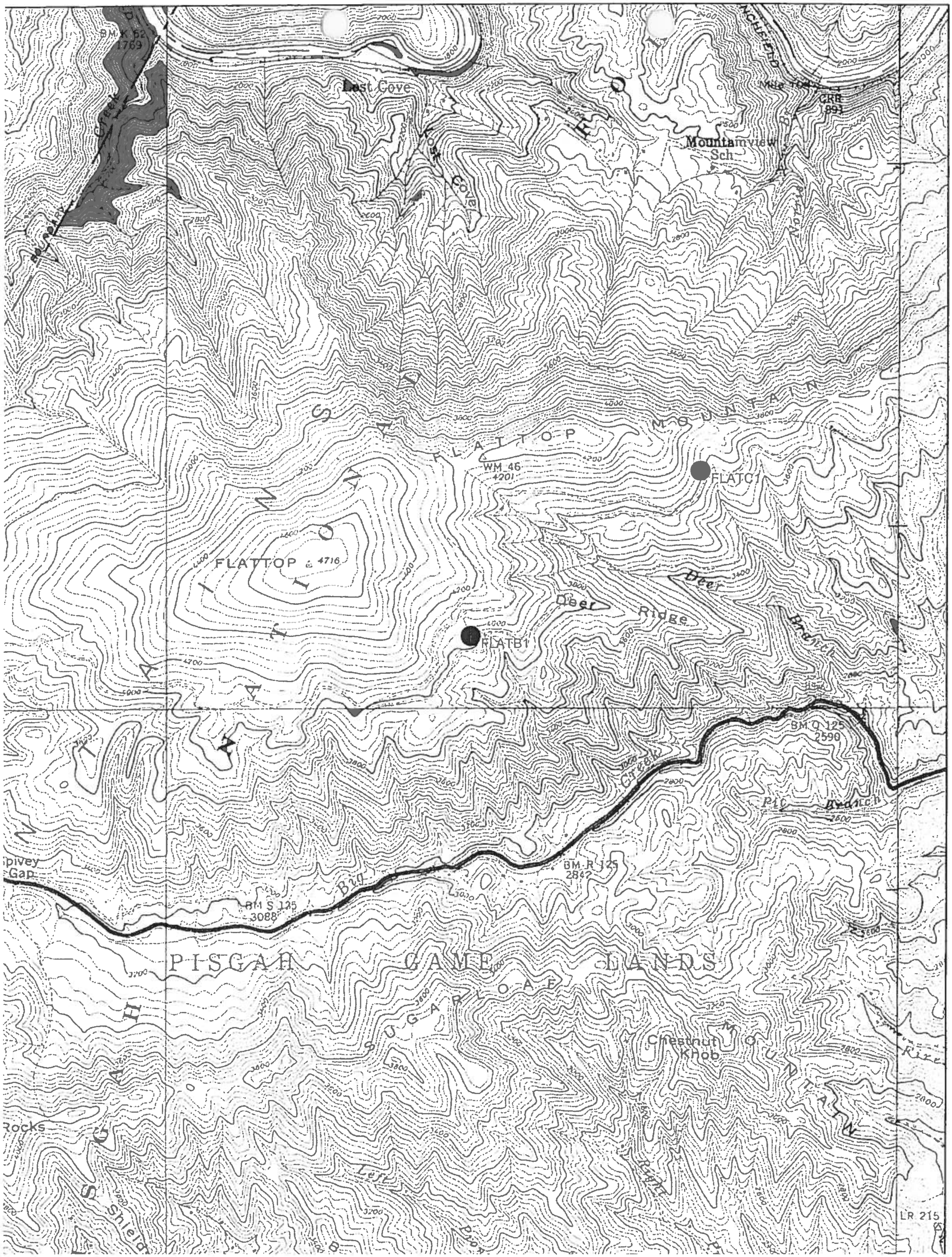
Norwood Hollow
Aerial Cableway
Peak Mountain
Watauga
Mountain
AVERY CO
Linville Gap
Flattop Mountain
Grandfather
WATAUGA CO
CALDWELL CO
United States Weather Station
Radio Tower
Pilot Knob
Rough Ridge
Beacon Heights
Linville
Grandmother Mountain
Little Bald
Big Rough Knob
Sassafras Knob
Roseborough
Lost Cove Ridge
MEMORIAL PARK
Boone Fork
JULIAN PRICE MEMORIAL PARK
Price Lake
Bull Mountain
Bass Lake
Blowing Rock
Water Tank
Round Mountain
Gragg
Anthony Creek
PISGAH NATIONAL FOREST
PISGAH GAME LANDS
Polecat Knob
Globe
Upton
Little Rock Knob
Mill Knob
Mulberry
BARKB1
BARKC1
Laurel Ridge
High Knob
Maple Grove
Apple Hole Knob
Miller Ridge
Edgemont
Mortimer
Harper
Kawana
AVERY CO
CALDWELL CO
Lookout
Cold Springs
Johns River
Wilson Ridge
PISGAH GAME LANDS
Collettsville
Brown Mountain Beach



VABM 4186
Big Peachtree Bald
Peachtree Creek
TRAIL
Shortoff Knob
CHEROKEE CO
CLAY CO
VALLEY RIVER MTS
Tarkiln Ridge
Laurel
Rockhouse Creek
Jake Cove
Tom Cove
Leatherwood
FIRES CREEK WILDLIFE MANAGEMENT AREA
NANTAHALA
Creek
LEATHERC1
LEATHERB1
Branch
Fires
Leatherwood Falls
Mile 3
Pendergrass Br.
Huskins
Ledford Br.
Jake Deal Cove
Barlow High Top
Old House
Stillhouse Br.
Newt Ridge
Branch
Fires Creek
Fires Creek Com
NAT.
Martin Hill Church
Ledford Cove
BM 1722
Mile 110



Cem
2675
Hannah
Branch
3000
2800
Little
Whiteoak
Shingle
Pile
Creek
Dovers
RIDGE
Hoover Meadow
Upper Falls
Ch
Creek
S G A H
Branch
3600
East
2800
L F O R E S T
Ridge
3200
Rich Knob
T O E
SEVEN MILE
Creek
Bracher Cem
3600
Crabtree
BLUE
Bridle
Prong
Stones Knob
3800
7MILE 7MILEB1
Big
Bee
Rock
Prong
Middle
DIVIDE
3600
2800
Sugar Cove Gap
N O R T H
3840
Good Cem
3800
3200
Ridge
Prong
Lee Fields Cem
Cove
VALLEY
RIDGE
3200
Prong
Horse Gap
Pine Ridge
Sugar
Left
Right
Branch
Hazelnut Gap
Busick
3200
Buck Creek Gap



BM K 62
1769
Lost Cove
Lost Cove
CRB
893
Mountainview
Sch
FLATTOP MOUNTAIN
WM 46
4201
FLATC1
FLATTOP 4716
Deer Ridge
Deer Branch
FLATB1
BM Q 125
2590
Pit Branch
Big Creek
BM R 125
2842
BM S 125
3088
Spivey
Gap
PISGAH GAME LANDS
SUGARLOAF MOUNTAIN
Chestnut
Knob
Rocks
Left
Right
LR 215

PART 4

SECTION 2

Responses of Forest-floor Material and Amphibians to Wildfire, Umpqua River, Oregon

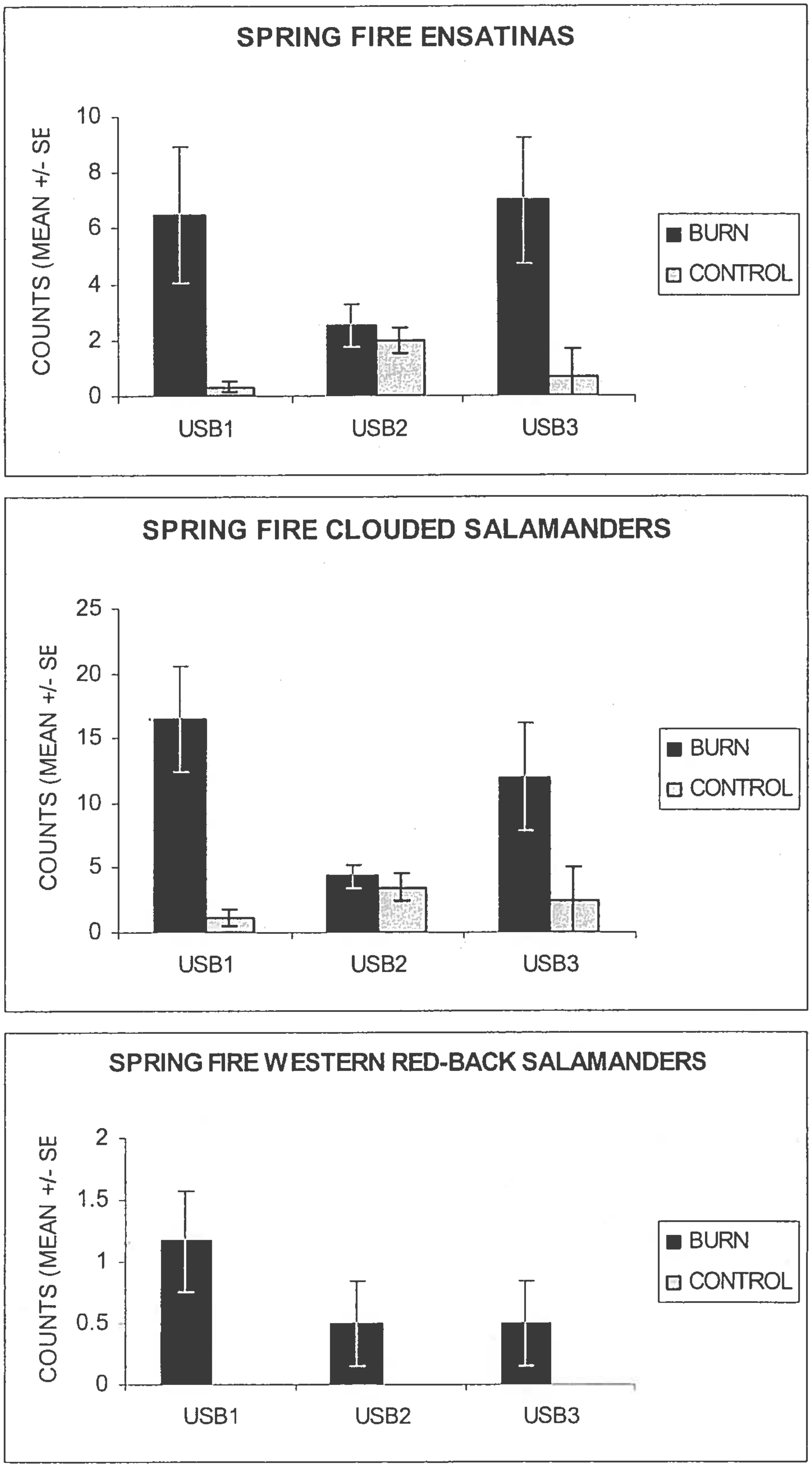
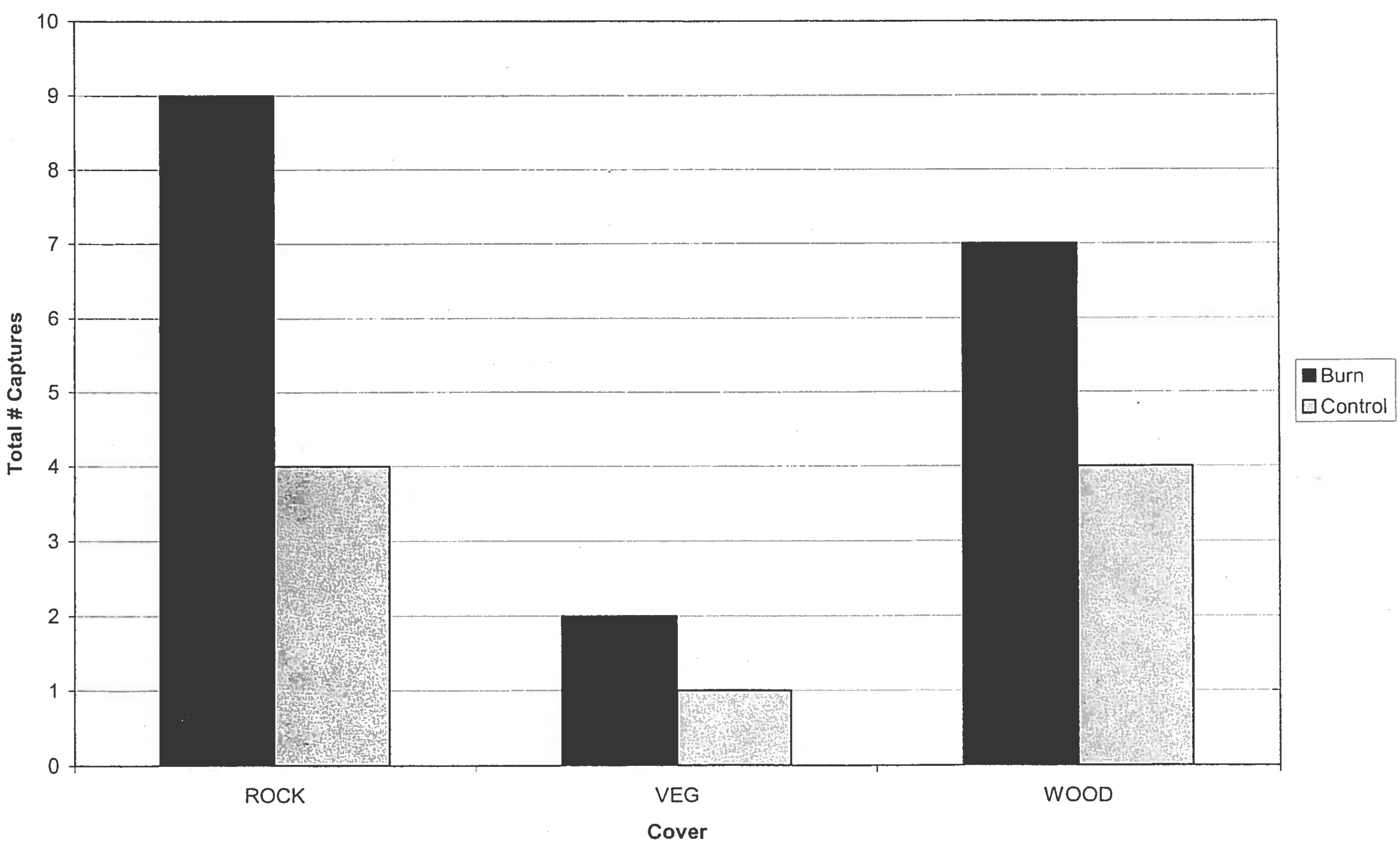
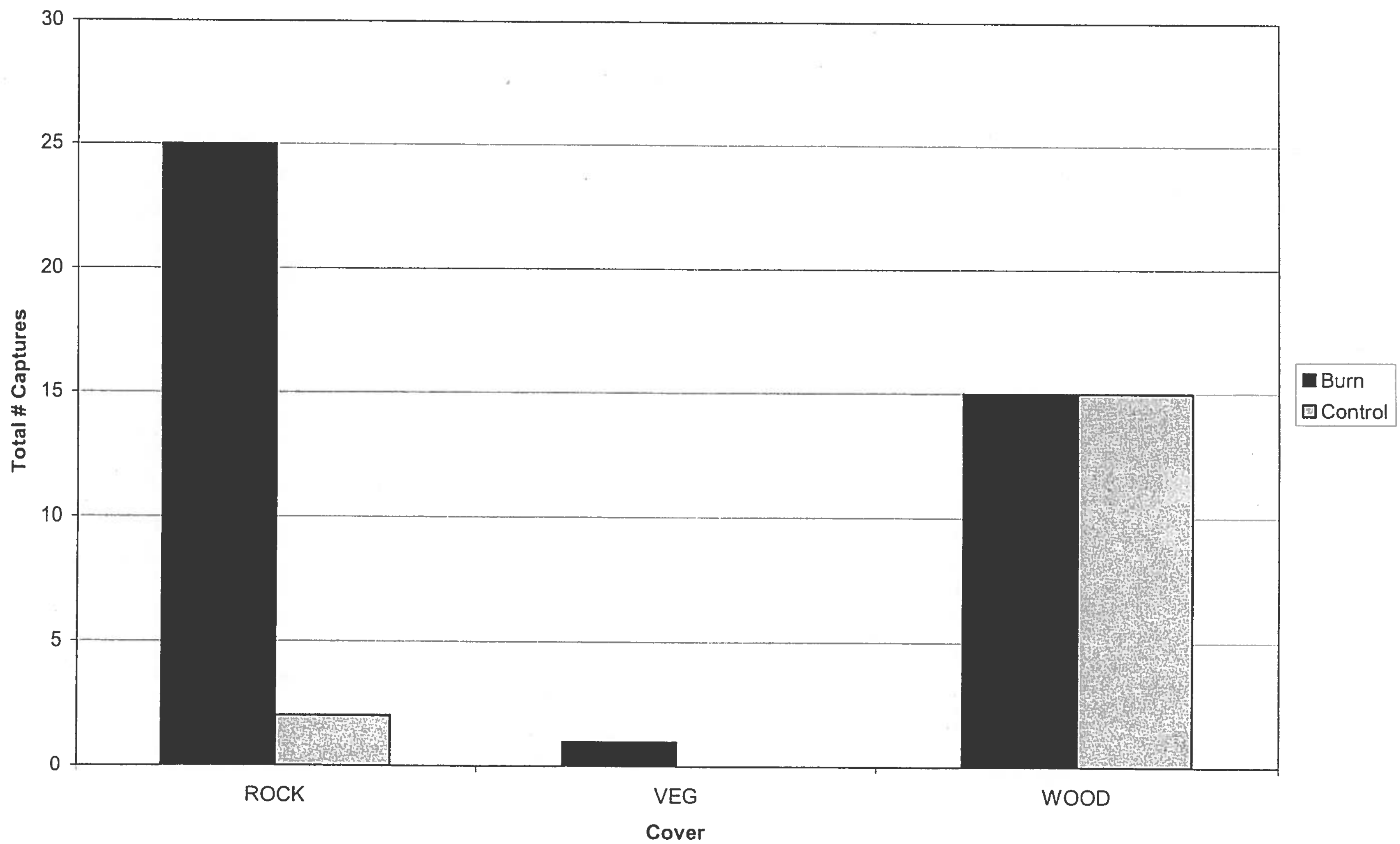


Figure x.x Relative abundance of dominant salamander species found in the Spring fire by paired sites. Relative abundance of salamanders in burn plots represented by black bars and control plots represented by grey bars.

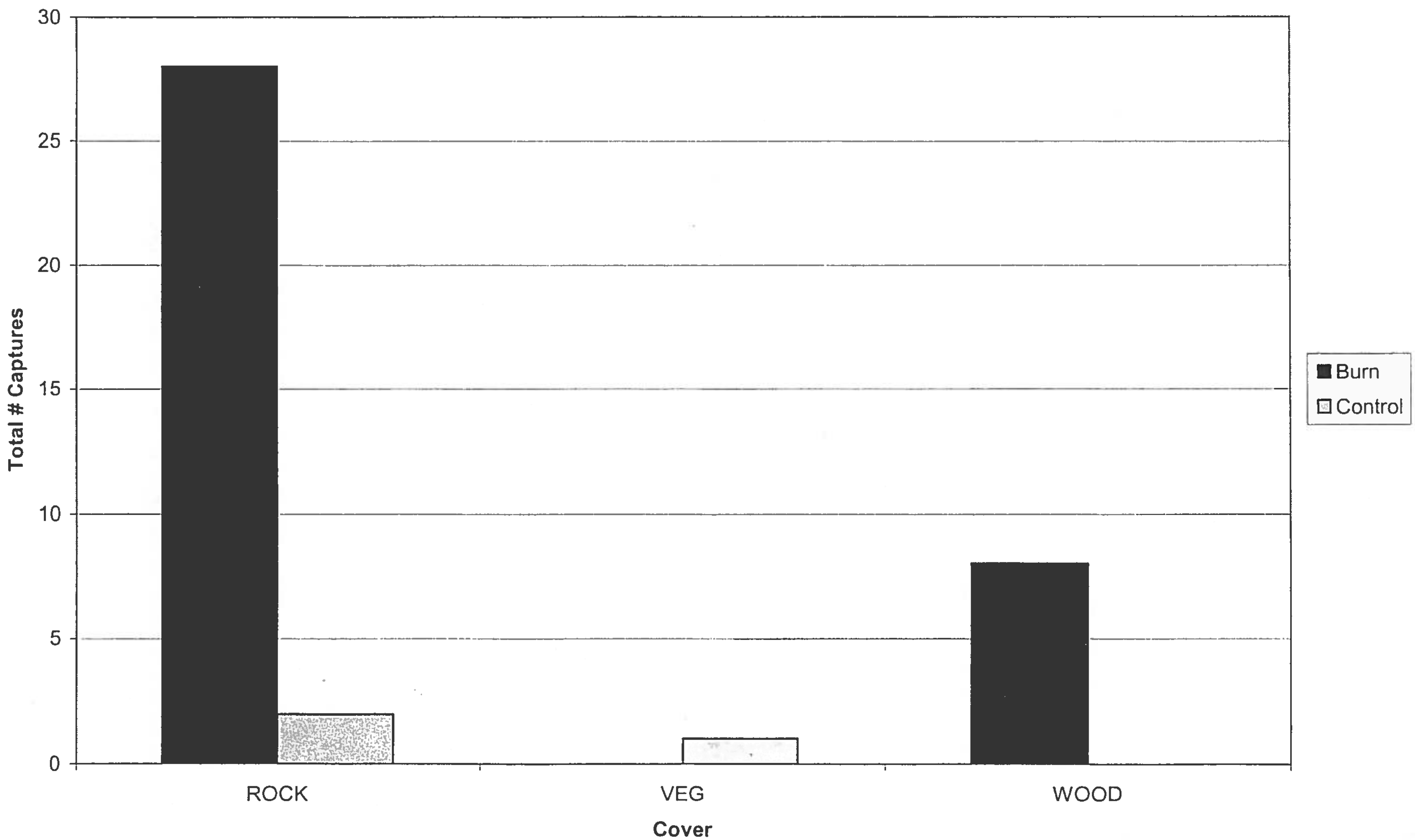
Spring ENES Cover Type



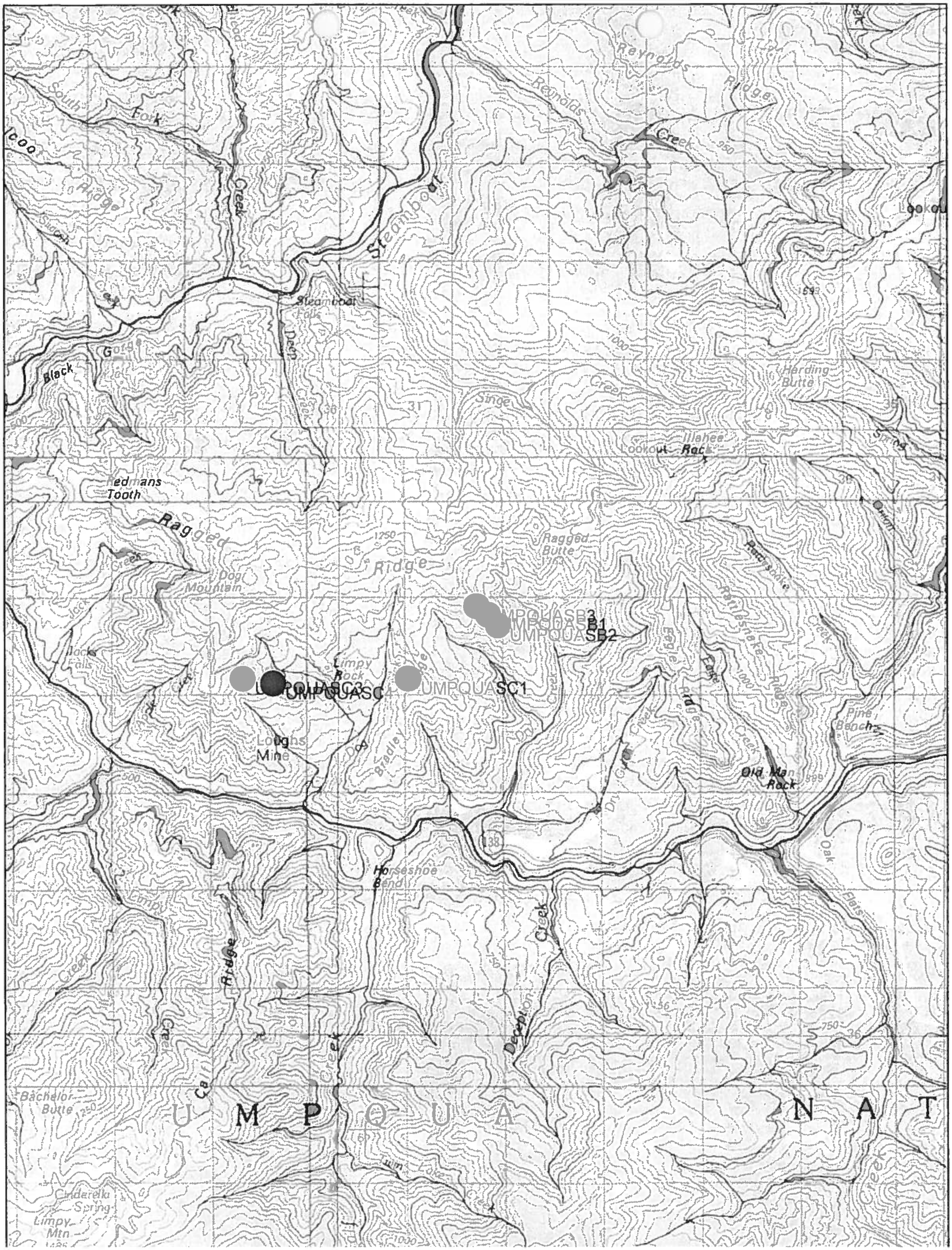
Spring ANFE Cover Type

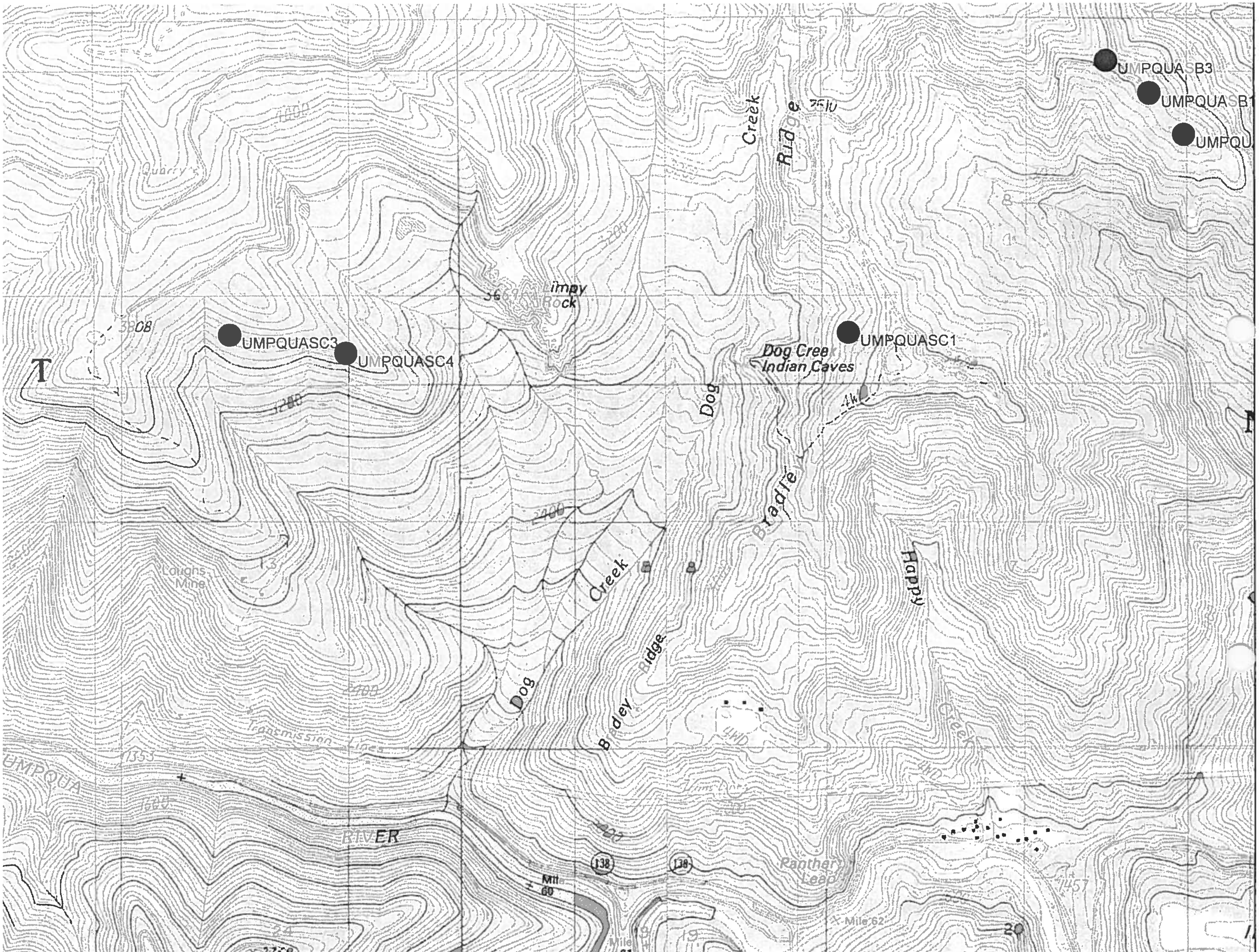


Spring PLVE Cover Type



Stand ID	Array ID	FirstOfBurn	Σ(0-1/4)	Σ(1/4-1)	Σ(1-3)	Σ(STEM_CNT)	Σ(LOG_CNT)	Σ(LITTER)	Σ(DUFF)	CountOfSP1	BUAM	BUWO	D_SP	ENES	HYRE	PLDU	PLEL	PLVE	RACA	TAGR	UNK	Richness
UMPQUA SB1	USB1SP1	BURN	213	16	13	174	8	0.417	0.150	12	0	0	0	5	0	0	0	6	0	0	0	3
UMPQUA SB1	USB1SP10	BURN	17	1	3	517	26	0.117	0.046	12	0	0	0	1	1	2	0	4	0	0	0	5
UMPQUA SB1	USB1SP16	BURN	57	5	2	279	13	0.038	0.017	32	18	2	2	0	0	0	0	0	0	0	0	5
UMPQUA SB1	USB1SP19	BURN	80	8	12	77	15	0.208	0.013	26	0	0	0	3	0	2	0	12	0	0	0	4
UMPQUA SB1	USB1SP4	BURN	111	3	9	14	9	0.683	0.033	8	0	0	0	5	0	1	0	1	0	0	0	4
UMPQUA SB1	USB1SP7	BURN	151	7	5	43	7	0.233	0.029	9	0	0	0	7	0	0	0	1	0	0	0	3
UMPQUA SB2	USB2SP11	BURN	171	20	7	77	7	0.083	0.000	3	0	0	0	2	1	0	0	0	0	0	0	2
UMPQUA SB2	USB2SP17	BURN	174	4	13	527	5	0.158	0.075	6	0	0	0	3	0	1	0	2	0	0	0	3
UMPQUA SB2	USB2SP2	BURN	51	1	4	101	10	0.254	0.000	5	0	0	0	4	1	0	0	0	0	0	0	2
UMPQUA SB2	USB2SP5	BURN	202	11	29	168	13	0.383	0.000	7	0	0	0	5	0	2	0	0	0	0	0	2
UMPQUA SB2	USB2SP7	BURN	51	5	2	853	4	0.354	0.025	1	0	0	0	0	1	0	0	0	0	0	0	1
UMPQUA SB2	USB2SP8	BURN	121	9	20	446	13	0.058	0.000	4	0	0	0	1	3	0	0	0	0	0	0	2
UMPQUA SB3	USB3SP12	BURN	89	20	22	285	3	0.183	0.488	1	0	0	0	1	0	0	0	0	0	0	0	1
UMPQUA SB3	USB3SP15	BURN	158	8	7	125	4	0.465	0.265	8	0	0	0	8	0	0	0	0	0	0	0	1
UMPQUA SB3	USB3SP18	BURN	177	14	10	27	6	0.171	0.175	12	0	0	0	6	0	0	0	0	0	0	0	2
UMPQUA SB3	USB3SP3	BURN	168	8	8	132	5	0.225	0.475	20	0	0	0	11	0	2	0	2	0	0	0	4
UMPQUA SB3	USB3SP6	BURN	150	9	13	136	9	0.338	0.596	3	0	0	0	1	1	0	0	0	0	0	0	3
UMPQUA SB3	USB3SP9	BURN	276	18	21	69	14	0.346	0.013	28	0	0	0	15	0	1	0	6	0	0	0	4
UMPQUA SC1	USC1SP1	CONTROL	172	37	26	81	8	0.665	0.600	3	0	0	0	1	1	0	0	0	0	0	0	3
UMPQUA SC1	USC1SP10	CONTROL	175	16	31	123	5	0.700	0.642	7	0	0	0	3	0	0	0	0	0	0	0	2
UMPQUA SC1	USC1SP13	CONTROL	144	10	23	256	1	0.783	0.467	3	0	0	0	3	0	0	0	0	0	0	0	1
UMPQUA SC1	USC1SP19	CONTROL	96	10	11	298	6	0.488	0.504	6	0	0	0	3	0	0	0	2	0	0	1	2
UMPQUA SC1	USC1SP4	CONTROL	153	19	7	147	8	0.683	2.017	1	0	0	0	1	0	0	0	0	0	0	0	1
UMPQUA SC1	USC1SP7	CONTROL	136	19	18	228	3	0.779	0.667	1	0	0	0	1	0	0	0	0	0	0	0	1
UMPQUA SC3	USC3SP1	CONTROL	172	15	27	36	18	0.871	1.204	3	0	0	0	2	0	0	0	0	0	1	0	2
UMPQUA SC3	USC3SP10	CONTROL	261	13	14	24	16	0.738	1.063	3	0	0	0	2	0	0	0	0	0	0	0	2
UMPQUA SC3	USC3SP13	CONTROL	153	27	16	173	13	1.071	1.579	0	0	0	0	0	0	0	0	0	0	0	0	0
UMPQUA SC3	USC3SP16	CONTROL	212	14	14	20	4	1.025	2.738	0	0	0	0	0	0	0	0	0	0	0	0	0
UMPQUA SC3	USC3SP4	CONTROL	279	18	24	52	2	0.500	0.542	2	0	0	0	0	0	0	0	0	0	0	0	1
UMPQUA SC3	USC3SP7	CONTROL	163	7	26	8	10	0.771	1.296	7	0	0	0	0	0	0	0	1	1	0	0	3
UMPQUA SC4	USC4SP1	CONTROL	121	9	13	113	9	0.317	0.229	3	0	0	0	0	0	0	0	0	0	0	0	1
UMPQUA SC4	USC4SP12	CONTROL	291	19	14	36	17	0.483	2.058	1	0	0	0	1	0	0	0	0	0	0	0	1
UMPQUA SC4	USC4SP15	CONTROL	157	20	19	0	12	0.817	1.713	0	0	0	0	0	0	0	0	0	0	0	0	0
UMPQUA SC4	USC4SP19	CONTROL	185	13	9	111	12	0.417	2.138	0	0	0	0	0	0	0	0	0	0	0	0	0
UMPQUA SC4	USC4SP20	CONTROL	210	15	15	33	9	0.696	1.313	0	0	0	0	0	0	0	0	0	0	0	0	0
UMPQUA SC4	USC4SP4	CONTROL	103	28	22	40	8	0.400	1.225	3	0	0	0	1	0	0	0	0	0	0	0	2


Reynolds Ridge
Reynolds Creek
Steamboat
Steamboat Falls
South Fork
Deep Creek
Black
Gorge
Singe Creek
Herding Butte
Illahee
Lookout Rock
Redmans Tooth
Ragged Ridge
Ragged Butte
Dog Mountain
Jack Falls
Limpy Rock
Loughs Mine
UMPQUASB3
UMPQUASB1
UMPQUASB2
UMPQUASC3
UMPQUASC4
UMPQUASC1
Bradley Ridge
Rattlesnake Creek
Rattlesnake Ridge
Pine Bench
Old Man Rock
138
Horseshoe Bend
Oak Flats
Deception Creek
Bachelor Butte
Cinderella Spring
Limpy Mtn
U M P Q U A N A T

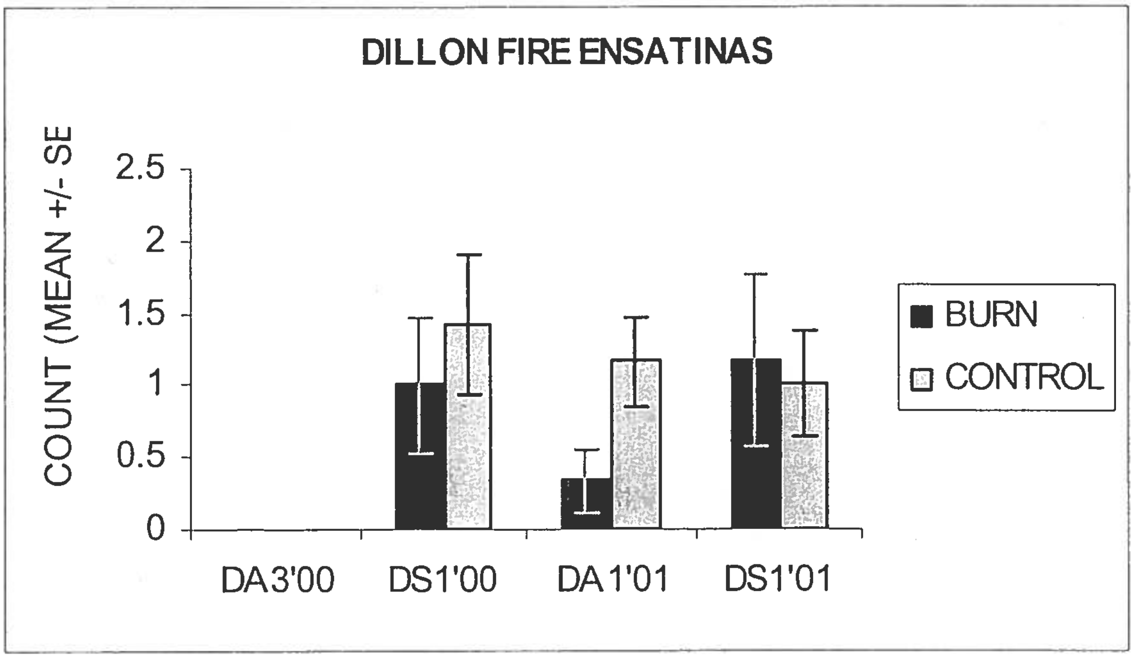


UMPQUASB3
UMPQUASB1
UMPQU
Creek
Ridge
2510
Quarry
3808
Limpy Rock
UMPQUASC3
UMPQUASC4
UMPQUASC1
Dog Cree
Indian Caves
Dog
4WD
Bradle
Happy
Creek
2400
Dog
Creek
Bradley Ridge
Dog
Loughs Mine
Transmission Lines
UMPQUA
1353
RIVER
138
138
Mile 60
Mile 61
Panther Leap
1457
Mile 62
2758

PART 4

SECTION 3

Responses of Forest-floor Material and Amphibians to Wildfire, Klamath River, northern California



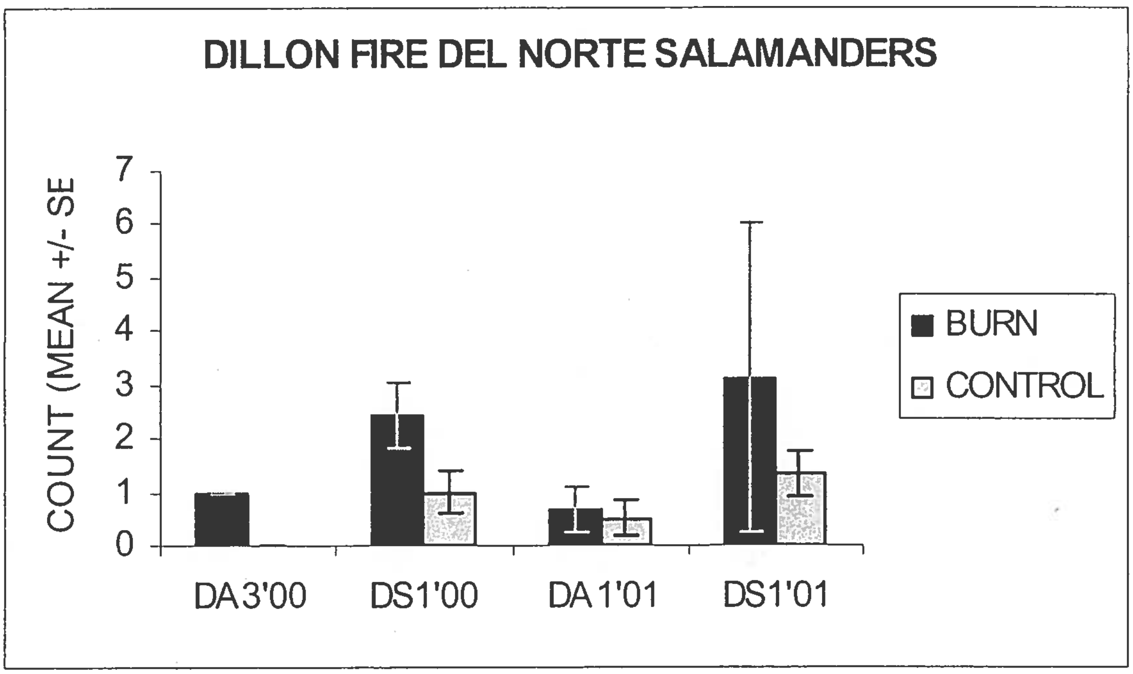
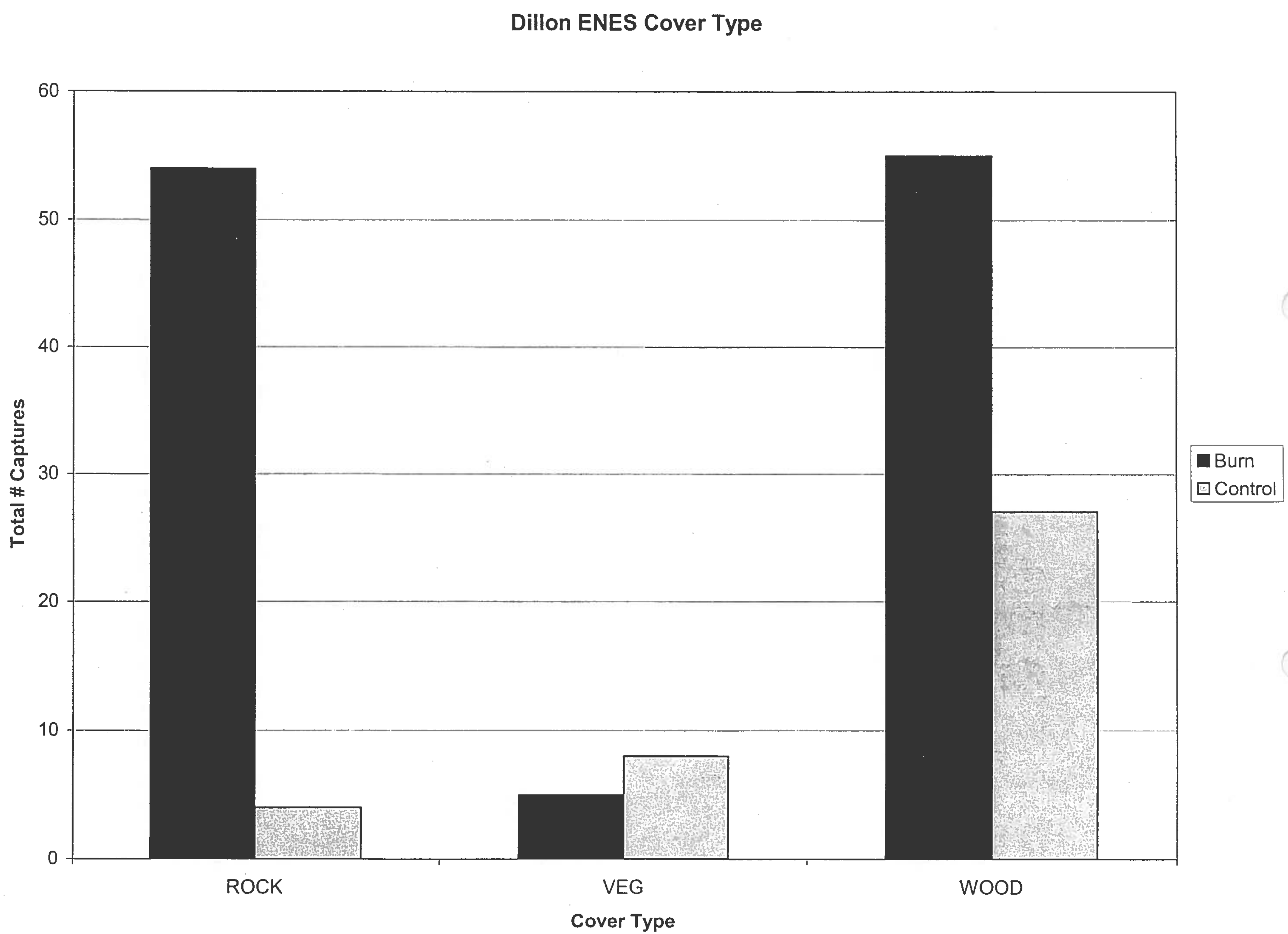
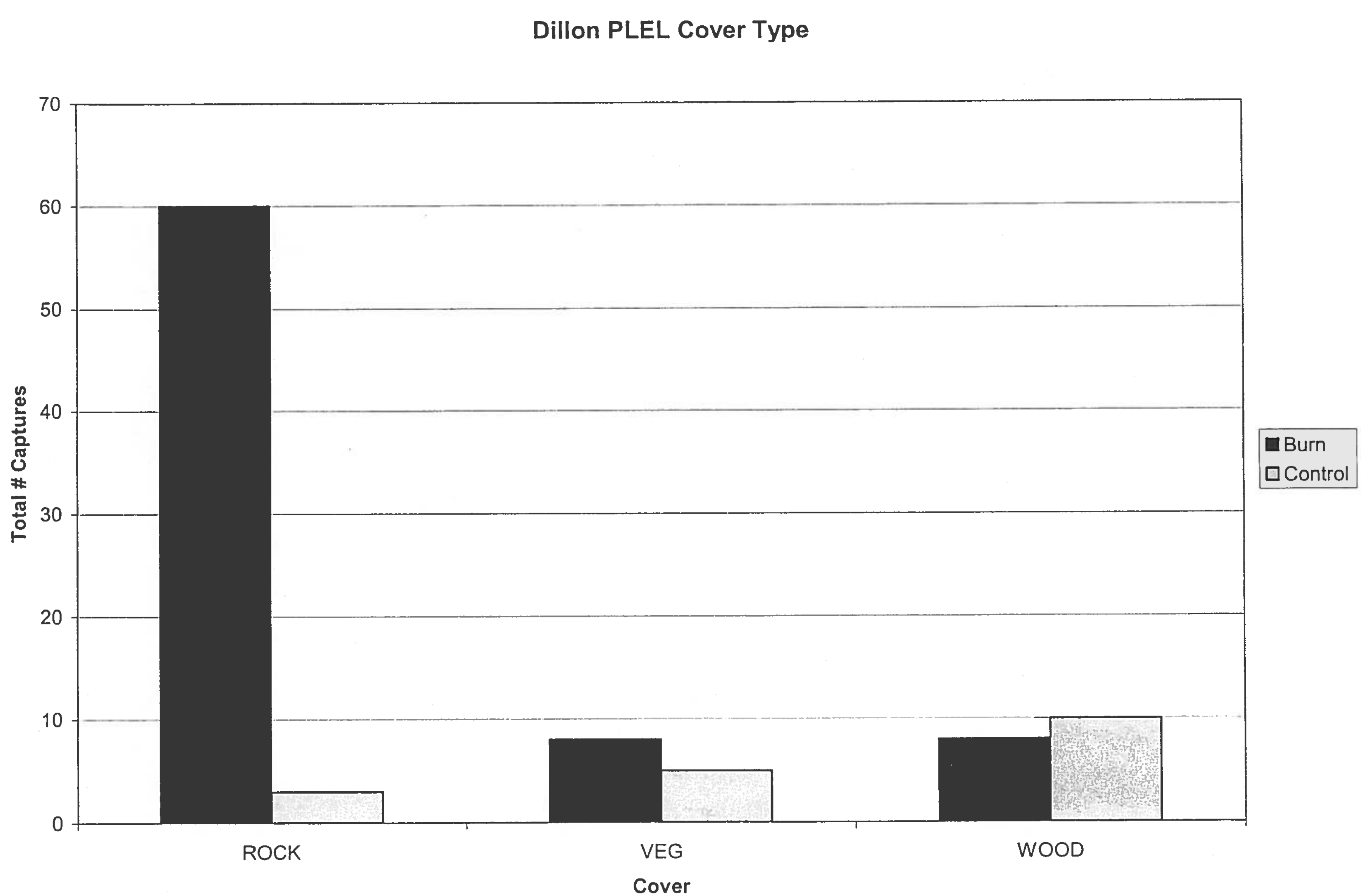


Figure x.x Relative abundance of dominant salamander species found in the Dillon fire by paired sites. Relative abundance of salamanders in burn plots represented by black bars and control plots represented by grey bars.

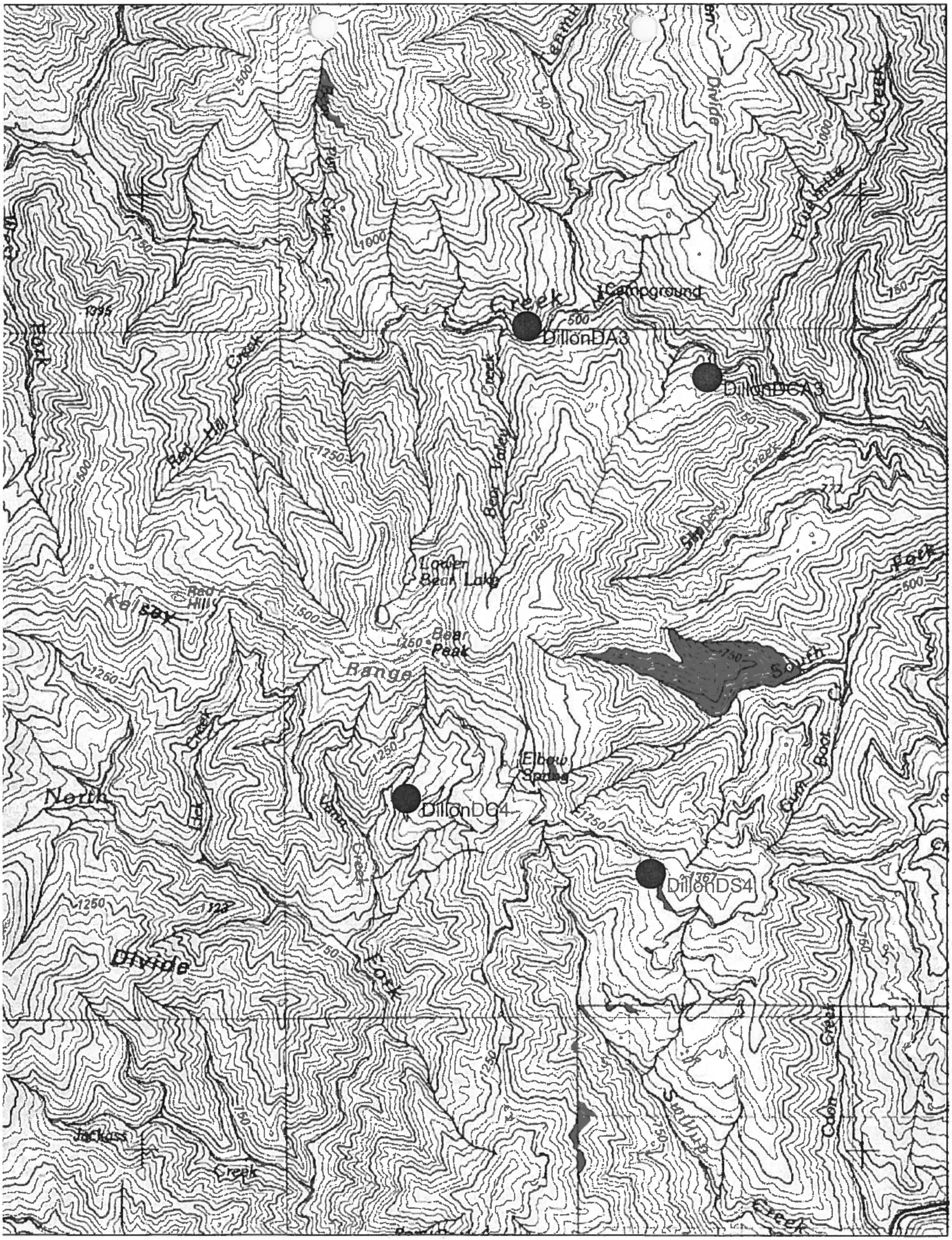


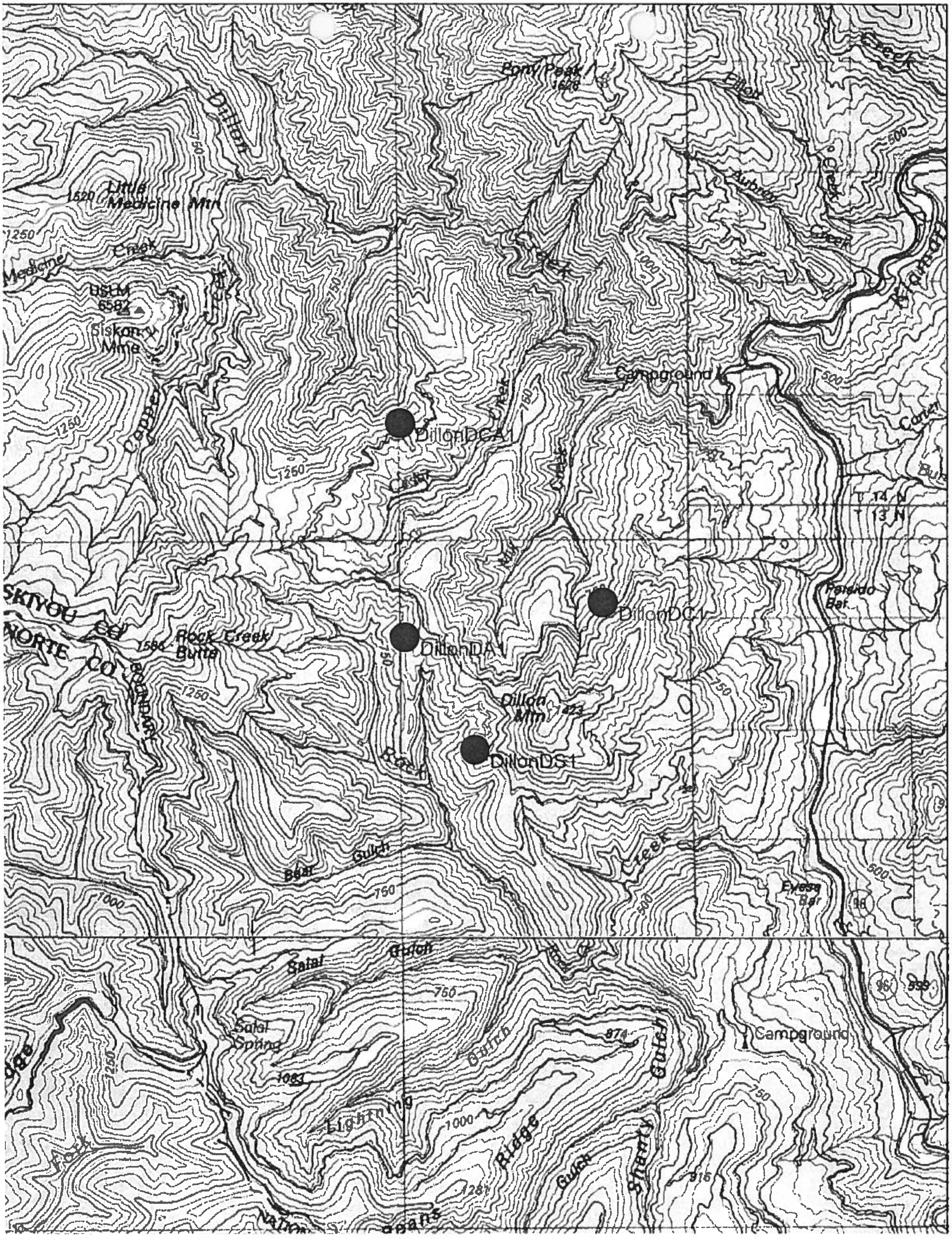
Dillon ENES Cover Type
Total # Captures
60
50
40
30
20
10
0
ROCK
VEG
WOOD
Cover Type
Burn
Control



Dillon PLEL Cover Type
Total # Captures
70
60
50
40
30
20
10
0
ROCK
VEG
WOOD
Cover
Burn
Control

YEAR	Site	ArrayID	FirstOfBurn	Σ(0-1/4)	Σ(1/4-1)	Σ(1-3)	Σ(STEM_CNT)	Σ(LOG_CNT)	Σ(LITTER)	Σ(DUFF)	CountOfSP1	BUWO	ENES	GECO	PLEL	RHVA
2001	DILLON DC1	DC1SPA1	CONTROL	194	20	24	13	2	0.596	0.529	4	0	4	0	0	0
2001	DILLON DC1	DC1SPA2	CONTROL	178	24	12	3	2	1.125	0.983	4	0	2	0	2	0
2001	DILLON DS1	DS1SP1	BURN	255	11	5	0	1	0.717	0.009	5	0	0	0	5	0
2001	DILLON DS1	DS1SP11	BURN	127	4	4	2	4	0.438	0.000	4	0	4	0	0	0
2001	DILLON DS1	DS1SP13	BURN	165	5	4	0	1	0.613	0.000	2	0	1	0	1	0
2001	DILLON DS1	DS1SP14	BURN	187	14	4	5	2	0.521	0.008	6	0	2	0	4	0
2001	DILLON DS1	DS1SP2	BURN	154	10	6	12	1	0.408	0.000	1	0	0	0	1	0
2001	DILLON DS1	DS1SP9	BURN	98	18	14	18	3	0.454	0.129	4	0	2	0	2	0
2001	DILLON DA1	DA1SP1	BURN	164	46	15	10	5	0.504	0.413	9	0	7	0	2	0
2001	DILLON DA1	DA1SP3	BURN	114	12	6	25	0	0.746	0.450	4	0	0	0	4	0
2001	DILLON DA1	DA1SP6	BURN	78	13	9	0	5	0.092	0.000	3	0	1	1	1	0
2001	DILLON DA1	DA1SP7	BURN	94	19	14	0	3	0.258	0.033	2	0	2	0	0	0
2001	DILLON DA1	DA1SP8	BURN	91	5	13	0	2	0.717	0.317	1	0	0	0	1	0
2001	DILLON DA1	DA1SP9	BURN	92	10	8	0	1	0.783	0.258	0	0	0	0	0	0
2001	DILLON DC1	DC1SP2	CONTROL	37	11	15	0	3	0.855	1.355	2	0	0	0	2	0
2001	DILLON DC1	DC1SP4	CONTROL	276	25	15	10	1	1.058	1.029	5	0	0	0	4	0
2001	DILLON DC1	DC1SP5	CONTROL	142	14	18	0	4	1.113	1.004	6	0	1	0	5	0
2001	DILLON DC1	DC1SP6	CONTROL	77	3	13	8	2	1.113	1.792	1	0	1	0	0	0
2001	DILLON DCA1	DCA1SP1	CONTROL	315	47	30	11	7	1.579	2.733	2	0	1	0	1	0
2001	DILLON DCA1	DCA1SP2	CONTROL	128	12	8	158	3	1.033	1.796	39	0	0	0	6	32
2001	DILLON DCA1	DCA1SP3	CONTROL	74	14	11	0	5	1.308	2.283	0	0	0	0	0	0
2001	DILLON DCA1	DCA1SP4	CONTROL	193	27	11	0	9	1.213	2.096	1	0	1	0	0	0
2001	DILLON DCA1	DCA1SP5	CONTROL	123	12	9	0	8	1.146	1.742	0	0	0	0	0	0
2001	DILLON DCA1	DCA1SP6	CONTROL	332	26	15	8	0	1.671	2.863	2	0	1	0	1	0
2001	DILLON DS1	DS1SP1	BURN	255	11	5	0	1	0.717	0.009	18	0	0	0	18	0
2001	DILLON DS1	DS1SP11	BURN	127	4	4	2	4	0.438	0.000	5	0	5	0	0	0
2001	DILLON DS1	DS1SP13	BURN	165	5	4	0	1	0.613	0.000	2	0	1	0	1	0
2001	DILLON DS1	DS1SP14	BURN	187	14	4	5	2	0.521	0.008	26	0	1	0	25	0
2001	DILLON DS1	DS1SP2	BURN	154	10	6	12	1	0.408	0.000	10	0	0	0	10	0
2001	DILLON DS1	DS1SP9	BURN	98	18	14	18	3	0.454	0.129	18	0	3	0	15	0
2001	DILLON DA1	DA1SP1	BURN	164	46	15	10	5	0.504	0.413	0	0	0	0	0	0
2001	DILLON DA1	DA1SP3	BURN	114	12	6	25	0	0.746	0.450	3	0	1	0	2	0
2001	DILLON DA1	DA1SP6	BURN	78	13	9	0	5	0.092	0.000	0	0	0	0	0	0
2001	DILLON DA1	DA1SP7	BURN	94	19	14	0	3	0.258	0.033	0	0	0	0	0	0
2001	DILLON DA1	DA1SP8	BURN	91	5	13	0	2	0.717	0.317	2	0	0	0	2	0
2001	DILLON DA1	DA1SP9	BURN	92	10	8	0	1	0.783	0.258	1	0	1	0	0	0
2001	DILLON DC1	DC1SP2	CONTROL	37	11	15	0	3	0.855	1.355	2	0	2	0	0	0
2001	DILLON DC1	DC1SP4	CONTROL	276	25	15	10	1	1.058	1.029	3	0	0	0	3	0
2001	DILLON DC1	DC1SP5	CONTROL	142	14	18	0	4	1.113	1.004	3	0	1	0	2	0
2001	DILLON DC1	DC1SP6	CONTROL	77	3	13	8	2	1.113	1.792	3	0	2	0	1	0
2001	DILLON DC1	DC1SPA1	CONTROL	194	20	24	13	2	0.596	0.529	1	0	0	0	1	0
2001	DILLON DC1	DC1SPA2	CONTROL	178	24	12	3	2	1.125	0.983	2	0	1	0	1	0
2001	DILLON DCA1	DCA1SP1	CONTROL	315	47	30	11	7	1.579	2.733	3	0	1	0	2	0
2001	DILLON DCA1	DCA1SP2	CONTROL	128	12	8	158	3	1.033	1.796	0	0	0	0	0	0
2001	DILLON DCA1	DCA1SP3	CONTROL	74	14	11	0	5	1.308	2.283	2	0	1	0	1	0
2001	DILLON DCA1	DCA1SP4	CONTROL	193	27	11	0	9	1.213	2.096	1	0	1	0	0	0
2001	DILLON DCA1	DCA1SP5	CONTROL	123	12	9	0	8	1.146	1.742	2	0	2	0	0	0
2001	DILLON DCA1	DCA1SP6	CONTROL	332	26	15	8	0	1.671	2.863	2	0	2	0	0	0
2001	DILLON DS1	DS1SP1	BURN	255	11	5	0	1	0.717	0.009	14	0	1	0	13	0
2001	DILLON DS1	DS1SP11	BURN	127	4	4	2	4	0.438	0.000	1	0	1	0	0	0
2001	DILLON DS1	DS1SP13	BURN	165	5	4	0	1	0.613	0.000	2	0	0	0	2	0
2001	DILLON DS1	DS1SP14	BURN	187	14	4	5	2	0.521	0.008	20	1	1	0	18	0
2001	DILLON DS1	DS1SP2	BURN	154	10	6	12	1	0.408	0.000	3	0	0	0	3	0
2001	DILLON DS1	DS1SP9	BURN	98	18	14	18	3	0.454	0.129	14	0	4	0	10	0


Creek
Campground
500
DillonDA3
DillonDCA3
Red Hill Creek
Bear Lake Creek
Lower Bear Lake
Red Hill
Kelsey
Bear Peak
Range
South
Fork
Elbow Spring
North
DillonDG4
DillonDS4
Divide
Fork
Jackass
Creek
Coon Creek
1250
1500
750
1000



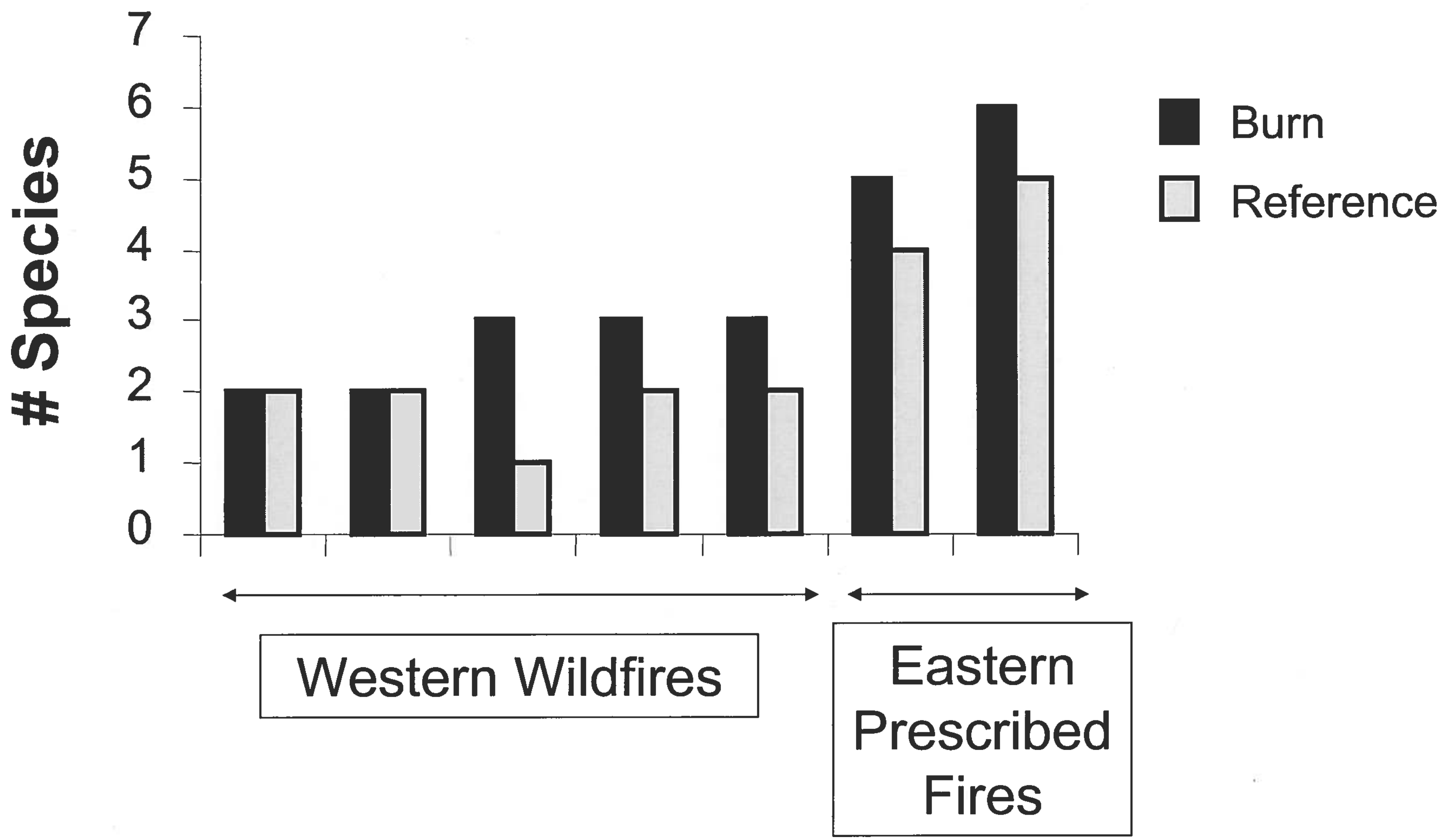
Pony Peak
Dillon
Little
Medicine Mtn
1520
Medicine
Creek
USLM
6582
Siskon
Mine
Aubrey
Creek
Campground
DillonDCA1
DillonDC1
DillonDA1
DillonDS1
Rock Creek
Butte
1586
SKIYOU
NORTE
CO
Dillon
Mtn
Bear
Gulch
Salal
Gulch
Salal
Spring
Lightning
Ridge
Shanty
Gulch
Campground
T 14 N
T 13 N

PART 4

SECTION 4

Comparative Summary of Data from western Wildfires & SE Prescribed Fires

Terrestrial Species Richness



Spring Wildfire			Herp Capture Cover Objects			Animals Found			
BURN	SITENAME	# LOGS	ROCK	VEG	WOOD	HERPS	ENES	PLDU	PLVE
BURN	UMPQUA SB1	78	47	4	47	99	39	7	26
CONTROL	UMPQUA SC4	67	1	0	6	7	2	0	0
BURN	UMPQUA SB2	52	7	4	15	26	15	3	2
CONTROL	UMPQUA SC1	31	3	3	15	21	12	0	2
BURN	UMPQUA SB3	41	36	2	16	54	42	3	8
CONTROL	UMPQUA SC3	63	3	1	11	15	4	0	1

Southeast Prescribed Fires			Herp Capture Cover Objects			Animals Found			
BURN	SITENAME	# LOGS	ROCK	VEG	WOOD	HERPS	DEOC	PLCI	PLJO
BURN	7MILEB1	8	0	5	81	86	5	0	69
CONTROL	7MILEC1	10	1	6	58	65	31	0	29
BURN	BARKB1	14	0	0	1	1	0	0	0
CONTROL	BARKC1	8	0	1	3	4	0	0	0
BURN	FLATB1	16	37	1	87	125	16	13	50
CONTROL	FLATC1	13	15	11	41	67	19	14	55
BURN	LEATHERB1	9	1	0	0	1	0	0	0
CONTROL	LEATHERC1	2	0	4	5	9	0	0	0

Average percent char in burned areas ranged from 48.3 to 71.4 in Oregon wildfires and from 10% t 39% on N.C. prescribed fires.

92% of downed logs had char in Oregon wildfires
98% of downed logs had char in SE prescribed fires.

No sig diff in sum of tree volume between burn and unburn in wildlandfires.
P=0.856 df=8

Sig more sticks 0-1/4 on control than on burn in wildland fires.
p=0.0576 df=8

Sig more sticks ¼-1 on control than on burn in wildland fires.
p=0.0161 df=8

Sig more sticks 1-3 on control than on burn in wildland fires.
p=0.057 df=8

No diff in stemcnt on burn/unburn in wildland fires.
p=0.3609, df=8

No diff in logcnt b/w burn/unburn in wildland fires.
p=0.922 df=8

Significantly more litter on control than on burn in wildland fires.
p=0.0108 df=8

Significantly more duff on control than on burn in wildland fires.
p=0.0009 df=8

Significantly more salamanders were found on burned sites than on control sites in wildland fires. p=0.0514, df=8.

No diff in ENES onwildland. p=0.1165 df=8

No diff in PLEL on wildland p=0.4196 df=8

No diff in slope on wildland p=0.3419 df=8

Significantly lower canopy on burn than unburn in wildland fire.
p=0.0025, df=8

no diff in North on wildland p=0.817 df=8.

SE SUMXSITE DATA

No difference between wood volume by burn in SE. p=0.627 df=6

No diff in 0.1.4 in prescribed. p=0.291 df=6

No diff in 1.4.1 in prescribed p=0.3193, df=6

No diff in 1.3 in prescribed p=0.7766, df=6

No diff in stem.cnt in prescribed p=0.2452, df=6

No diff in log.cnt in prescribed p=0.2906, df=6

Significantly more litter in control than in burn on prescribed.
p=0.0058, df=6

No sig diff in duff in control than in burn on prescribed
p=0.1138, df=6

No diff in sal count on prescribed. p=0.8478, df=6

No diff in DEOC on prescribed p=0.3899, df=6

No diff in EUBI on prescribed p=0.8896, df=6

No diff in PLJO on prescribed p=0.7049, df=6

NO diff in PLGL on prescribed p=0.5891, df=6

No diff in PLSE on prescribed p=0.3559, df=6

No diff in slope on prescribed p=0.871, df-6

No diff in Canopy on prescribed p=0.922, df=6

No diff in North on prescribed p=0.9161, df=6

AVERAGE ACROSS SITE

No difference in volume in burn/unburn on wildland. p=0.9245, df=8

Slight sig differnce between 0.1.4 by burn on wildland. p=0.0576, df-8

Significant difference in sticks 1.4.1 by burn on wildland p=0.0161, df=8

Sig difference in sticks 1.3 by burn in wildland fires p=0.0057, df=8

No difference in stem cnt by burn in wildland p=0.3609, df=8

No difference in logcnt with burn in wildland. p=0.922, df=8

Significant more litter on control than burn on wildland. p=0.0108, df=8.

Significant more duff on control than burn on wildland. p=0.0009, df=8

Signficant more salamanders on burn than control inwildland.
p=0.0514, df=8

No diff in enes on wildland. p=.1165, df=8

No diff in PLEL on wildland p=0.4196 , df=8.

No diff in Slope on wildland. p=0.3419, df=8.

Sig diff in canopy with burn on wildland. p=0.0025, df=8

No diff in north on wildland. p=0.817, df=8

SE AVERAGE ACROSS SITES

No difference in volume by burn on prescribed, p=0.6385, df=6
No difference in stick 0.1.4 by burn on prescribed. p=0.291, df=6
No difference in stick 1.4.1 by burn on prescribed p=0.3193, df=6
No diff in stick 1.3 by burn on prescribed. p=0.7766, df=6
No diff in stem_cnt by burn on prescribed. p=0.2452, df=6.
No diff in logcnt by burn on prescribed p=0.2906, df=6

Significant more litter on burn than control on prescribed. p=0.0058. df=6
No significant difference in duff by burn on prescribed.p=0.1138, df=6
No sig difference in salcnt by burn onprescribed. p=0.8478, df=6
No diff in DEOC by burn in prescribed. p=0.3899, df=6
No diff in EUWI by burn in prescribed. p= 0.3464 , df=6
No diff in PLGL by burn in prescribed p= 0.5891 , df=6
No diff in PLJO by burn in prescribed p=0.7049, df=6

No diff in slope by burn in prescribed. p=.871, df=6
No diff in canopy by burn in prescribed. p=0.922, df=6.
No diff in north by burn in prescribed. p=0.9161, df=6

	Salamander Rel. Abundance		Number of Species	
Site	Burn	Reference	Burn	Reference
DILLON DA1	6	10	2	2
DILLON DS1	54	14	2	2
UMPQUA 1	99	7	3	1
UMPQUA 2	26	21	3	2
UMPQUA 3	72	15	3	2

	Salamander Rel. Abundance		Number of Species	
Site	Burn	Reference	Burn	Reference
7MILE	86	75	5	4
BARK	1	4	1	2
FLAT	125	94	6	5
LEATHER	1	9	1	4

	avg wildfire	avg prescribed	sum wildfire	sum prescribed
Tree Volume			x	X
0-1/4 sticks			0.0576	X
¼-1 sticks			0.016	X
1-3 sticks			0.057	X
stems			x	X
logs			x	X
litter			0.0108	0.0058
duff			0.0009	X
salamanders			0.05	X
enes			x	
plel			x	
slope			x	X
canopy			0.0025	X

Burn	FOREST	Site	AvgOfArray_Aspect	AvgOfArray_Slope	AvgOfPct_Canopy	AvgOf0-1/4	AvgOf1/4-1	AvgOf1-3	AvgOfSTEM_CNT
BURN	DILLON	DILLON DA1	143.167	53.667	50.833	105.500	17.500	10.833	5.833
BURN	DILLON	DILLON DS1	303.167	61.167	56.667	164.333	10.333	6.167	6.167
BURN	SE	7MILEB1	308.500	14.500	93.333	46.333	9.667	5.000	311.667
BURN	SE	BARKB1	91.333	36.333	75.000	43.333	9.000	6.000	19.000
BURN	SE	FLATB1	172.000	26.000	80.000	129.667	20.667	7.667	176.333
BURN	SE	LEATHERB1	127.667	41.000	78.333	46.667	6.000	4.000	91.000
BURN	UMPQUA	UMPQUA SB1	47.167	55.400	31.667	104.833	6.667	7.333	184.000
BURN	UMPQUA	UMPQUA SB2	217.333	34.167	47.500	128.333	8.333	12.500	362.000
BURN	UMPQUA	UMPQUA SB3	154.000	42.000	53.333	169.667	12.833	13.500	129.000
CONTROL	DILLON	DILLON DC1	319.000	45.500	71.667	150.667	16.167	16.167	5.667
CONTROL	DILLON	DILLON DCA1	244.167	50.667	83.333	194.167	23.000	14.000	29.500
CONTROL	SE	7MILEC1	164.667	3.667	86.333	41.000	4.667	3.000	80.667
CONTROL	SE	BARKC1	141.000	35.000	81.667	29.333	8.333	5.667	9.333
CONTROL	SE	FLATC1	127.667	40.000	83.333	48.000	10.667	8.333	134.667
CONTROL	SE	LEATHERC1	135.667	32.333	73.333	48.000	6.667	4.000	15.000
CONTROL	UMPQUA	UMPQUA SC1	266.333	44.833	65.000	146.000	18.500	19.333	188.833
CONTROL	UMPQUA	UMPQUA SC3	181.000	40.833	75.833	206.667	15.667	20.167	52.167
CONTROL	UMPQUA	UMPQUA SC4	65.667	37.333	65.000	177.833	17.333	15.333	55.500

AvgOfLOG_CNT	AvgOfLITTER	AvgOfDUFF	AvgOfPCT_CHAR	AvgOfVOLUME	AvgOfSAL_CNT	AvgOfDEOC_	AvgOfENES_	AvgOfPLEL_	AvgOfPLJO_
2.667	0.517	0.245	71.393	6.315	1.000	0.000	0.333	0.667	0.000
2.000	0.525	0.024	48.278	0.447	9.000	0.000	1.167	7.667	0.000
2.667	0.438	1.035	53.056	7.404	28.667	1.667	0.000	0.000	23.000
4.667	0.675	0.681	22.333	1.587	0.333	0.000	0.000	0.000	0.000
5.333	0.800	1.439	9.933	0.988	41.667	5.333	0.000	0.000	16.667
3.000	0.692	0.500	38.889	0.853	0.333	0.000	0.000	0.000	0.000
13.000	0.283	0.048	68.606	4.468	16.500	0.000	6.500	0.000	0.000
8.667	0.215	0.017	51.946	5.188	4.333	0.000	2.500	0.000	0.000
6.833	0.288	0.335	54.627	3.911	12.000	0.000	7.000	0.000	0.000
2.333	0.976	1.115	0.278	0.414	2.333	0.000	1.000	1.333	0.000
5.333	1.325	2.252	0.000	0.812	1.667	0.000	1.167	0.500	0.000
3.333	1.225	1.369	0.000	5.516	25.000	13.333	0.000	0.000	9.667
2.667	2.015	1.621	0.000	0.491	1.333	0.000	0.000	0.000	0.000
4.333	1.257	1.013	0.000	0.579	31.333	6.333	0.000	0.000	18.333
0.667	1.428	2.601	0.000	0.080	3.000	0.000	0.000	0.000	0.000
5.167	0.683	0.816	0.000	1.831	3.500	0.000	2.000	0.000	0.000
10.500	0.829	1.403	0.566	7.193	2.500	0.000	0.667	0.000	0.000
11.167	0.522	1.446	0.278	12.442	1.167	0.000	0.333	0.000	0.000

PART 5

SECTION 1

Protocols and Dataforms

Subsection A

Materials List & Plot Location

Materials List

Fuels/Wildlife Project
USGS-FRESC
8/18/01

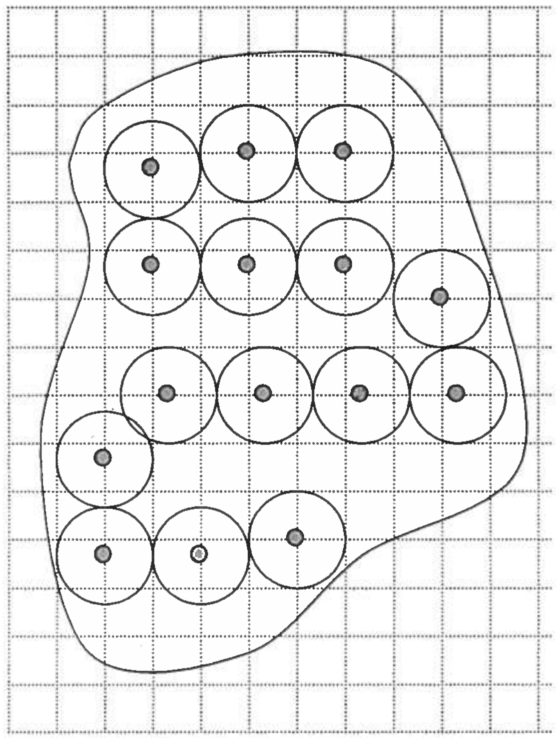
A. FORMS
1. Plot Location
2. Herp Array
3. Fuels Plot
4. Herp Capture

B. SITE SET-UP and VEG/WOOD SURVEYS
1. Tape Measures (50, 30, and 15 meters)
2. Clinometers
3. Compasses
4. PVC, Titanium Alloy Poles
5. Camera and Film
6. Go-No-Go's
7. GPS unit
8. Pin Flags
9. Flagging Tape

C. SALAMANDER SURVEYS
1. Hygrometer
2. Thermometers
3. Knee Pads
4. Small Garden Potato Rakes
5. Ziploc Baggies

D. MISCELLANEOUS ITEMS
1. Rulers
2. Sharpies
3. Pencils
4. Rite-In-The-Rain Books
5. Ziploc Baggies

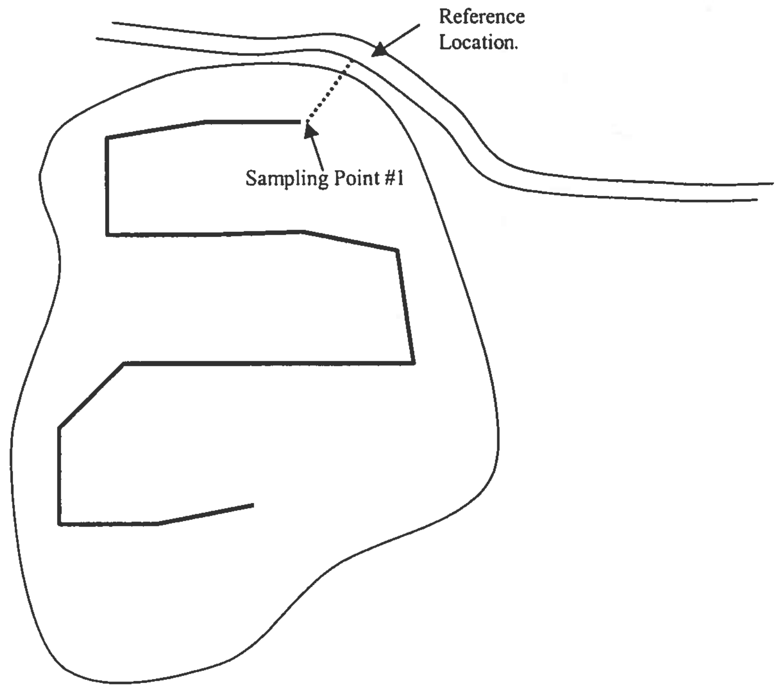
Sampling Design for Fuels/Wildlife Project



Locat Study Site and establish sampling route

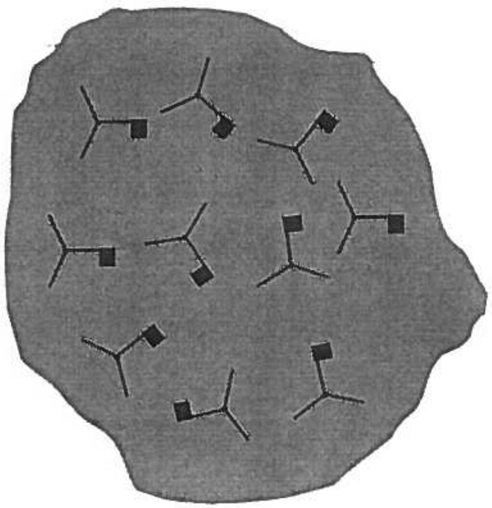
Criteria:
Sites size 30 ac minimum
Sampling intensity
1 sampling point for every 2 ac of stand area
ex., For a 30 acre stand you would sample
30 / 2 or 15 sampling points

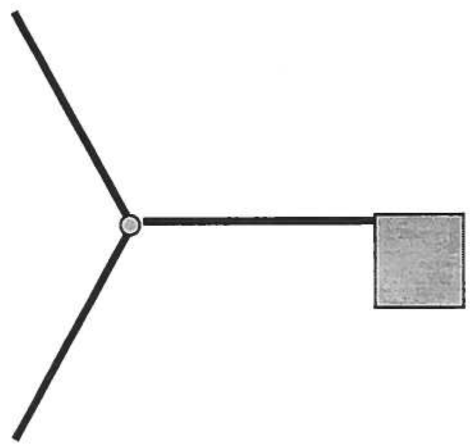
Sampling points are located 60 meters apart, so you would then design a route that effectively covers the entire stand. This can be accomplished with the use of a 60-m dot grid and orienting it on the stand map for maximum coverage we have also used GIS to conduct this exercise.



Connect the dots and this will be your sampling Route. ID North on your map and you can determine ALL the compass bearings required to orient the sampling course.

Sampling Protocols



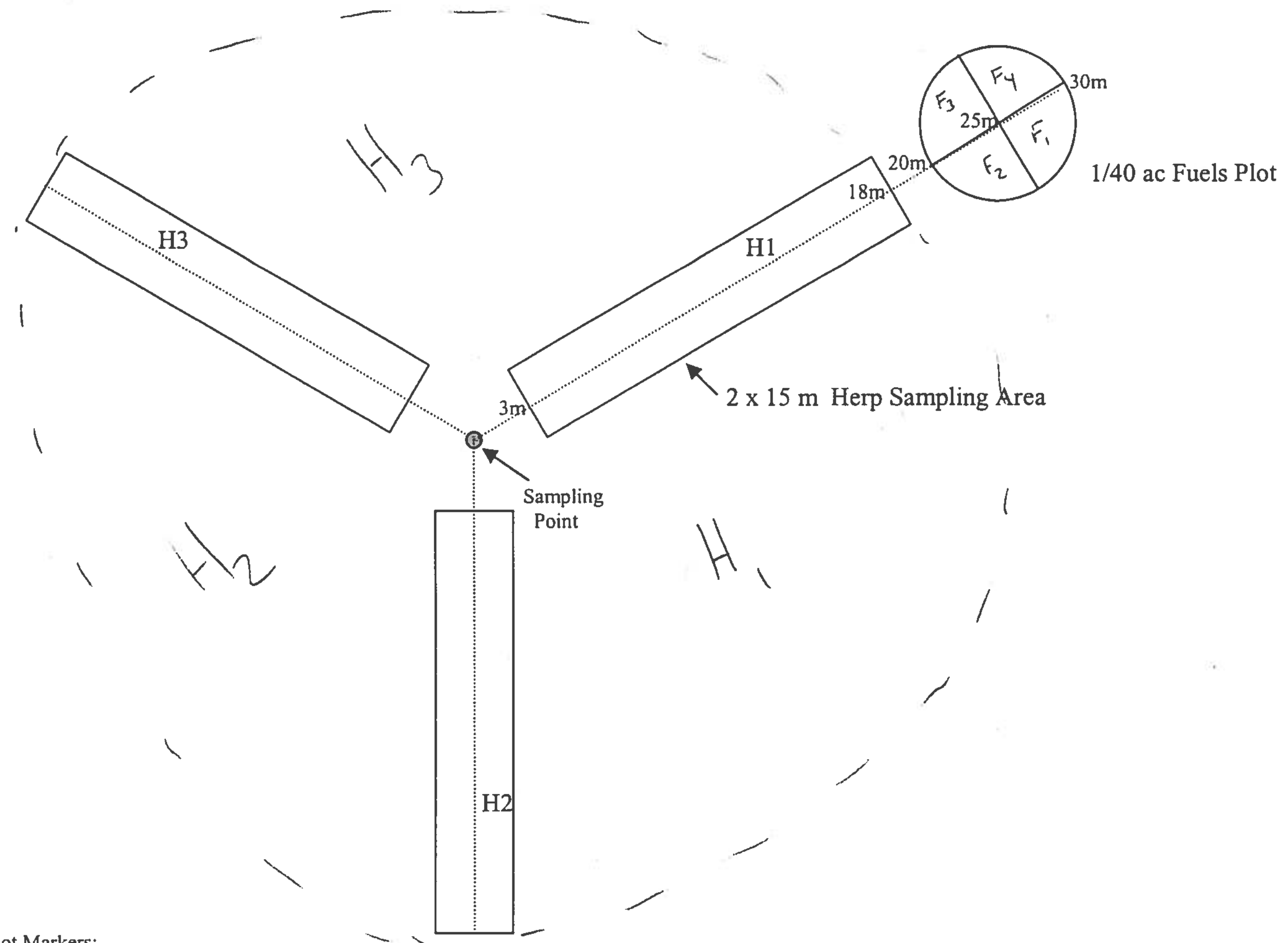


25-m Transect sampling
Down Wood/Fine Fuels
Amphibian/Reptile

10-m² Plot
Down Wood/Fine Fuels

? Shrub density/cover
? Herbaceous density/cover

Establishing Herp Array + 1/40 ac Fuels Plot from Sampling Point

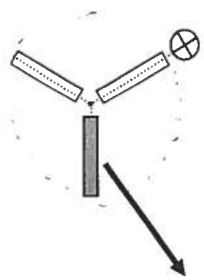


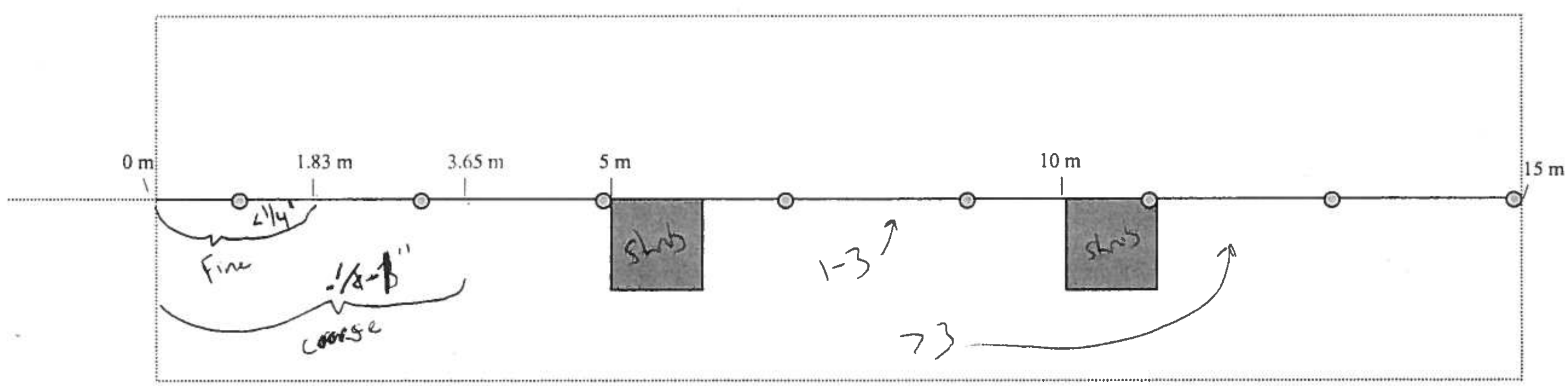
Long-term Plot Markers:
Sampling Point - Mark w/ 26" length of 1/2" alum. Conduit
Fuels Plot Origin - Mark w/26" alum. conduit

1. At Sampling point shoot the Random Generated compass bearing identified for the point (this will be H-1 of the Herp Array) Have a second person pull a 30-m tape along this bearing. Setting Pin flags at 3m, 18m, 20m, 25m, and 30m.
2. Reel in tape and repeat the same process for H-2 (H-1 bearing + 120 degrees) and H-3 (H-1 bearing - 120 degrees). Note: Only pull 18-m of tape and set Pin flags at 3m and 18m.

Correct

Sampling Herp Array - Fuels/Habitat





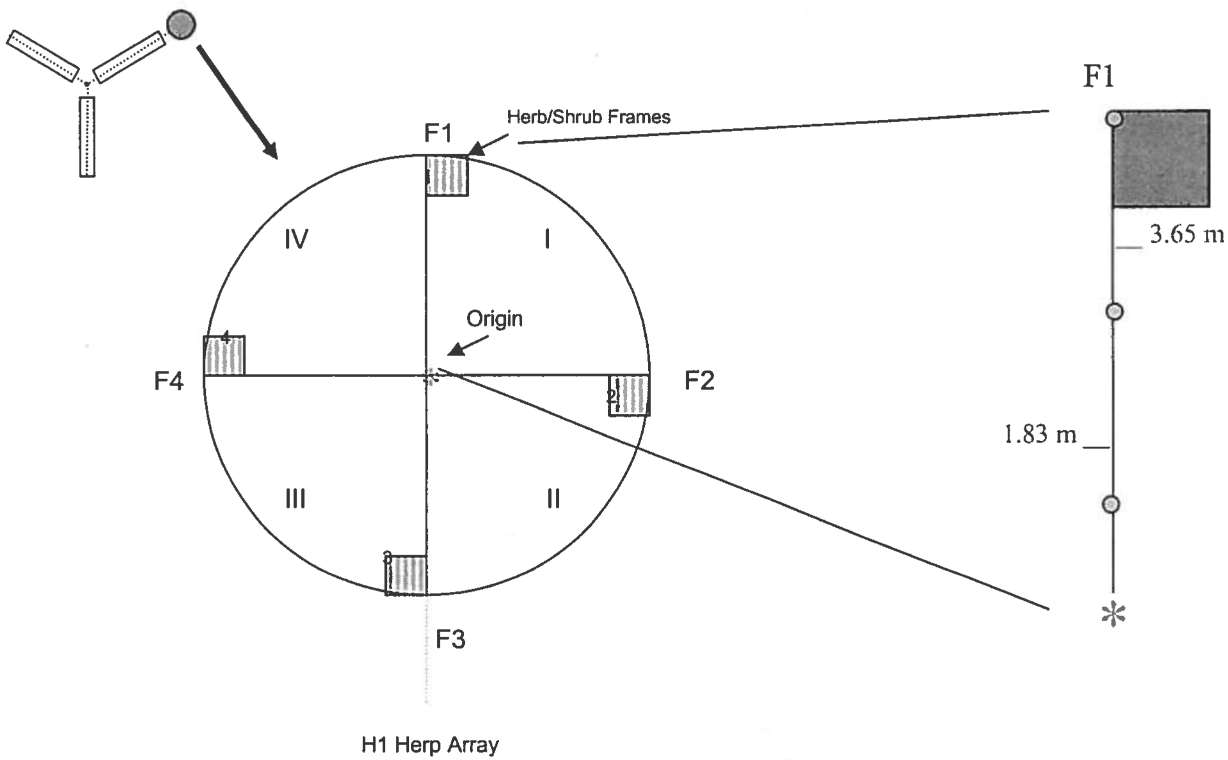
metric

Long-term Plot Markers:

1. Within the sampling array, fuels/habitat data will be recorded using a combination of Planar intercept and area plots. Fine Fuels (Type 1: 0-0.25" and Type 2: 0.25-1.0") will be sampled from 0-6 ft (1.83 m). Fuel type 3: 1.0-3.0 will be sampled between 0-12 ft (3.65 m). Any large wood greater than 3" (or 10 cm) will be sampled along the entire 15 m transect.

2. Litter/Duff samples (◎) will be taken at Meter 1 and every 2 meters thereafter to 15. Shrub/Herbaceous data will be recorded from 1 m^2 sampling frames ■ established at meters 5 and 10 of each array. Note - Shrub plot 1 will be located adjacent to the Sampling point on each array.

Sampling 1/40 ac Fuels Plot - Fuels/Habitat



Long-term Plot Markers:

* Mark Origin w/ aluminum conduti

Pin-flag end point of each transect (F1-F4)

1. Within the 1/40 ac fuels plot, fuels/habitat data will be recorded using a combination of Planar intercept and area plots. Fine Fuels (Type 1: 0-0.25 and Type 2: 0.25-1.0) will be sampled from 0-6 ft (1.83 m). Fuel type 3: 1.0-3.0 will be sampled between 0-12 ft (3.65 m). Any large wood greater than 3" (or 10 cm) will be sampled along the entire 5 m transect and within each Quadrat (I, II, III, IV).

2. Litter/Duff samples (◉) will be taken at Meter 1 and every 2 meters thereafter to 5. Shrub/Herbaceous data will be recorded from 1 m^2 sampling frames ■ established at meter 5 of each transect (F1, F2, F3, F4). Note - Shrub plot 1 will be located adjacent to the Sampling point on each array.

PLOT LOCATION DATA SHEET

Proofed Entered

Page ___ of ____ Date _________ Recorders _______________

Basin Name _________ Watershed No.________ Stand ID____________Topo. Quad.____________ Aspect _____

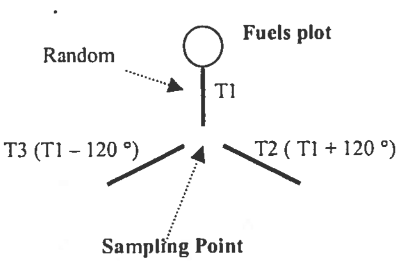
Elevation _______ Forest Type _______ UTMN________________ UTME _________________T___ R___ S___

Compass bearing (from reference location to 1st sampling plot)_______° Distance__________m / ft. / chains (circle one)

Offset? Compass bearing to offset ________° Distance to offset ________ m/ ft. /chains (circle one) Declination ______°

Directions to study plot. (Information on how to get to the reference location, and to the general area: Township/Range, Sec. No., Hwy., Rt., FS, and trail no., driving mileages, hiking distances, etc.

S. P. #	C. B. °	Off set dist / °	Array Center		Transects			Fuels plot (At Origin)		Fuels Plot Photos Roll # _______ Roll # _______							
					T1	T2	T3			T1-Orig		T2 - Orig		T-3 Orig		T4 - Orig	
			UTMN	UTME	R °	+120°	-120°	UTMN	UTME	#	time	#	time	#	time	#	time
1																	
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	
11																	
12																	
13																	
14																	
15																	
16																	
17																	
18																	
19																	
20	none	none															



Notes: Deviations from protocol, etc

Terms:
S. P. # = Sampling Pt. number
C. B. = Compass bearing
R = Random
Offset = a new point if the original one is void because of an obstruction

GLOSSARY FOR PLOT LOCATION DATA SHEET

DATE = Format YYMMDD. This is the date the plot was sampled and the data recorded. If the data is recorded on two different occasions (i.e. you start late one day, and it gets finished the following day), record the date the following way: 99/7/12 – 99/7/13.

Recorders = The name of the person doing the sampling (first initial, last name) followed by the name of the person recording the data (ex: D. Major/ A. Rifá). If there is only one name, it will be assumed the person did both.

Basin Name = The basin's name from a GIS coverage or 7.5 Min. Quadrangle map.

Watershed No. = A unique number provided by the hydrology layer of a GIS coverage

STAND ID = If this is an area that is scheduled to be burned by prescribed fire, it should have a burn unit name or number, otherwise, the stand (the whole area encompassing the study plot) should have a particular identifier.

Aspect = North, South, East, or West. Taken from the reference location as you face the stand.

Elevation = At the reference location from an altimeter reading, or as an estimation from the topographic map.

Forest Type = The vegetation association or community of the stand, for example: Montane Mixed Conifer Forest.

UTMN = Taken with a GPS unit at the *reference location*. This is the northing.

UTME = Taken with a GPS unit at the *reference location*. This is the easting.

Compass bearing (from reference location to 1st sampling plot) = A random bearing from the reference location to the center of the first sampling point.

Distance = A random distance from the reference location to the center of the first transect array. Circle one of the measuring units.

Offset? Compass bearing to offset = If there is an obstruction at the original reference location, choose a random bearing to the *new* reference location.

Distance = The offset random distance to the *new* reference location.

Directions to study plot = Information on how to get to the reference location and to the general area. Give precise and detailed information. Example: *From Hwy 99W go South for 5 miles and turn left onto FS 234. Take it for 0.8 miles to the junction of an unmarked road (right). Take it for 1.5 miles. Park and walk 500 meters to the reference location—T5NR3W, Sec. 2.*

S. P. # = SAMPLING POINT number. These are the location identifiers for the combined Herp Arrays and Fuels plots. They are established across the stand; 30 m apart, to provide 'coverage' of the stand.

C. B. ° = Compass bearing. The random compass bearing to each of the array centers from the preceding one. The bearing at S.P. # 1 will take you to S.P. # 2, and so on.

Offset – dist / ° = The offset distance and bearing in the event there is an obstacle at one of the array centers.

~~Array Center UTMN UTME = Taken with a GPS unit at each array center.~~

Transects T1 T2 T3 = The center-line of each Herp transect (2 x 15 m) that form the array. T1 is a random bearing, T2 is T1 plus 120°, T3 is T1 - 120°.

Fuels plot (at origin) UTMN - UTME = The origin (center point) of the 1/40 ac Fuels Plot. This is done at each plot.

Fuels plot photos = This photos are to be taken at each of the fuels plot from the end of each fuels transect (T1, T2, T3, T4) facing the fuels plot origin. Record their exposure number, and the time for each of them.

Notes = Things to note, such as deviations from protocol.

Study Plot ID = This is found at the top left of the data sheet in the boxes. It is a unique identifier generated from the database that will consist of the ownership name (up to four characters), the basin name or the watershed id (up to 4 characters), and the year (2 characters). Example: KLFCE2299 (KLF= Klamath Forest, Cedar 22 = watershed id, 99 = year).

PART 5

SECTION 1

Protocols and Dataforms

Subsection B

Herp Array

Proofed	Entered

HERP ARRAY HABITAT DATA FORM

USGS FRESC D. Major *v. 1.1 Feb. 2000*

Page __ of __

DATE	STAND ID	ARRAY ID	ARRAY TERRAIN Slope Aspect Elev.	% CANOPY	RECORDERS

BURN TYPE (Circle one) Wildland Rx-Natural RX Other ________	BURN STATUS (Circle one) Preburn Post burn Y1 Post Y2 Post Other ________	Azimuth - Centerline

PLANAR INTERCEPT DATA

HERP ARRAY	Number of Intercepts 0-6 ft.	0-6 ft.	0-12 ft.	Litter /Duff Depth (cm) at following points						
	0 - .25	*0.25 – 1*	*1 - 3*		L	D		L	D	
Transect H1 Slope ____%				1 3 5 7			9 11 13 15			
Transect H2 Slope ____%				1 3 5 7			9 11 13 15			
Transect H3 Slope ____%				1 3 5 7			9 11 13 15			

Comments:

HERBACEOUS / SHRUB DATA

Frame	VEG GROUP	HEIGHT	LIVE	STEM CNT
(1)	______	HI LO	Y N	______
SC	______	HI LO	Y N	______
	______	HI LO	Y N	______
	______	HI LO	Y N	______
	______	HI LO	Y N	______
2	______	HI LO	Y N	______
SC	______	HI LO	Y N	______
	______	HI LO	Y N	______
	______	HI LO	Y N	______
	______	HI LO	Y N	______
3	______	HI LO	Y N	______
SC	______	HI LO	Y N	______
	______	HI LO	Y N	______
	______	HI LO	Y N	______
	______	HI LO	Y N	______
7	______	HI LO	Y N	______
SC	______	HI LO	Y N	______
	______	HI LO	Y N	______
	______	HI LO	Y N	______
	______	HI LO	Y N	______

Frame	VEG GROUP	HEIGHT	LIVE	STEM CNT
4	______	HI LO	Y N	______
SC	______	HI LO	Y N	______
	______	HI LO	Y N	______
	______	HI LO	Y N	______
	______	HI LO	Y N	______
5	______	HI LO	Y N	______
SC	______	HI LO	Y N	______
	______	HI LO	Y N	______
	______	HI LO	Y N	______
	______	HI LO	Y N	______
6	______	HI LO	Y N	______
SC	______	HI LO	Y N	______
	______	HI LO	Y N	______
	______	HI LO	Y N	______
	______	HI LO	Y N	______

Comments:

DATE ____________ STAND ID ________________ ARRAY ID _______________ RECORDERS __________________

LOG INVENTORY

Transct Number	Segm #	Log. #	Log Class	Log SP	Structural Code	MEASURES LG Dia.(m)	SM Dia. (m)	Length (m)	Hollow Y / N	Char Y / N	Percent Char	

COMMENTS

Log Class

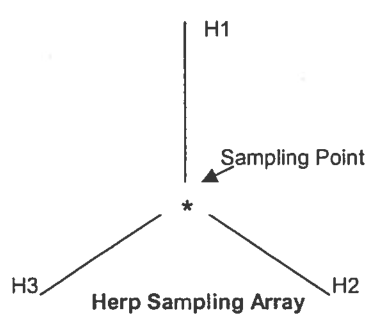
1 = Natural log
2 = Cut log
3 = Nat stump
4 = Cut stump

Segment #
1 = 0-5 m
2 = 5-10 m
3= 10-15 m

Structural Code
(circle one)
1-3: PNW GTR 391

1-5; Maser et. al. 1979

Other ____________



Log Measures

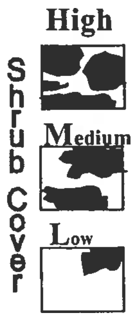
LG = Large diameter of log is taken just Above butt-swell at "stump" height

Use length column to record height of Stump

Use LG column to record stump diameter

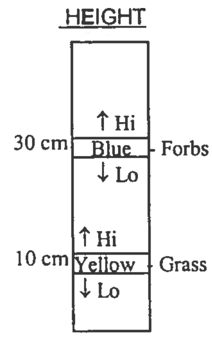
SP = Log Species

1=	2=	3=	4=	5=	6=	7=	8=	9=	10=



VegGroups:

Grass or
Forb or
Riparian
Other _______



GLOSSARY FOR HERP ARRAY HABITAT DATA

DATE = Format YYMMDD. This is the date the plot was sampled and the data recorded. If the data is recorded on two different occasions (i.e. you start late one day, and it gets finished the following day), record the date the following way: 99/7/12 – 99/7/13.

STAND ID = If this is an area that is scheduled to be burned by prescribed fire, it should have a burn unit name or number, otherwise, the stand (the whole area encompassing the study plot) should have a particular identifier.

ARRAY ID = The identification number for a single herp array composed of a the SAMPLING POINT plus a character and numeric. For example: in the 1/40 acre circular fuels plot (with 4 transects each 5 meters long) the ID would be SAMPLING POINT -F01, -F02, and so on; for the herpetofaunal transects (with 3 transects ea. 2 x 15 m, in a "Y" array) the ID would be SAMPLING POINT-H01, -H02, etc.

RECORDERS = The name of the person doing the sampling (first initial, last name) followed by the name of the person recording the data (ex: K. Irwin/D. Major). If there is only one name, it will be assumed the person did both.

BURN TYPE = The type of fire that occurred in the stand. Circle the appropriate one.
Wildland = Designation for areas that were burned by wild fires within the last five years, and are not scheduled to be burned by prescribed fire.
Rx-Natural = Prescribed *natural* fire.
RX = Prescribed fire

BURN STATUS = The status of the plot at the time of that particular visit. Circle the appropriate one each time.
Preburn = The sampling done before the area is burned by prescribed fire.
Post burn = The sampling done immediately (within 2 months) after the area is burned by prescribed fire.
Yr1 = The sampling done the first year after the prescribed burn, on the same day as the preburn reading.
Yr2 = The sampling done the second year after the prescribed burn, on the same day as the preburn and yr1 reading.
Other = May include one of the following:
Green-up 1 = The *first* sampling done during green-up (Spring), and after the area was burned by prescribed fire.
Green-up 2 = The *second* sampling done during green-up (Spring), and after the area was burned by prescribed fire.

Planar Intercept Data

AZIMUTH CENTERLINE = The compass bearing along the first arm (H1) of the Herp array. This is a randomly generated bearing.

TRANSECT H1 – TRANSECT H3 = Herp habitat inventory transects that extend at +/- 120 degrees intervals from the sampling point. Herp Habitat transects originate 3 meters from the sampling point and extend for *15 meters*. Each transect is tagged at their end point.
Slope = Taken with a clinometer at each of the transects from the sampling point. For example, for Transect H1 it is taken from the array center (sampling point) looking towards the end of the transect. This is taken in percent.

NUMBER OF INTERCEPTS = Tally each particle intersected along each individual fuels transect along the right side of the tape (as you face the end of the 15 -m tape). Count all dead and downed woody material (except for cones, bark, needles and leaves) intersected along the transect plane up to 6 ft. from the ground. Do not count stems and branches attached to a *standing* tree or brush.
0 - 0.25 = A fuel size class (particles between 0 – ¼ inch in diameter) sampled only between 0 and 6 ft. Use the go-no-go gauge.
0.25 - 1 = A fuel size class (particles between ¼ - 1 inch in diameter) sampled only between 0 and 6 ft. Use the go-no-go gauge.
1 – 3 = A fuel size class (particles between 1 - 3 inches in diameter) sampled only between 0 and 12 ft. Use the go-no-go gauge.

LITTER AND DUFF DEPTHS = Vertically measure the litter and duff depths to the nearest centimeter starting at the 1 m mark on the herp habitat transect, and every 2 m. subsequently. The last sampling point on the transect will be the 15 m mark. If there's an obstacle at one of the sampling points, move 1 foot perpendicular to the line and sample there. Make a note of this. Litter is considered the top, unconsolidated, and undecomposed layer. Twigs and larger stems are not measured in the litter depth. Duff is the fibrous, consolidated, decomposed layer above mineral soil. Make the holes with your finger, and refill them afterwards.

Herbaceous / Shrub Data

FRAMES 1 – 7 = Refers to 1 square meter frames used to sample the herbaceous density and the shrub cover. These frames are set at the 5 m and 10 m mark on each of the 15 m herp habitat transects. *Frame 1* is placed at the sampling point; subsequest frames are numbered as follows: Transect H1- Frames 2,3; Transect H2 – Frames 4,5; Transect H3 – Frames 6,7.

VEG GROUPS = The particular vegetation group sampled in each frame. The categories are : Grass, Forb, and Riparian (sedges, rushes, etc.). The base of the plant needs to be inside the frame in order to be considered.

HEIGHT = Place the range pole in the center of each frame, and use the markings on it to determine the height of each individual in a vegetation group. Circle HI (high), or LO (low). For forbs, above the blue mark is high, below is low. For grasses, above the yellow mark is high, below is low.

Live = Determine whether each individual plant (grass, forb, or riparian) inside the frame is alive or not. Circle Y (yes) or N (no).

STEM COUNT = Keep a count (tally) of each individual whose base falls inside the frame, and has all of the other same criteria in common. For example: FRM 1—Grass—HI—Y-- lll
FRM 1—Grass--LO—N-- ll1l

SC = *Shrub cover*. Visually estimate the shrub cover in each frame by following the diagram provided at the bottom of the data sheet. For example: if the shrub (do not consider grasses or forbs) cover is dense, as in the diagram titled "High", write an H inside the SC box.

Log Inventory

ONLY for logs with large end diameter > 10 cm.

TRANSECT NUMBER = The Herp Array Transect (H1, H2, H3) wherein the mid-point of the log resides.

LOG INTERCEPT = Intersection point of the log along the 15 m transect.

LOG # = Sequential number of each log encountered within a specific quadrat.

LOG CLASS = Physical characteristic of the log. Includes 4 classes – 1= Natural log; 2= Cut log; 3= Natural stump; 4= Cut stump.

LOG SPECIES = Species of log being examined. Record as a numeric category based on species identified in table at bottom of data form.

STRUCTURAL CODE = Method used to identify *Decay Class* of log being examined. For example, Maser et. al. (1979) established a Decay Class gradient from 1 to 5. If using this method you would circle the appropriate method under Structural Code and categorize logs as 1, 2, 3, 4, or 5.

MEASURES – These are physical measurements (in meters) recorded for each log sampled.
- LG Dia. – Diameter of log at largest end. Diameter is taken perpendicular to mid-line of log. Recorded in meters.
- SM Dia. – Diameter of log at smallest end (10 cm MINIMUM). Diameter is taken perpendicular to mid-line of log. Recoded in meters.
- Length – Total length of log. Recorded in meters.

HOLLOW – Record "Y" if log is hollow, "N" if it is not.

CHAR – Record "Y" if log shows charring from fire, "N" if it does not.

PERCENT CHAR – Visually estimate percent of log that is charred. Record as percent (max. 100%)

Terrestrial Herp Capture Form

USGS FRESC D. Major v. 1 Jan 2000

Page ___ of ___

DATE Y-M-D	STAND ID	ARRAY ID Sampl Pt. ____ H #	Clouds ___ Precip ___ Wind ___	Air 1-m ____ C F 10-cm ____ C F Ground ____ C F	RH ____%	RECORDERS	Proofed	Entered

TIME Start / End

CAPTURE DATA									HABITAT DATA						If Log > 10 cm dia.				
Cap Num	ICPT	Species	ST	SX	SVL mm	TL mm	M/R	ID	Pos	Hab	Hab Num	Length m	Width m	Diam m	Log Class	Structural Code	Char Y N	% Char	Prev. Sampled

Environ. Codes

Clouds
1 = Clear
2 = Partly cloudy
3 = Overcast

Precip
1 = Dry
2 = Drizzle
3 = Lt rain
4 = Hvy rain
5 = Snow/Sleet

Wind
1 = Calm
2 = Lt wind
3 = Hi wind

Capture Codes

ST
A = Adult
J = Juvenile
U = Unk

SX
F = female
M = male
U = unk

M/R
M = Marked
R = Recap

Habitat Codes

Pos
I = In
O = on
U = under

Hab
W = wood
R = rock
V = vegetation

HabNum

WOOD	ROCK	VEGETATION
1 Log> 10 cm	6 Single rock	10 Moss
2 Log/branch < 10 cm	7 Outcrop	11 Duff
3 Branch pile	8 rock pile	12 Litter
4 Bark Single	9 talus	13 Herbs
5 Bark pile		14 Shrub

COMMENTS

Terrestrial Survey Data Form: Definitions of Variables (TSDF v1.0 , D.J. Major)

Location Information

SITE NAME - A name that has some relation to the site being surveyed, such as the name of the stream.
SITE NUMBER - This will be provided by the computer when data is entered.
BELT - Number of the belt being surveyed.
PLOT - Type of plot being surveyed (i.e. old-growth).
DATE - dd/mm/yy
WEATHER - Codes:

Cloud cover	Precipitation	Wind
CL=Clear	D=Dry	C=Calm
PC=Partly Cloudy	F=Fog	LB=Lt Breeze
CO=Cloudy/Overcast	M=Mist	MB=Moderate Breeze
	LR=Lt Rain	W=Windy
	HR=Heavy Rain	G=Gusting
	SL=Sleet	
	SN=Snow	

AIR 1-M - Temperature of the air taken at least 1 meter above the ground. Use degrees Celsius, unless only a Fahrenheit thermometer is available. Circle C or F depending upon scale used.
GROUND - Temperature of the soil. Use degrees Celsius, unless only a Fahrenheit thermometer is available. Circle C or F depending upon scale used.
TIME - Record starting and ending times of the survey.
SURVEYOR - Record the first and last initial of the person doing the survey.

Habitat Data

TYPE - The type of habitat each animal was captured in, on , or under. Circle W for wood, R for rock, and V for vegetation.
LENGTH -The length of the cover object used by the captured animal. Measurements should be recorded in m.
DIA - Diameter of the cover object. Measurements should be recorded in m.
WIDTH - Width of the cover object. Measurements should be recorded in m.
COUNT OF OBJECT TYPES - Using tic marks, keep a running count of the different object types searched.
COMMENTS - General comments/notes pertaining to the specific survey (e.g., deviations from protocol, problems encountered, etc) and/or general departures from the 'norm'.

Capture Data

CAP# - Number captured animals.
SPECIES - Use the first two letters of the genus and the first two letters of the species name to record species captured (i.e. ANFE for *Aneides ferreus*).
STG - Stage of the animal. Codes: A=Adult, AF=Adult female, AM=Adult male, G=Gravid female, SA=Subadult, J=Juvenile
POS - Position of the animal in relation to the cover object. Code: **I**=In **O**=On **U**= Under
HAB# - Use the numbers to the left of the the object types listed in the habitat data section to identify the cover object where the animal was captured (i.e. 1 for hard log, 2 for soft log, etc.).
SVL - Snout-vent length. Measure from the end of the snout to the front corner of the vent. Measurements should be recorded in mm.
TL - Total length. Measure from the end of the snout to the tip of the tail. Measurements should be recorded in mm.
Note if the tail is regenerating, but do not record a total length.

PART 5

SECTION 1

Protocols and Dataforms

Subsection C

Fuels Plot

Proofed	Entered

FUELS PLOT INVENTORY DATA FORM

USGS FRESC D. Major *v. 1.1 Feb. 2000*

Page __ of __

DATE	STAND ID	PLOT ID	PLOT TERRAIN Slope Aspect Elev.	% CANOPY	RECORDERS

BURN TYPE (Circle one) Wildland Rx-Natural RX Other ________	BURN STATUS (Circle one) Preburn Post burn Y1 Post Y2 Post Other ________	Azimuth - Centerline

PLANAR INTERCEPT DATA

FUELS PLOT	Number of Intercepts 0-6 ft.	0-6 ft.	0-12 ft.	Litter /Duff Depth (cm) at following points						
	0 - .25	*0.25 – 1*	*1 - 3*		L	D		L	D	
Transect F1 Slope _____%				1 3 5 7			9 11 13 15			
Transect F2 Slope _____%				1 3 5 7			9 11 13 15			
Transect F3 Slope _____%				1 3 5 7			9 11 13 15			
Transect F4 Slope _____%				1 3 5 7			9 11 13 15			

HERBACEOUS / SHRUB DATA

Frame	VEG GROUP	HEIGHT	LIVE	STEM CNT	Frame	VEG GROUP	HEIGHT	LIVE	STEM CNT
1	________	HI LO	Y N	________	3	________	HI LO	Y N	________
	________	HI LO	Y N	________		________	HI LO	Y N	________
SC	________	HI LO	Y N	________	SC	________	HI LO	Y N	________
	________	HI LO	Y N	________		________	HI LO	Y N	________
	________	HI LO	Y N	________		________	HI LO	Y N	________
	________	HI LO	Y N	________		________	HI LO	Y N	________
2	________	HI LO	Y N	________	4	________	HI LO	Y N	________
	________	HI LO	Y N	________		________	HI LO	Y N	________
SC	________	HI LO	Y N	________	SC	________	HI LO	Y N	________
	________	HI LO	Y N	________		________	HI LO	Y N	________
	________	HI LO	Y N	________		________	HI LO	Y N	________
	________	HI LO	Y N	________		________	HI LO	Y N	________

DATE ____________ STAND ID ______________ PLOT ID ______________ RECORDERS ________________

LOG INVENTORY

Quadrat Number	Log. #	Log Class	Log Species	Structural Code	MEASURES LG Dia.(m)	SM Dia. (m)	Length (m)	Hollow Y / N	Char Y / N	Percent Char	

COMMENTS

Log Class

1 = Natural log
2 = Cut log
3 = Nat stump
4 = Cut stump

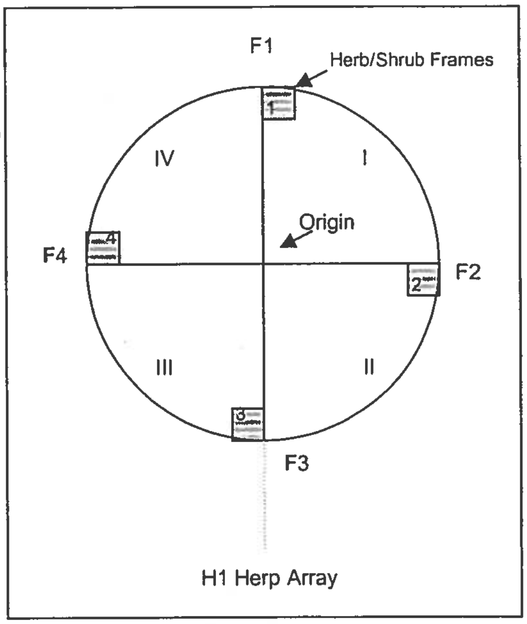
Structural Code

1-3: PNW GTR 391

1-5; Maser et. al. 1979

Other ____________

(circle one)



Log Measures

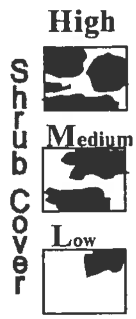
LG = Large diameter of log is taken just Above butt-swell at "stump" height

Use length column to record height of Stump

Use LG column to record stump diameter

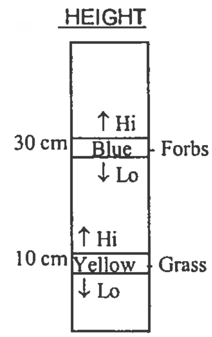
SP = Log Species

1=	2=	3=	4=	5=	6=	7=	8=	9=	10=



VegGroups:

Grass or
Forb or
Riparian
Other _______



GLOSSARY FOR FUELS PLOT INVENTORY DATA FORM

DATE = Format YYMMDD. This is the date the plot was sampled and the data recorded. If the data is recorded on two different occasions (i.e. you start late one day, and it gets finished the following day), record the date the following way: 99/7/12 – 99/7/13.

STAND ID = If this is an area that is scheduled to be burned by prescribed fire, it should have a burn unit name or number, otherwise, the stand (the whole area encompassing the study plot) should have a particular identifier.

PLOT ID = The identification number for a single fuels plot composed of a the SAMPLING POINT plus a character and numeric. For example: in the 1/40 acre circular fuels plot (with 4 transects each 5 meters long) the ID would be SAMPLING POINT -F01, -F02, and so on; for the herpetofaunal transects (with 3 transects ea. 2 x 15 m, in a "Y" array) the ID would be SAMPLING POINT-H01, -H02, etc.

RECORDERS = The name of the person doing the sampling (first initial, last name) followed by the name of the person recording the data (ex: K. Irwin/D. Major). If there is only one name, it will be assumed the person did both.

BURN TYPE = The type of fire that occurred in the stand. Circle the appropriate one.
Wildland = Designation for areas that were burned by wild fires within the last five years, and are not scheduled to be burned by prescribed fire.
Rx-Natural = Prescribed *natural* fire.
RX = Prescribed fire

BURN STATUS = The status of the plot at the time of that particular visit. Circle the appropriate one each time.
Preburn = The sampling done before the area is burned by prescribed fire.
Post burn = The sampling done immediately (within 2 months) after the area is burned by prescribed fire.
Yr1 = The sampling done the first year after the prescribed burn, on the same day as the preburn reading.
Yr2 = The sampling done the second year after the prescribed burn, on the same day as the preburn and yr1 reading.
Other = May include one of the following:
Green-up 1 = The *first* sampling done during green-up (Spring), and after the area was burned by prescribed fire.
Green-up 2 = The *second* sampling done during green-up (Spring), and after the area was burned by prescribed fire.

Planar Intercept Data

AZIMUTH CENTERLINE = The compass bearing along the midline of the 1/40 ac fuels plot. This is also the random bearing of the Herpetofaunal Transect 1 (H01).

TRANSECT 1 – TRANSECT 4 = Fuel inventory transects that extend at 90 degree angles originating from the azimuth centerline. These transects extend for *5 meters*. Each transect is tagged at their.
Slope = Taken with a clinometer at each of the fuels transects from the origin. For example, for Transect 1 it is taken from 1A looking towards 2A. This is taken in percent.

NUMBER OF INTERCEPTS = Tally each particle intersected along each individual fuels transect along the right side of the tape (as you face the end of the 5 -m tape). Count all dead and downed woody material (except for cones, bark, needles and leaves) intersected along the transect plane up to 6 ft. from the ground. Do not count stems and branches attached to a *standing* tree or brush.
0 - 0.25 = A fuel size class (particles between 0 – ¼ inch in diameter) sampled only between 0 and 6 ft. Use the go-no-go gauge.
0.25 - 1 = A fuel size class (particles between ¼ - 1 inch in diameter) sampled only between 0 and 6 ft. Use the go-no-go gauge.
1 – 3 = A fuel size class (particles between 1 - 3 inches in diameter) sampled only between 0 and 12 ft. Use the go-no-go gauge.

LITTER AND DUFF DEPTHS = Vertically measure the litter and duff depths to the nearest centimeter starting at the **1 ft**. mark on the fuels transect, and every 2 ft. subsequently. The last sampling point on the transect will be the 15 ft. mark. If there's an obstacle at one of the sampling points, move 1 foot perpendicular to the line and sample there. Make a note of this. Litter is considered the top, unconsolidated, and undecomposed layer. Twigs and larger stems are not measured in the litter depth. Duff is the fibrous, consolidated, decomposed layer above mineral soil. Make the holes with your finger, and refill them afterwards.

Herbaceous / Shrub Data

FRAMES 1 – 4 = Refers to 1 square meter frames used to sample the herbaceous density and the shrub cover. These frames are set on each of the 5 m transects fuels plot, at the 4 to 5 meter segment. The frames are numbered sequentially as you move from Quadrat I to IV.

VEG GROUPS = The particular vegetation group sampled in each frame. The categories are : Grass, Forb, and Riparian (sedges, rushes, etc.). The base of the plant needs to be inside the frame in order to be considered.

HEIGHT = Place the range pole in the center of each frame, and use the markings on it to determine the height of each individual in a vegetation group. Circle HI (high), or LO (low). For forbs, above the blue mark is high, below is low. For grasses, above the yellow mark is high, below is low.

Live = Determine whether each individual plant (grass, forb, or riparian) inside the frame is alive or not. Circle Y (yes) or N (no).

STEM COUNT = Keep a count (tally) of each individual whose base falls inside the frame, and has all of the other same criteria in common. For example: FRM 1—Grass—HI—Y-- lll
FRM 1—Grass--LO—N-- llll

SC = *Shrub cover*. Visually estimate the shrub cover in each frame by following the diagram provided at the bottom of the data sheet. For example: if the shrub (do not consider grasses or forbs) cover is dense, as in the diagram titled "High", write an H inside the SC box.

Log Inventory

<u>ONLY for logs with large end diameter > 10 cm</u>.

QUADRAT NUMBER = The Fuels Plot quadrat (I, II, III, or IV) wherein the mid-point of the log resides.

LOG # = Sequential number of each log encountered within a specific quadrat.

LOG CLASS = Physical characteristic of the log. Includes 4 classes – 1= Natural log; 2= Cut log; 3= Natural stump; 4= Cut stump.

LOG SPECIES = Species of log being examined. Record as a numeric category based on species identified in table at bottom of data form.

STRUCTURAL CODE = Method used to identify *Decay Class* of log being examined. For example, Maser et. al. (1979) established a Decay Class gradient from 1 to 5. If using this method you would circle the appropriate method under Structural Code and categorize logs as 1, 2, 3, 4, or 5.

MEASURES – These are physical measurements (in meters) recorded for each log sampled.
<u>LG Dia</u>. – Diameter of log at largest end. Diameter is taken perpendicular to mid-line of log. Recorded in meters.
<u>SM Dia</u>. – Diameter of log at smallest end (10 cm MINIMUM). Diameter is taken perpendicular to mid-line of log. Recoded in meters.
<u>Length</u> – Total length of log. Recorded in meters.

HOLLOW – Record "Y" if log is hollow, "N" if it is not.

CHAR – Record "Y" if log shows charring from fire, "N" if it does not.

PERCENT CHAR – Visually estimate percent of log that is charred. Record as percent (max. 100%)

PART 6

SECTION 1

Bibliographies

Subsection A

Major, D.J., and R.B. Bury. 2000.
Annotated bibliography: Fire effects on wildlife (amphibians, reptiles and small ammals).

Subsection B

Hyde, E., R.B. Bury, and D.J. Major. 2003.
Fire bibliography. 313 entries.

Major, D.J., and R.B. Bury. 2000. Annotated bibliography: Fire effects on wildlife (amphibians, reptiles and small mammals).

Available online at: http://zippy.fsl.orst.edu/Fuels/annotated_bibliography.htm

Reference List

1. Ash, Andrew N. Disappearance and return of Plethodontid salamanders to clearcut plots in the southern Blue Ridge mountains. Cons. Biol. 1997; 11(4):983-989.
The disappearance and return of plethodontid salamanders on clearcuts has been monitored since 1979 in the southern Blue Ridge Mountains at three sites near Highlands, North Carolina. Salamander abundance on 225 m^2 plots located on clearcuts and in nearby forest was determined by nightly non-destructive searches. Abundances on clearcut and forest plots at a given site were compared for each year in which sampling occurred. Numbers of salamanders on clearcut plots decreased to 30-50% of forested plots in the first year after logging and were almost zero by the second year. Decreases in standing crop and moisture content of leaf litter seem responsible for salamander disappearance. Salamanders returned to clearcuts 4-6 years after cutting, and their numbers increased rapidly. Linear regressions estimate that salamander numbers on clearcut plots will equal or exceed numbers on forested plots by 20-24 years after cutting. The pattern of salamander return to clearcuts appears closely correlated with the timing of litter layer reformation. All sex and age classes of the most common species, Plethodon jordani, disappear from clearcuts at equal rates, whereas the earliest colonizers are predominantly large adults. Plethodon oconaluftee, a desiccation-resistant species, exists on regenerating clearcuts in disproportionately large numbers. Large adults of all species, including Plethodon oconaluftee, may be better able to withstand the drier, sparse litter cover of young, regenerating stands. Adults might move to clearcuts to avoid competition from smaller and immature salamanders restricted to mature forests with abundant, moist litter.

2. Babbitt, Lewis H. and Corinne H. Babbitt. A herpetological study of burned-over areas in Dade county, Florida. Copeia. 1951; 59.
Note: Research Note.

3. Bamford, Michael J. The impact of fire and increasing time after fire upon *Helleioporus eyrei*, *Limnodynastes dorsalis*, and *Myobatrachus gouldii* (Anura: Leptodactylidae) in *Banksia* Woodland near Perth, Western Australia. Wildlife Research. 1992; 19:169-178.
Banksia woodland is a seasonally arid and fire-prone environment. Although a seemingly inhospitable environment for frogs, seven species were recorded in pitfall-trapping carried out in six areas of Banksia woodland. These areas had different fire histories, ranging from recently burnt to unburnt for 23 years. One of the areas was burnt during the course of this study. Three species made up 95% of captures; *Helleioporus eyrei*, *Limnodynastes dorsalis*, and *Myobatrachus gouldi.* Annual numbers of captures of *H. eyrei* were not generally affected by fire or increasing time after fire. *L. dorsalis*, and to a lesser extent, *M. gouldii* were caught in higher numbers in long-unburnt areas than in recently burnt areas. Variation in the abundance of *L. dorsalis* and *M. gouldii* with time after fire did not appear to be related to changes in leaf litter and vegetation density, or to the abundance of invertebrates as potential prey.

4. Braithwaite, R. W. and Estbergs, J. A. Fire-birds of the Top End. Aust. Nat. Hist. 1987; 23.

5. Braithwaite, Richard W. Effects of fire regimes on lizards in the wet-dry tropics of Australia. J. Trop. Ecol. 1987; 3:265-275.
A quantitative analysis of the effect of fire regime on the abundance of common lizard species and genera and the species richness of two lizard groups in Kakadu National Park (12 degrees S) is presented. A surprising range of relationships between species abundance and components of fire regimes was revealed. Carlia amax, Heteronotia binoei and Carlia gracilis appear to be fire-sensitive, Diporiphora bilineata and Carlia triacantha are favoured by early hot fires, Cryptoblepharus plagiocephalus seems relatively unaffected, Carlia foliorum seems very tolerant of fires, while Ctenotus and Sphenomorphus spp. are favoured by low intensity, patchy fires with high intensity spots.
Lizard species experiencing the high-frequency fire regimes of the savannas and dry forests of the Australian wet-dry tropics are not able to select habitat at different stages of regeneration after fire

but select habitat produced by fires of different types. The implication for management is that no one fire regime is optimal for the fauna as a whole. A range of fire regimes within a park should be maintained in order to retain the whole fauna.

6. Breininger, D. R.; Schmalzer, P. A., and Hinkle, C. R. Gopher tortoise (*Gopherus polyphemus*) densities in coastal scrub and slash pine flatwoods in Florida. J. Herpetol. 1994; 28(1):60-65.
   Densities of gopher tortoises were compared with habitat characteristics in scrub and in flatwood habitats on the Kennedy Space Center, Florida. Tortoises were distributed widely among habitat types and did not have higher densities in well-drained (oak-palmetto) than in poorly-drained (saw palmetto) habitats. Fall densities of tortoises ranged from a mean of 2.7 individuals/ha in disturbed habitat to 0.0 individuals/ha in saw palmetto habitat. Spring densities of tortoises ranged from a mean of 2.5 individuals/ha in saw palmetto habitat to 0.7 individuals/ha in oak-palmetto habitat. Densities of tortoises were correlated positively with the percent herbaceous cover, an indicator of food resources. Plots were divided into three burn classes; these were areas burned within three years, burned four to seven years, and unburned for more than seven years prior to the study. Relationships between densities of tortoises and time-since-fire classes were inconsistent.

7. Butts, Sally R. and McComb, William C. Associations of forest-floor vertebrates with coarse woody debris in managed forests of western Oregon. J. Wildl. Manage. 2000; 64(1):95-104.
   Forests managed primarily for wood resources may be lacking in adequate amounts of coarse woody debris (CWD) for forest-floor vertebrates, We assessed associations between captures of forest-floor vertebrates and volume of CWD in 18 closed-canopy stands of Douglas-fir (Pseudotsuga menziesii). The volume of CWD ranged from 14 to 859 m super(3)/ha. Pitfall traps and timed, area-constrained ground searches were used to capture small mammals and amphibians. The abundance of ensatina (Ensatina eschscholtzii) and clouded salamanders (Aneides ferreus) increased with volume of CWD. In addition, the probability of encountering either ensatina or Trowbridge's shrew (Sorex trowbridgii)increased with cover of CWD on the forest-floor. The average distance from the nearest CWD for amphibians captured during timed, area-constrained ground searches was 0.5 m, versus 1 m between random points and the nearest CWD. Our study suggests that current management guidelines for CWD retention may not provide adequate habitat for forest-floor vertebrates that depend on this component of the habitat.

8. Campbell, R. G. and Hughes, J. H. Impact of forestry operations on pocosins and associated wetlands. Wetlands. 1991; 11(Special Issue):467-479.
   Current forestry practices in pocosins and associated wetlands (PAAWS) consist of site-specific prescriptions to harvest the existing timber, re-establish a forest stand, increase growth of crop trees, and manage for non-timber values. Most activities are directed at short-term modifications to ameliorate site-specific productivity limitations. Forestry operations have progressed from the cut-and-run practices of exploitative harvesting to intensive management of productivity potential using environmentally sound techniques. Research to understand the interactions between various site factors and management practices continues. With site-specific prescriptions based on research and economic principles, investments in productive forestry allow forest product demands to be met while maintaining other forested wetland functions and values.

9. Cavitt, John F. Fire and a tallgrass prairie reptile communitiy: Effects on relative abundance and seasonal activity. Journal of Herpetology. 2000; 34(1):12-20.
   Few intensive studies have been conducted on reptile populations of the tallgrass prairie. In addition, the effects of fire on these populations are also largely unknown. I established drift fence arrays connected to funnel traps to study the community composition and seasonal activity of reptiles found on the Konza Prairie Research Natural Area located near Manhattan, Kansas. This design also gave me the opportunity to examine the response of reptile populations to a spring wildfire. A total of 657 individuals representing 12 species were captured from 1994-1996. The results suggest that one species, Coluber constrictor, may respond negatively to recent fire.

10. Chazal, Anne C. and Niewiarowski, Peter H. Responses of mole salamanders to clearcutting: using field experiments in forest management. Ecol. Applic. 1998; 8(4):1133-1143.

Impacts of forest management practices on amphibian populations have received growing attention in the last 10 yr. However, to date, measured responses include only comparisons of species diversity indices and population counts without true spatial and temporal controls. We used an experimental approach to test for differences in growth rate, fecundity, age at maturity, and whole-body storage lipids in individual mole salamanders, *Ambystoma talpoideum*, placed in differently managed habitats. Four 100-m^2 field enclosures were built in each of two habitats, a 4-mo-old clearcut and an adjacent 40-yr-old pine forest. On 19 July 1994, 80 recently metamorphosed and individually marked, weighed, and measured (snout-vent length) *A.talpoideum* were randomly assigned to field enclosures (n = 640 salamanders). Between 31 October 1994 and 31 March 1995, salamanders were collected from the enclosures using pitfall traps. Body mass and length, whole-body nonpolar storage lipids, clutch size, and egg nonpolar lipids were determined for sexually mature salamanders. After an average of 5-6 mo exposure to clearcut and 40-yr-old pine forest, there were no significant differences between habitats for number of recaptured salamanders, final body mass, final body length, percent whole-body storage lipid, clutch size, or percent storage lipid of eggs. Our results suggest, in contrast to expectations based on many comparative studies with other species, that habitat modification resulting from clearcutting may not have detrimental effects on newly metamorphosed *A. talpoideum*. We contrast our experimental approach, with its strengths and weaknesses, to previous comparative studies and identify the inherent complexities involved in establishing a causal link between habitat management (clearcutting) and effects on amphibians.

11. Cole, Elizabeth C.; McComb, William C.; Newton, Michael; Chambers, Carol L, and Leeming, J. P. Response of amphibians to clearcutting, burning, and glyphosate application in the Oregon coast range. J. Wildl. Manage. 1997; 61(3):656-664.

We sampled amphibians on 3 red alder (Alnus rubra) sites 1 year before and 1 and 2 years after the following treatments were applied to each site: (1) control (uncut), (2) clearcut and broadcast burned, and (3) clearcut, broadcast burned, and then sprayed with the herbicide glyphosate. All sites included uncut riparian buffer strips. For 3 of the 6 species with greater than or equal to 20 captures in pitfall traps, we did not detect changes in capture rates after clearcutting. Capture rates of ensatinas (*Ensatina eschscholtzii*) and Pacific giant salamanders (*Dicamptodon tenebrosus*) decreased after logging. Capture rates of western redback salamanders (*Plethodon vehiculum*) increased the first year after logging, probably because the salamanders sheltered in pitfalls, but effects on populations were unclear. Logging did not significantly alter capture rates of rough-skin newts (*Taricha granulosa*), Dunn's salamanders (*P. dunni*), and red-legged frogs (*Rana aurora*). Planning the location and timing of clearcuts or other silvicultural practices over a landscape and retaining riparian buffer strips may be necessary to ensure long-term persistence of Pacific giant salamanders. We did not detect any effects of herbicide spraying on capture rates. Capture rates for rough-skin newts and red-legged frogs were higher in uncut red alder stands than in Douglas-fir (*Pseudotsuga menziesii*) stands sampled in other studies, an indication that, when red alder stands are converted to Douglas-fir, some alders should be left adjacent to streams to provide habitat for these species and other hardwood associates.

12. deMaynadier, P. G. and Hunter, M. L. Jr. Effects of silvicultural edges on the distribution and abundance of amphibians in Maine. Cons. Biol. 1998; 12(2):340-352.

Amphibians share several biological characteristics that may cause them to be sensitive to abrupt transitions in microhabitat and microclimate that occur across forest edges. To better understand the importance of edge effects on amphibians in a forested landscape we sampled the distribution of populations along drift fences placed perpendicular to silvicultural edges of varying contrast in central Maine. Within the community of amphibians sampled (14 species), salamanders generally were more sensitive to even-aged harvesting and associated edge effects than were anurans, but forest habitat generalists and specialists were identified within both groups. We conservatively estimated the depth of edge effects at 25-35 m for a subset of management-sensitive species (Plethodon cinereus, Ambystoma maculatum, A. laterale, and Rana sylvatica). An index of edge

contrast, calculated using ambient light penetration levels, was valuable in predicting the magnitude of edge effects among sites that included silvicultural edges of different age and origin (old field plantations versus recent clearcuts). Some structural microhabitat variables relevant to forest management were identified as potentially limiting to amphibians near forest edges, including canopy cover, litter cover, and a measure of stumps, snags, and their root channels. Our observations are consistent with the results of other work on biotic edge effects in the eastern United States and suggest that impacts from intensive forest management practices extend beyond the boundaries of harvested stands.

13. Diemer, Joan E. The ecology and management of the gopher tortoise in the southeastern united states. Herpetologica. 1986; 42(1):125-133.
Recent research on the gopher tortoise (Gopherus polyphemus) has indicated its ecological importance, revealed reasons for its decline, and suggested management strategies. It is generally associated with the sandhill community but occurs in a variety of other natural and ruderal habitats. Limiting factors include well-drained sandy soil, adequate herbaceous food, and sunlit nesting sites. Tortoise densities and movements are related to herbaceous biomass. As the principal sandhill grazer, the gopher tortoise serves as a seed dispersal agent for native groundstory plants. The burrowing habits of the gopher tortoise return leached nutrients to the surface and the burrows provide refuges for many other species. Female gopher tortoises reach sexual maturity at 10-20 yr of age and produce a single annual clutch of about 6 eggs. Recruitment is reduced by heavy egg and hatchling predation. The major reasons for the decline of the gopher tortoise are habitat destruction, habitat degradation, and human predation. Recommended conservation measures include prescribed burning of sandhill habitat, establishment of preserves, protection from over-harvest, restocking, and public education.

14. Dodd Jr, C. Kenneth. Biological diversity of a temporary pond herpetofauna in north Florida sandhills. Biodiversity and Conservation. 1992; 1:125-142.
From 1985 through 1990, the herpetofauna of a temporary pond in an uplands longleaf pine sandhills community in north-central Florida was monitored. A drift fence completely encircled the pond. Animals were captured in pitfall traps and marked as they entered and exited the pond basin. I captured 16,155 individuals of 42 species (16 amphibians, 26 reptiles). The species richness, diversity (using Margalef's Diversity Index) and dominance (using the Berger-Parker Index) varied among years. Between 62.5% and 87.5% of the amphibian species and 65% to 81% of the reptile species were captured in any one year. Daily amphibian capture was positively correlated with rainfall, whereas reptile capture was either not correlated or weakly negatively correlated with rainfall. Hydroperiod duration was not correlated with the numbers of either amphibians or reptiles captured. Neither the amphibian nor the reptile community showed any trends in diversity or dominance indices during the course of the study, although both communities were dominated by a few species. However, the species responsible for community dominance changed somewhat as the study progressed. Assessing the results of this study is hampered by the lack of comparable studies elsewhere, expected natural fluctuations of amphibian populations, and a prolonged drought, especially during the latter stages of the study. The herpetological community at Breezeway Pond does not appear to follow theoretical predictions of community response to stress. Temporary ponds are important centers of herpetofaunal biodiversity in uplands sandills communities. Long-term studies are needed to monitor the composition, structure, and functional interactions of their resident species.

15. Driscoll, Don A. and Roberts, J. Dale. Impact of fuel-reduction burning on the frog *Geocrinia lutea* in southwest Western Australia. Aust. J. Ecol. 1997; 22:334-339.
The four frog species in the Geocrinia rosea complex occur in state forest in southwest Western Australia. Fire management of these forests involves fuel-reduction burning with an average rotation of five to nine years. In this study we examined the impact of fire on Geocrinia lutea by counting calling males in six pairs of burned and control sites from 1992 to 1994. The immediate impact of the fire on G. lutea adults, and the survival of G. lutea eggs and larvae after the fire, were also addressed. We found that fuel-reduction burning in spring was associated with a significant decline

in the number of calling males. The populations had not recovered two years after the fire. Up to 29% of the calling males may have been killed in the fire. Egg and larval survival was not significantly different between treatments. However, the treatments did differ in the cause of death, with higher in-situ egg death and lower predation at burned sites. The short-term impact of spring fuel-reduction burns may pose a serious threat of extinction for very small populations. The endangered species Geocrinia alba has many small, isolated populations and frequent fire may therefore be inimical to their survival. However, we do not know if there is a long-term effect. Populations may or may not have time to recover between fires.

16. Duck, T. A.; Esque, T. C., and Hughes, T. J. Fighting wildfire in Desert tortoise habitat: considerations for land managers. Fire effects on rare and endangered species and habitats conference; 1995; Coeur d'Alene, Idaho. 1997.
We describe our experience as biologists/resource advisors working with firefighting personnel to reduce the risk of impacts and disturbances to desert tortoises and their habitats. Pre-fire season planning is essential preparation for risk assessment and identifying sensitive areas of habitat between biologists/resource advisors and fire managers. Having resource advisors present at the onset of fire operations can prevent potentially destructive activities related to the logistics of having vehicles in habitat and providing for the needs of groups of fire suppression personnel. Rehabilitation of road heads in tortoise habitat is a useful means of deterring further long-term degradation of habitat in some cases. We provide two appendices for use in the field: 1) an outline of fire management activities to be used by fire managers, and 2) an outline of a shift briefing used to educate firefighters at the scene of a fire. These prescriptions for action and education were developed for use in the northeast Mojave Desert of Utah and Arizona. These procedures are not universal in application and should be tailored to local needs and consideration of other resource values than tortoises. THe Sonoran Desert of Arizona differs substantially in physiography, and plant species composition and fuel loads. THerefore, we should consider habitat characteristics and habitat use by tortoises in the Sonoran Desert of Arizona specifically to assess the possible effects of fire suppression activities and to minimize adverse impacts to desert tortoises and their habitats. This approach could be useful for protecting other sensitive species and habitats in a variety of areas.

17. Dupuis, Linda A. and Bunnell, Fred L. Effects of stand age, size, and juxtaposition on abundance of western red-back salamanders (*Plethodon vehiculum*) in coastal British Columbia. Northwest Sci. 1999; 73(1):27-33.
Terrestrial-breeding amphibians live at high densities, show strong site fidelity, and have relatively stable populations, long life spans, and high vulnerability to dehydration. These traits make them potentially useful indicators of effects of canopy removal during logging. We compared the relative abundance of western redback salamanders (*Plethodon vehiculum*) in old-growth and managed second-growth stands on Vancouver Island, and found significantly more individuals in old-growth stands. Salamanders were more abundant in larger stands of old growth, but showed no relationship with stand or patch size among mature second-growth stands. Managed stands contained more salamanders when old growth was adjacent. Juvenile:adult ratios within managed stands were significantly higher in stands not adjacent to old growth, suggesting poor survivorship to adulthood in younger stands.

18. Enge, Kevin M. and Marion, Wayne R. Effects of clearcutting and site preparation on herpetofauna of a north Florida Flatwoods. Forest Ecology and Management. 1986; 14:177-192.
Drift-fence sampling for 1 year yielded information on the effects of clearcutting and site-preparation intensity on flatwoods herpetofauna in northern Florida. Sampling occurred in a naturally regenerated 40-year-old slash pine forest and two adjacent 3-4-year old clearcuts subjected to different site treatments.
Four drift-fence arrays (16 fences) in the forest captured totals of 6266 amphibians (15 species) and 230 reptiles (21 species). From an equal number of arrays in both the minimum- and maximum-treatment clearcuts, amphibian captures totalled 592 (9 species) and 758 (11 species), respecively, and reptile captures totalled 196 (19 species) and 85 (14 species), respectively. Clearcutting and site-preparation treatments did not affect amphibian species richness, but reptile

species richness was lower in the maximum-treatment clearcut, due to the absence of some arboreal lizard and snake species. CLearcutting reduced amphibian abundance tenfold by affecting reproductive success. Reptile abundance was reduced by maximum site-preparation but not by minimum site-preparation. Arboreal lizard populations were severely reduced by clearcutting. Herpetofaunal biomass was not affected by clearcutting and site-preparation, but the biomass was apportioned differently among taxonomic groups. The minimum-treatment clearcut had higher snake biomass and lower anuran biomass than the other two sites, whereas the maximum-treatment clearcut had lower lizard biomass than the other two sites.
Reptile communities in flatwoods would be favored by site-preparation practices that minimized site disturbances and maximized presence of logging debris. Responses of amphibian communities seemed to be dependent upon availability of water. Overall herpetofaunal diversity would be greatest in an area containing a mosaic of small clearcuts, cypress domes, and different-aged pine stands.

19. Ernst, C. H.; Boucher, T. P.; Sekscienski, S. W., and Wilgenbusch, J. C. Fire ecology and the Florida box turtle, *Terrapene carolina bauri*. Herpetol. Rev. 1995; 26(4):185-187.
Note: Research Note.
The Florida box turtle, *Terrapene carolina bauri*, ranges over most of central and eastern peninsular Florida and the Keys. Over the range of *T. c. bauri*, the pine flatwoods habitat with which it is best associated is subject to periodic burning. The authors look at the extent to which the Florida box turtle is adversely affected by such events by examining a series of *T. c. bauri* in the collections of the United States National Museum of Natural History, Smithsonian Institution, and George Mason University. Their observations indicate that fire may play a critical role in the ecology of Florida box turtle populations. Unfortunately, so little has been published on the life history of this animal that it is difficult to assess its ecological and behavioral requirements with any degree of certainty. (extracted from paper by SWS).

20. Erwin, William J. and Richard H. Stasiak. Vertebrate mortality during the burning of a reestablished prairie in Nebraska. American Midland Naturalist. 1979; 101(1):247-249.
Evidence of direct mortality to vertebrates was gathered following controlled spring burns in a reestablished prairie in eastern Nebraska. During 3 years (1974-1976) in which observations were made, several species were killed by fires, including: cottontail rabbits (*Sylvilagus floridanus*), western harvest mice (*Reithrodontomys megalotis*), voles (*Microtus pennsylvanicus* and *M. ochrogaster*), bull snakes (*Pituophis melanoleucas*), plains garter snakes (*Thamnophis radix*) and red-sided garter snakes (*T. sirtalis*). Young harvest mice pups were partially susceptible to spring prairie fires; morrtality to these on a 22.8-ha section burned 26 April 1976 was estimated at between 208 and 522 individuals. Many eggs of ground-nesting birds were destroyed by the fires; species included were ring-necked pheasant (*Phasianus colchicus*), bobwhite quail (*Colinus virginianus*), mallard duck (*Anas platyrhynchus*) and meadowlark (*Sturnella neglecta*).

21. Fair, W. Scott and Scott E. Henke. Effects of habitat manipulations on Texas harned lizards and their prey. Journal of Wildlife Management. 1997; 61(4):1366-1370.
The effects of habitat manipulations on Texas horned lizards (Phyrnosoma cornutum) and their main prey, harvester ants (Pogonomyrmex spp.) were studied in South Texas. The relative abundance of lizards, their scat, and active harvester ant mounds was assessed on 1-ha plots that were manipulated with either prescribed burning, disking, burning and disking combination, grazing, or land in the Conservation Reserve Program (CRP). We determined differential habitat use or avoidance using Chi-square analysis and Bonferroni Z-statistics to control the experiment-wise error probability at 10%. Lizards used burned plots disproportionately more, were neutral in their use of the disked and grazed plots, and under-utilized the burned and disked combination and CRP plots. Analysis of scat led to similar conclusions in relation to burned, grazed, and CRP plots, but scats were distributed on combination plots pro rata to availability and were underrepresented on the disked plots. No difference was detected in the relative abundance of active ant mounds among the 5 land management practices. Even though Texas horned lizards preferentially used areas that were

recently burned, the process of burning may harm them due to the shallow depths in which they hibernate.

22. Ford, William M.; Menzel, Alex M.; McGill, David W.; Laerm, Joshua, and McCay, Timothy S. Effects of a community restoration fire on small mammals and herpetofauna in the southern Appalachians. Forest Ecology and Management. 1999; 114:233-243.
As part of the Wine Spring Creek ecosystem management project on the Natahala National forest, North Carolina, we assessed the effects of a community restoration fire on small mammals and herpetofauna in the upper slope pitch pine (Pinus rigida) stands, neighboring mid-slope oak (Quercus spp.) stands and rhododendron (Rhododendron maximum) dominated riparian areas during 1995 and 1996. Using drift-fence arrays with pitfalls and snap-trapping, we collected these small mammals: masked shrew (Sorex cinereus), smoky shrew (S. fumeus), water shrew (S. palustris), pygmy shrew (S. hoyi), northern short-tailed shrew (Blarina brevicauda), deer mouse (peromyscus maniculatus), white-footed mouse (P. leucopus), golden mouse (Ochrotomys nuttalli), southern red-backed vole (Clethrionomys gapperi), pine vole (Microtus pinetorum) and woodland jumping mouse (Napaeozapus insignis). Herpetofauna collected fom drift-fence arrays and time-constrained searches included: eastern newt (Notophtalmus viridescens), seepage salamander (Desmognathus aeneus), mountain dusky salamander (D. ochrophaeus), Blue Ridge two-lined salamander (Eurycea wilderae), spring salamander (Gyrinophilus porphyriticus), Jordan's salamander (Plethodon jordani), wood frog (Rana sylvatica), five-lined skink (Eumeces fasciatus), eastern garter snake (Thamnophis sirtalis), and northern ringneck snake (Diadophis punctatus). Prior to the prescribed community restoration fire in the spring of 1995, there were no significant differences in small mammal or herpetofauna collections between burned and control areas. Slope position accounted for more variation among the species of greatest abundance than did burning. Concern for the effects of prescribed fire as a management tool on small mammals and herpetofauna in the southern Appalachians seems unwarranted.

23. Friend, Gordon R. Impact of fire on small vertebrates in Mallee woodlands and heathlands of temperate Australia: A review. Biological Conservation. 1993; 65:99-114.
The short- and long-term post-fire response patterns of small mammals, reptiles and amphibians inhabiting mallee woodlands and heathlands in temperate Australia are reviewed with respect to species' life history parameters in a search for unifying trends. Pyric response patterns of small mammal species are closely tied to their shelter, food and breeding requirements. There is a trend of increased specificity and reduced flexibility in life history traits concomitant with increased impact of fire and later post-fire recolonization. For reptiles there appears to be a strong relationship between the shelter and foraging requirements of species and their abundance in various successional states. The high incidence of burrowing in mallee/heath amphibian fauna imparts considerable resilience to fire, and most species' abundance and distribution patterns seem more closely related to moisture regimes than to fire perse.
The high degree of consistency between species' post-fire response patterns and their life history parameters points to the feasibility of developing a model to predict the impact of fire on small vertebrates. Such a model is currently being developed.

24. Gamradt, Seth C. and Kats, Lee B. Impact of chaparral wildfire-induced sedimentation on oviposition of stream-breeding California newts (Taricha torosa). Oecologia. 1997; 110:546-549.
We examined the effects of chaparral wildfire on stream-breeding California newts (Taricha torosa) in a 750-m stretch of a perennial Santa Monica Mountain stream (Los Angeles County). Detailed field surveys of 1992 and 1993 established the composition (run, riffle, pool) of this habitat and determined oviposition sites of newts. We also quantified California newt egg mass density and estimated density of newt adults. A chaparral wildfire burned the entire study site on 2 November 1993. Using the same methods, we collected field survey data in 1994 and 1996. Erosion following the 1993 wildfire produced major changes in stream morphology and composition. Pools and runs represented approximately 40-50% of pre-fire stream area. In the spring following the fire, the stream consisted of less than 20% run and pool. Pools that did remain were often smaller and shallower. The average density of adult California newts did not differ among years. The total

number of newt egg masses in the spring after the fire was approximately one-third of egg mass counts from pre-fire surveys. Most California newt egg masses were laid in pools and runs; California newts prefer deeper slow-moving water. We conclude that fire-induced landslides and siltation have eliminated pools and runs, thus reducing the amount of habitat suitable for oviposition. Habitat alterations caused by fire likely account for the observed reduction of egg masses at the stream.

25. Gibbs, James P. Distribution of woodland amphibians along a forest fragmentation gradient. Landscape Ecology. 1998; 13:263-268.
Understanding how changes in land-use affect the distribution and abundance of organisms is an increasingly important question in landscape ecology. Amphibians may be especially prone to local extinction resulting from human-caused transformation and fragmentation of their habitats owing to the spatially and temporally dynamic nature of their populations. In this study, distributions of five species of woodland amphibians with differing life histories were surveyed along a 10 km, spatially continuous gradient of forest fragmentation in southern Connecticut, U.S.A. Redback salamanders (Plethodon cinereus) and northern spring peepers (Pseudacris c. crucifer) occupied available habitat along the gradient's length. Wood frogs (Rana sylvatica) and spotted salamanders (Ambystoma maculatum) were absent from portions of the gradient where forest cover was reduced to below about 30%. Red-spotted newts (Notophthalmus v. viridescens) did not persist below a forest cover threshold of about 50%. Correlations between species' biological traits and their fragmentation tolerance imply that low density, population variability, and high mobility coupled with restricted habitat needs predispose woodland amphibians to local extinction caused by habitat fragmentation. These patterns are in contrast to the widely held notion that populations of the best dispersers are those most tolerant of habitat fragmentation.

26. Greenberg, Cathryn H.; Neary, Daniel G., and Harris, Larry D. Effect of high-intensity wildfire and silvicultural treatments on reptile communities in sand-pine scrub. Conservation Biology. 1994; 8(4):1047-1057.
We tested whether the herpetofaunal response to clearcutting followed by site preparation was similar to high-intensity wildfire followed by salvage-logging in sand-pine scrub. Herpetofaunal communities were compared in three replicated 5- to 7-year post-disturbance treatments and mature sand-pine forest. The three disturbance treatments were (1) high-intensity wildfire, salvage-logging, and natural regeneration; (2) clearcutting, roller-chopping, and broadcast-seeding; and (3) clearcutting and bracke-seeding. Animals were trapped over a 14-month period using pitfall traps with drift-fences. Micro-habitat features were measured along line transects. Because amphibian (frog) occurrence appeared to be unaffected by treatment, this paper focuses only on reptile communities. Six species of lizards and one snake species were numerically dominant. Reptile species richness, diversity, and evenness did not differ among treatments or mature forest. Species composition differed markedly, however, between mature forest and disturbance treatments. Typical open scrub species such as *Cnemidophorus sexlineaus*, *Sceloporus woodi*, and *Eumeces egregius*, were dominant in high-intensity burn, roller-chopped, and bracke-seeded stands but scarce in mature forests, and they were positively correlated with bare sand and other micro-habitat features typical of open scrub. Conversely, *Eumeces inexpectatus* was most abundant in mature forests and was correlated with ground litter and other features typical of mature forest. With respect to the species sampled, especially the lizards (including endemic species) of open scrub, clearcutting appeared to mimmic high-intensity wildfire followed by salvage-logging by creating microhabitat features such as bare sand. In a mirror image of the usual concept, forest maturation historically served as the fragmenting agent of an extensive open-scrub landscape matrix that was maintained by high-intensity wildfire. Hence, the patchwork of age classes created by current clearcutting patterns could serve as a barrier to lizard dispersal and impede meta-population dynamics. The absence of a true control (unsalvaged burns) suggests caution in interpreting the results of this study.

27. Grialou, Julie A. and West, Stephen D. Wilkins R. Neal. The effects of forest clearcut harvesting and thinning on terrestrial salamanders. J. Wildl. Manage. 2000; 64(1):105-113.
We studied short-term effects of forest clearcut harvesting and thinning on species presence,

abundance, and demographics of terrestrial salamanders in an area intensively managed for forest products in southwestern Washington. We used pitfall traps to sample 4 previously harvested 45-60-year-old forested areas and 4 adjacent areas clearcut 2-5 years previously. In a separate experiment, we conducted surveys before and after thinning on 4 control and 4 treatment sites. Western red-backed salamanders (Plethodon vehiculum), ensatinas (ensatina eschscholtzii), northwestern salamanders (Ambystoma gracile), rough-skinned newts (Taricha granulosa), and Dunn's salamander (Plethodon dunni) were captured in both forested and clearcut areas. Columbia torrent salamanders (Rhyacotriton kezeri) and Pacific giant salamanders (Dicamptodon tenebrosus) were captured only in forested areas. Capture rates of red-backed salamanders were greater in forested than clearcut areas in fall 1994 and 1995. The size-class distribution of red-backed salamanders was skewed towards the smaller size classes in clearcut areas in fall 1994 but not 1995. Ensatina showed no difference in capture rate or size-class distribution between forested and clearcut areas in fall 1994, but showed a reduced rate of capture in clearcut areas relative to forested areas in fall 1995. Gravid females were present in both clearcut and forested areas for western red-backed salamanders and ensatinas. Although species presence was unaffected by thinning, western red-backed salamander capture rates on treatment sites were reduced after thinning. Population responses of salamander species to forest management are variable, with some species declining in abundance after clearcutting and thinning.

28. Griffiths, A. D. and K. A. Christian. The effects of fire on the frillneck lizard (Chlamydosarus kingii) in northern Australia. Australian Journal of Ecology. 1996; 21:386-398.
A population of frillneck lizards, *Chlamydosarus kingii*, was monitored by radio telemetry and mark-recapture techniques between April 1991 and April 1994, as part of a landscape-scale fire experiment, in Kakadu National Park, Northern Territory. The study aimed to investigate both the short- and longer-term effects of fire on a lizard species in a tropical savanna where fires are frequent and often annual. Frillneck lizards are able to survive fires that occur in the first few months of the dry season by remaining perched in trees. A high level of mortality (29%) occurred during late dry-season fires, along with changes in their behavioural response to fire; sheltering in either larger trees or hollow termite mounds. Food is more accessible after fires due to the removal of ground vegetation. This is reflected in greater volume and diversity of prey in stomach contents after fires. This increase is more pronounced after late dry-season fires, possibly due to increased accessibility of prey caused by more complete vegetation removal. Frillneck lizards show an overall preference for trees with a dense canopy cover located in an area with a low density of grass. Fire has an effect on this relationship. Frillneck lizards in habitat unburnt for a number of years tend to perch in trees with a smaller canopy. Volume and composition of lizard stomach contents was broadly similar among fire treatments over a 2-year period, although termites were more predominant in stomach contents of lizards in unburnt habitat. Wet-season body condition is lower in lizards from unburnt habitat, although the reason for this is unclear. These results demonstrate the importance of different fire intensities and regimes on the ecology of a lizard species in a tropical savanna.

29. Grover, Mark C. Influence of cover and moisture on abundances of the terrestrial salamanders *Plethodon cinereus* and *Plethodon glutinosus*. J. Herpetol. 1998; 32(4):489-497.
I evaluated how the abundances of two species of forest-dwelling plethodontid salamanders, *Plethodon cinereus* and *P. glutinosus*, are related to moisture level and availability of cover by manipulating moisture levels and cover object density on experimental plots. I also investigated how cover and moisture influence the physical condition and activity level of the most common of the two species, *P. cinereus*. The experiment was a 2 x 2 factorial design in which plots had either low or high densities of cover objects (rocks, logs, and coarse woody debris) and were either watered by sprinklers two to three times weekly or received no supplemental watering. Nocturnal searches of the plots revealed that watering increased the abundance of juvenile *P. cinereus*, and increased the activity levels of both juveniles and adults. Increased densities of cover objects resulted in increased abundance of both adult and juvenile *P. cinereus*. *Plethodon glutinosus* was more abundant on watered plots and on plots with high densities of cover objects than on unwatered plots and plots with low densities of cover objects. The *P. cinereus* on plots with high densities of

cover objects were of higher mass, adjusted for body length and tail length, than conspecifics on plots with low densities of cover objects. This suggests that the foraging success of terrestrial salamanders is dependent on cover object availability. The findings of this study indicate that moisture levels and cover object availability are both significant factors in regulating abundances of terrestrial salamanders, but that different species and different age-classes of the same species can vary in their responses to these factors.

30. Hanlin, Hugh G.; Martin, F. Douglas; Wike, Lynn D., and Bennett, Steven H. Terrestrial activity, abundance and species richness of amphibians in managed forests in South Carolina. Am. Midl. Nat. 2000; 143:70-83.
We determined the relative abundance, days of surface activity and indices of species diversity, evenness and richness for amphibians inhabiting three differently managed forests surrounding a Carolina Bay in South Carolina following restoration. We collected animals daily for 3 y (Oct. 1993-Sept. 1996) using drift fences with pitfall traps in three forest types: loblolly pine (Pinus taeda), slash pine (P. elliotti) and mixed hardwoods (predominantly oak, Quercus spp. and Hickory, Carya spp.). Captured animals were marked and recaptures were recorded but not included in statistical analyses, except in our evaluation of activity. We compared results to those of a more limited study conducted before restoration.
Amphibians were significantly more numerous and more active in the mixed hardwood forest than in the pine forest types. However, the hardwood forest had the lowest species diversity in 2 of the 3 y of the study. The slash pine habitat had the highest diversity in all 3 y and for the 3 y combined. Because the evenness index (J') values differ in step with the species diversity index (H') it appears that the evenness component of diversity, rather than the richness component, is what is determining H' variation. A summer subset of these data and summer data from an earlier study of 1977-1978 is in marked contrast with yearlong patterns. For our summer data each forest type had the highest H' value in one of the years of the study and again the J' values parallel the differences in H'.
Large numbers of southern toads (*Bufo terrestris*) reduced evenness, and therefore species diversity, for all three habitats particularly the mixed hardwoods where this species was especially abundant. Proportionally lower numbers of *B. terrestris* in the summer samples increased J' and H' indices. Overall lower abundance and H' values in the summer of 1994-1996 compared with 1977-1978 may be the result of habitat alteration during the restoration of the Carolina bay.

31. Hardy, Donna FitzRoy. Ecology and behavior of the six-lined Racerunner, *Cnemidophorous sexlineatus*. The University of Kansas Science Bulletin. 1962; 43(1):3-73.
A field and laboratory study of the six-lined racerunner, Cnemidophorus sexlineatus, was conducted in 1958. The purpose of the study was the further understanding of the role of behavior in the ecological relationships of this lizard. Food habits were studied, and it was found that choice of prey items varied with the availability of prey, sex and reproductive condition of adults, size of lizard, and between adults and young. Social behavior and dominance heirarchy where exhibited by the lizards; and behavioral releasers are the means by which individuals determine social status. Sequences of behavior are dependent upon attaining bodily temperatures within a "thermal activity-range", the highest temperature of which is the maximum temperature voluntarily tolerated by the individual, and the minimum temperature is the temperature threshold for basking. Fluctuation in daily and seasonal activity is correlated with the amount of bodily fat stored by the lizards and their temperature relationships. The behavioral responses of lizards to the thermal characteristics of their environment are discussed in detail.

32. Harper, Craig A. and Guynn, Jr. David C. Factors affecting salamander density and distribution within four forest types in the southern Appalachian Mountains. Forest Ecology and Management. 1999; 114:245-252.
We used a terrestrial vacuum to sample known area plots in order to obtain density estimates of salamanders and their primary prey, invertebrates of the forest floor. We sampled leaf litter and measured various vegetative and topographic parameters within four forest types (oak-pine, oak-hickory, mixed mesophytic and northern hardwoods) and three age classes (0-12, 13-39, and >40 years) over two field seasons within the Wine Spring Creek Ecosystem Management area in

western North Carolina. We found salamanders preferred moist microsites across all forest types with the highest salamander densities occurring on sites with a northern and/or eastern exposure and within northern hardwood forests. Salamander densities were lowest on 0-12 year plots, yet were equal on 13-39 and >40 year plots, suggesting a much quicker recovery from the impact of clearcutting than reported by previous researchers. Overall invertebrate densities did not influence salamander density or distribution although, plots in which salamanders were captured, harbored significantly higher numbers of snails than plots in which salamanders were not captured. We discuss the importance of calcium to salamanders and snails as a possible source thereof.

33. Harpole, Douglas N. and Haas, Carola A. Effects of seven silvicultural treatments on terrestrial salamanders. For. Ecol. Manage. 1999; 114(2-3):349-356.
We compared the relative abundance of terrestrial salamanders before and after application of seven regeneration treatments in a low-elevation, southern Appalachian hardwood forest in southwest Virginia. Treatments included understory removal, group selection, two shelterwoods, leave-tree, clearcut, and a control. Salamander relative abundance was significantly lower after harvest on the group selection ($p=0.005$), shelterwoods ($p=0.007$ and $p=0.015$), leave-tree ($p=0.001$), and clearcut treatments ($p=0.001$). There was no significant difference in relative abundance during the same period on the control ($p=0.788$) or understory removal ($p=0.862$) treatments.

34. Herbeck, Laura A. and Larsen, David R. Plethodontid salamander response to silvicultural practices in Missouri Ozark forests. Conservation Biology. 1999; 13(3):623-632.
There is little information on the effects of tree harvest on salamander populations in the midwestern United States. We present data on plethodontid salamander densities in replicated stands of three forest age classes in the southeastern Ozarks of Missouri. Forest age classes consisted of regeneration-cut sites <5 years old, second-growth sites 70-80 years old, and old-growth sites >120 years old. Salamander abundance on 21, 144-m^2 plots was determined by area- and time-constrained searches. We also compared age-class habitat characteristics, including downed woody debris, canopy cover, ground area cover, herbaceous vegetation, and woody vegetation. Salamander density was lowest in newly regenerated forests and highest in forests >120 years old. Comparisons of recently regenerated forests with mature forests >70 years old indicated that terrestrial salamanders were reduced to very low numbers when mature forests had been intensively harvested. This reduction may result from a decrease in microhabitat availability. Forest age-class comparisons further indicated that salamander abundance slowly increased over time after forests had regenerated. Management decisions that take into account plethodontid salamander abundance and their response to forest structural diversity are important components in sustaining ecosystem integrity while maximizing economic yield.

35. Howard, W. E.; R. L. Fenner, and H. E. Childs, jr. Wildlife survival in brush burns. J. Range Manage. 1959; 12:230-234.
Information on wildlife survival of prescribed (controlled) brushland fires was obtained by three methods: (1) 37 rodents and snakes in cages with temperature recording devices were placed in different habitat situations, and the area was control burned; (2) the number of birds and mammals drinking from a spring was counted both before and after the area was burned; and (3) the behavior of wild animals was observed from an observation point within the fire.
The cage temperature lethal to rodents was somewhere between 138° and 145° F. Results indicate that there was little chance of wild vertebrate animals getting caught in a situation that would lead to their death during such fires. Most species of vertebrates benefit from control burns, because the habitat then becomes more favorable.

36. Jensen, J. B. Distribution of the Pine Barrens treefrog, *Hyla andersonii*, in Conecuh National Forest, Alabama. Journal of the Alabama Academy of Science. 1992; 63(2):59.
Previous to this study, the Pine Barrens treefrog, *Hyla andersonii*, was known to occur at ten localities within Conecuh National Forest. During this study, the status of this frog species in the Forest was assessed from June through September 1991. Location of the frogs was accomplished by searching for suitable habitats by day, revisiting the sites at night, and listening for the distinct call of

males or eliciting them to call by vocally imitating their call. Thirteen new localities were discovered and six previous localities maintained calling males. At four previously known localities males were never heard, indicating that they no longer support *Hyla andersonii*. Lack of fire at these four localities is suspected to be the reason the frog populations have disappeared. (author's abstract).

37. Kahn, W. C. Observations on the Effect of a Burn on a Population of *Sceloporus occidentalis*. Ecology. 1960; 41:358-359.

38. Kerby, J. Lawrence and Kats, Lee B. Modified interactions between salamander life stages caused by wildfire-induced sedimentation. Ecology. 1998; 79(2):740-745.

    A 1993 wildfire and subsequent landslides modified many streams in the Santa Monica Mountains of southern California (USA). Prior to the fire at Cold Creek Canyon, adult California newts (*Taricha torosa*) frequently preyed on conspecific eggs and larvae. Post-fire landslides increased the number of stream pools containing terrestrial earthworms. Earthworms were more common in adult newt diets after the fire, and conspecifics were absent. More earthworms and fewer conspecifics were present in the stomachs of adult newts in streams at burned sites than at unburned sites. In laboratory experiments, newt larvae used refuges significantly less in the presence of combined chemical cues from both newt adults and earthworms as compared to adult-newt cues alone. These data suggest that cannibalism is reduced in the presence of increased alternative prey items and that larvae can detect this reduced predation risk.

39. Kirkland, Gordon L.; Snoddy, Heather W, and Amsler, Teresa L. Impact of fire on small mammals and amphibians in a central Appalachian deciduous forest. American Midland Naturalist. 1995; 135:253-260.
    The impact of fire on small mammals and amphibians was investigated in an Oak (Quercus spp.)-dominated forest in S-central Pennsylvania. Sampling with Y-shaped arrays of pitfalls and drift fences was conducted for 78 days between 31 March and 13 November 1992 following a fire in November 1991. Shrews, rodents and total small mammals were significantly less abundant in burned than in unburned forest: however, significant differences in habitats were recorded only for the first 3 sampling periods (April, June, July) for rodents and total small mammals. Eight species of small mammals were captured in unburned forest compared to six species in burned areas. The two species not taken in the burned forest were both arvicoline rodents, the meadow vole (microtus pennslvanicus) and southern red-backed vole (Clethrionomys gapperi). A significant corrrelation was found between the rank order of species of small mammals taken in burned and unburned habitats. The two most abundant species in both habitats were the white-footed mouse (Peromyscus leucopus) and Maryland shrew (Sorex fontinalis), which combined comprised 78.1% of the small mammals taken in the unburned forest and 72.4% of the sample from the burned site. In contrast to small mammals, significantly more amphibians were captured in the burned forest. The American toad (Bufo americanus) was the most abundant amphibian, comprising 70.8% of the amphibians captured: this species was largely responsible for the greater numbers of amphibians captured in the burned forest.

40. Kramp, Betty A.; Patton, David R., and Brady, Ward W. The effects of fire on wildlife habitat and species. USDA Forest Service, Southwest Region, Wildlife Unit Tech. Rept. 1983:29.
    The objective of this report is to organize literature on the effects of fire on wildlife into a publication for resource managers, particularly in the Southwest. Fire effects on wildlife habitat, wildlife fire response classifications, and detailed fire effects for classes and species of vertebrates are given.

41. Lawrence, George E. Ecology of vertebrate animals in relation to Chaparral fire in the Sierra Nevada foothills. Ecology. 1966; 47(2):278-291.
    Chaparrel fire brings decided changes in the species composition and density of both plant and

animal populations in the Sierra Nevada foothills. Some species decrease whereas others increase following a burn, but no species is totally eliminated, nor is there any apparent diminution of total life on a burn after plant growth resumes.
These conclusions were reached in the course of a 4-year study of adjoining burned and unburned areas near Glennville, Kern County, California. Field work began in 1953 at which time study plots were selected and plant and vertebrate population were censused. A year later part of the study area was burned, and ensuing investigation compared populations on the burned and check areas for a period of 3 years, terminating in 1957.
At the time of the fire, temperatures were recorded in the sites both above and below ground, and the actions of animals were observed. There was very little evidence of direct mortality among any of the vertebrates, most of them escaping the heat in one way or another. The woodrat was perhaps the most vulnerable species because of its dependence on houses made of dry twigs. However, in the bare ash after the fire many species were severely exposed to predation, and populations of most small mammals and some brush-dwelling birds decreased rapidly. Predatory birds and mammals increased, as did some seed-eating birds that found good foraging on the exposed earth.
When the rains stimulated new plant growth, a very different habitat developed in the area of burned chaparrel. Most of the original trees sustained little damage, although the pitchy digger pines were largely eliminated. However, the extensive brush stands were reduced by almost 90%, and there was a corresponding increase in the invading grasses and forbs.
Birds and mammals that normally exhibit a strong preference for chaparrel habitat were sustantially reduced in numbers in the years following the burn. Conversely, some of the birds that normally prefer grassland or oak woodland increased in number. The fire resulted in an overall increase in densities of nesting birds. None of the small mammals increased in numbers but some of the larger predators, such as coyote and badger, moved into the burn during the months following the fire.

42. Lillywhite, H. B.; Friedman, G., and Ford, N. Color Matching and Perch Selection by Lizards in Recently Burned Chaparral. Copeia. 1977; 1977:115-121.
The preference of *Sceloporus occidentalis* for perching on dark or light colored branches was studied in the field and in the laboratory. Lizards perched preferentially on dark branches and tended to avoid those which were light in color. In southern California chaparral active *S. occidentalis* perch selectively on blackened stalks of burned shrubs for at least several years following a fire. The lizards are cryptically colored on the black stalks and match reflectance within a few percent over the visible spectrum. However, as the char on the outer surfaces of the stalks wears off, the lizards are no longer color-matched, are seen less frequently on the stalks, and appear to center activities on rock outcrops. The association and color match between lizards and shrubs coincides with postfire conditions of reduced cover and increased predator abundance.

43. Lillywhite, H. B. and North, F. Perching Behavior of *Sceloporus occidentalis* in Recently Burned Chaparral. Copeia. 1974; 1974:256-257.
Herpetological Notes.

44. Lillywhite, Harvey B. Effects of Chaparral Conversion on Small Vertebrates in Southern California. Biological Conservation. 1977; 11:171-184.
Lizard and small mammals faunas were sampled on eight sites of chaparral and artificial chaparral-grass conversions in southern California. The abundance and diversity of these faunas were characteristically greater in chaparral than in areas of grass. The deer mouse *(Peromyscus maniculatus)* was the only animal studied was abundant on both chaparral and grass sites. In early stages of chaparral-grass conversion, mechanical brush clearing (bulldozing, discing) appeared to cause greater initial reductions in small vertebrate populations than did the use of selective herbicides (primarily 2, 4-D). Both lizards and small mammals were virtually absent from grass that was heavily grazed. Lizards reached peak abundance in recently burned (relatively open) chaparral.

45. Lips, K. R. Vertebrates associated with tortoise (*Gopherus polyphemus*) burrows in four habitats in south-central Florida. Journal of Herpetology. 1991; 25(4):477-481.
Note: Research Note.

The author examined the role of habitat, size, status of the burrow, and season on species composition and abundance of vertebrates associated with gopher tortoise (*Gopherus polyphemus*) burrows. The study was conducted from September 1987 through June 1988 at the Archbold Biological Station (ABS) in Highlands County, Florida. Observations were made in four habitats: sand pine scrub (SPS); slash pine-turkey oak (TO); and scrubby flatwoods, both burned (SFB) and unburned (SFU) areas. A total of 319 individuals of 16 vertebrate species was trapped from burrows in the four habitats. Species richness ranged from 5 (SFU) to 12 (SFB), whereas total number of captures ranged from 37 (SFU) to 139 (TO). Values of evenness ranged from 0.441 (TO) to 0.848 (SFB), and Simpson diversity indices ranged from 0.390 (SFU) to 0.915 (SFB). The diversity (H') for the burned scrubby flatwoods was significantly different from that of the turkey oak ($t = 6.98$, $df = 129$, $P < 0.0005$), sand pine scrub ($t = 5.93$, $df = 141$; $P < 0.0005$), and unburned scrubby flatwoods ($t = 5.96$, $df = 68$; $P < 0.0005$). Habitat, status, and season all had significant effects on the mean number of individuals captured per burrow, whereas size of the burrow did not have a significant effect. Habitat types had the greatest influence on the number of individuals captured from burrows, and had a significant effect on the diversity of species captured. TO had the greatest mean number of individuals captured, followed by SPS, SFB, and SFU. (extracted from paper by DJM).

46. Lunney, Daniel; Peggy Eby, and Michael O'Connell. Effects of logging, fire and drought on three species of lizards in Mumbulla State Forest on the south coast of New South Whales. Australian Journal of Ecology. 1991; 16:33-46.
The effects of logging on three species of common skinks were estimated from censuses in four age classes of forest: unlogged, just logged, 1-year logged and 10-15 year regrowth. The effects of topography (ridge and gully) were examined in each age class. A fire in November 1980 occurred just after the initial census was completed. ANother census was taken in December 1980 to assess its immediate effects. Further censuses were carried out each December from 1981 to 1984. An intense drought overlapped from 1980 to 1983 with the census period. Lampropholis guichenoti occurred in about equal numbers in unlogged and recently logged forests, but its numbers were reduced in the 10-15 year regrowth forest. This was attributed to changes in the amount and pattern of sunlight reaching the ground. A similar pattern of response was found for Lampropholis delicata. The numbers of Eulamprus heatwolei, a gully species requiring partial shade, were lowest in the exposed, recently logged forest, but had increased in the 10-15 year regrowth class to about equal their numbers in unlogged forest. Fire reduced the numbers of L. guichenoti on ridges but had no immediate impact on numbers of the other species, while drought markedly depressed numbers of all species. Lampropholis guichenoti recovered more quickly from the drought than did L. delicata, but the numbers of E. heatwolei were still declining 19 months after the drought broke. The drought also revealed a habitat (ridge/gully) difference between the two Lampropholis species. The management of these species in commercial forests requires that some areas, particularly gullies, be reserved and the logging sequence modified to prevent the creation of widespread stands of uniform regrowth.

47. McCoy, E. D. and Mushinsky, H. R. Effects of fragmentation on the richness of vertebrates in the Florida scrub habitat. Ecology. 1994; 75(2):446-457.
Structures of habitat fragments interact with autecologies of resident species to produce patterns in taxonomic richness. Understanding this interaction is crucial to habitat conservation. We studied the vertebrates inhabiting fragments of the severely threatened sand pine scrub habitat of interior peninsular Florida. We surveyed 16 scrubs in south-central Florida that were categorized as either "large," "medium," or "small." For each scrub, we determined (1) vegetational structure, (2) vegetational composition, (3) distance to the nearest scrub, (4) distance to the nearest larger scrub, (5) presence/absence of potential "corridor" habitats between scrubs, (6) types of habitats between scrubs, (7) distance to the nearest permanent water, (8) percent coverage of surrounding habitats, and (9) area reduction over time. The principal methods used to census nonavian taxa were pitfall and double-ended funnel traps, while the principal method for avian taxa was transect surveys. Many of the nine scrub attributes were intercorrelated. Scrub size was the only attribute that correlated strongly with vertebrate richness. Distance, both to permanent water and to the nearest

scrub, correlated strongly with nonavian richness after the influence of size was removed, however. We detected significant nestedness, but when the taxon-area relationship was taken into consideration, we could not demonstrate that any taxa were excluded from small scrubs. We constructed joint lists of taxa from various hypothetical "archipelagos" of the 16 individual scrubs, and found that the archipelagos often supported more taxa than large individual scrubs. We found no tendency for small scrubs to be depauperate, in general, and no matter how rare taxa were identified, they were more common than expected in medium and small scrubs, and less common than expected in large scrubs. The mere observation of either a taxon-area relationship or a nested taxonomic composition reveals little about underlying ecological processes. Our detailed analysis leads us to conclude that no evidence indicates the need for single large scrub reserves for resident vertebrates: an archipelago of individually smaller reserves could support at least as many taxa. This conclusion is based solely on the simple presence-absence of taxa in scrubs that were treated as replicates within size categories, however, and consideration of the abundances and distributions of individual taxa, and of the variation among scrubs of similar size, may lead to a different conclusion.

48. McLeod, Roderick F. and Gates, J. Edward. Response of Herpetofaunal Communities to Forest Cutting and Burning at Chesapeake Farms, Maryland. American Midland Naturalist. 1997; 139:164-177.
The distribution and abundance of amphibians and reptiles in forest stands subjected to salvage cutting and prescribed burning were compared with their unmanaged counterparts. The study was conducted on the Atlantic coastal plain at Chesapeake Farms near Chestertown, Maryland. Three herpetofaunal trapping arrays were systematically located in each of four forest stand types: hardwood (Hardwood), cut-over hardwood (Cut), mixed pine-hardwood (Pine) and prescribed burn pine (Burn). A total of 3931 individuals representing 29 species were captured in 30,540 trap nights during the spring and summer 1992 and 1993. Felling of hardwoods and prescribed burning of pine resulted in similar responses from the herpetological communities; Hardwood had the most distinctive herpetofaunal community of the four stands. Adults and young-of-the-year (YOY) of six amphibian species were significantly more abundant in Hardwood than Cut. Only one amphibian species, Pseudacris triseriata, was less abundant in Hardwood than Cut. Total ranid captures did not differ between Hardwood and Cut. Snake and total reptile captures, and *Elaphe obsoleta* and *Eumeces faciatus* abundances were significantly less in Hardwood than Cut. Hardwood also had fewer small mammals than Cut, particularly *Microtus pennsylvanicus* and *Zapus hudsonius*, that might serve as large prey for snakes. Adults of four amphibian species, YOY of five amphibian species, and three reptile species (*Carphophis amoenus*, *Storeria dekayi*, and *Thamnophis sirtalis*) were significantly more abundant in Pine than Burn; two reptile species (*Coluber constrictor* and *Lampropeltis getula*) were significantly less abundant. Potential small mammal prey of the latter two snakes were not significantly different between Pine and Burn; however, *Zapus hudsonius* was less abundant in Pine than Burn. More amphibians were captured in Hardwood and Pine stands than in their respective logged and burned counterparts. The trend for reptiles tended to depend on the mix of species present and their habitat preferences. Greater canopy cover and depth of leaf litter in Hardwood and Pine stands likely had a moderating effect on temperature and helped to maintain a moist microenvironment for mesophilic species. Disturbance of a small patch of forest could locally decrease herpetofaunal diversity, but diversity on a much larger scale would likely increase.

49. Means, Bruce D.; Palis, John G., and Baggett, Mary. Effects of slash pine silviculture on a Florida population of flatwoods salamanders. Conservation Biology. 1996; 10(2):426-437.
The largest known breeding migration of the flatwoods salamander (Ambystoma cingulatum) was monitored over a 22-year period following its discovery in 1970 in Liberty County, Florida (USA). Nightly migrations of 200-30 adults across a 4.3-km stretch of paved highway in 1970-1972 had dwindled to less than one individual per night in 1990-1992; the decline apparently was already underway in the 1980s. We discuss possible natural and anthropogenic causes of the decline. The silvicultural practice of converting native longleaf pine savanna to bedded slash pine plantation, implemented on our study site about 1968, may have interfered with migration, successful hatching, larval life, feeding, and finding suitable cover post-metamorphosis. Longleaf pine-wiregrass flatwoods inhabited by adults have been drastically reduced and severely degraded throughout the coastal plain and may explain why the species is rare and deserving of threatened status.

50. Milstead, William W. Observations on the natural history of four species of whiptail lizard, *Cnemidophorus* (Sauria, Teiidae) in Trans-Pecos Texas. Southwest. Nat. 1957; 2(2-3):105-121.
During the summers of 1951 and 1952, observations were made of the activities of four species of Cnemidophorous (*perplexus*, *sacki*, *tessellatus*, *tigris*) at three stations in Brewster and Presidio counties, Texas. The activities reported upon include foraging habits, responses to heat, home range, and breeding activities.

51. Mitchell, Joseph C.; Rinehart, Sherry C.; Pagels, John F.; Buhlman, Kurt A., and Pague, Christopher A. Foctors influencing amphibian and small mammal assemblages in central Appalachian forests. For. Ecol. Manage. 1997; 96:65-76.
We studied terrestrial amphibian and small mammal assemblages with drift fences and pitfall traps in five forested stands during 1987-1988 on Shenandoah Mountain in the George Washington National Forest, Virginia, USA. Eleven species of salamanders, five frogs, five shrews, and seven rodents were monitored. Amphibians were significantly more abundant in forest stands consisting of mature hardwoods than in a recent clearcut and a white pine plantation. Although there was considerable variation in abundance among species in the five stands, small mammal abundance was high in all five habitats studied. Amphibian species diversity (Shannon Index) was less than half that for small mammals because red-backed salamanders (*Plethodon cinereus*) were dominant in most assemblages. Amphibian and small mammal diversity and total species richness were not related to estimated stand age, total number of canopy trees, tree diversity, or frequency of underground rocks. Maintenance of amphibian biodiversity requires the combination of mature hardwoods and wetland habitats (e.g. wildlife ponds and seepages). Most of the small mammals encountered were habitat generalists. Management focus on mature hardwood forests would maintain populations of small mammals requiring cool, moist situations in upper-elevation habitats in the central Appalachian Mountains.

52. Mushinski, Henry R. Fire and the Florida sandhill herpetofaunal community: with special attention to responses of *Cnemidophorous sexlineatus*. Herpetologica. 1985; 41(3):333-342.
A system of drift fences and pitfall traps was used over a 2-yr period to monitor the herpetofaunal community on four plots of land (1 ha each) maintained on different burn schedules. Experimental plots were burned every year (1E), every 2 yr (2E), or every 7 yr (7E); the control plot (CE) has not burned for 20 yr. A total of 1236 amphibians and reptiles of 27 species were captured during 1983 and 1984. Severe cold in December 1983 may have caused a large decline in herpetofauna in 1984; over two-thirds of the animals were captured in the first year of the study. Both Shannon-Weiner and Simpson's diversity indexes indicated that plot 2E had the lowest diversity each year. THe greatest diversity was found on 1E or 7E. The 2-yr fire periodicity produced a dense layer of grasses and herbaceous plants that was not readily occupied by sandhill herpetofauna.
The most abundant reptile was the six-lined racerunner, Cnemidophorous sexlineatus, which comprised about 33% of all captures. The highest density of racerunners was found on 1E, while lizards on 7E showed the greatest philopatric tendencies (especially in 1983, the year 7E was burned). The results indicated that burning increased diversity and abundance of amphibians and reptiles over control plots, and some fire periodicities were better than others for maintaining high diversity.

53. Mushinsky, H. R. Natural history and abundance of southeastern five-lined skinks, *Eumeces inexpectatus*, on a periodically burned sandhill in Florida. Herpetologica. 1992; 48(3):307-312.
The southeastern five-lined skink, *Eumeces inexpectatus*, occurs in a wide range of habitats throughout Florida, but it is most abundant in scrub and sandhill (high pine) habitats. Both the scrub and sandhill habitats are fire maintained, and resident animals respond to the frequency of burning. During 7 yr of study, adult males were trapped most often in March and April and adult females most often after nesting and hatching of young, from late June to mid-July. As judged by the number of individuals captured, [the author] determined that plots of sandhill protected from fire for about two decades or burned on 5 or 7 yr cycles support more individuals than plots burned on either 1 or 2 yr cycles. Differences in the number of skinks found in plots subjected to the three burn frequencies likely reflect the structure of the habitat. Frequent burning reduces the amount of

litter and tree canopy, produces patches of open ground, and promotes the growth of herbaceous plants. Plots protected from fire have thick layers of litter which provide shelter and foraging habitat for southeastern five-lined skinks. Plots burned on 5 or 7 yr cycles have sufficient time to accumulate litter between fires to provide good quality habitat for this species. (author's abstract).

54. Mushinsky, H. R. and Gibson, D. J. The influence of fire periodicity on habitat structure. Bell, S. S.; McCoy, E. D., and Mushinsky, H. R., eds. Habitat structure: the physical arrangement of objects in space. London: Chapman and Hall; 1991; pp. 237-259. 438pp.
The authors discuss the ecology of fire, effects of fire on habitat heterogeneity and plant structure, post-fire habitat structure and mechanisms of regeneration, and post-fire animal responses to vegetation structure. The paper also discusses two contrasting fire-maintained ecosystems which illustrate the diversity of responses of plant and animal communities to burning. One of these systems is the sandhill or tall-pine habitat typical of coastal regions of southeastern North America and most of peninsular Florida. In this case study, it is found that fire on the sandhills of Florida reduces tree canopy and facilitates growth of the grass and herbaceous plant layer. Very frequent fires promote a lush ground cover that favors reptilian success. At this time, the cause of this success is not clear; an increase in insect abundance and/or availability could provide food for these opportunitistic reptiles, or the dense vegetation at ground level could provide protection from predators, or a combination of these and other benefits may be operational. Both case studies illustrate that fire (or the absence of it) can influence community dynamics in a complex manner. (extracted from paper by SWS).

55. Mushinsky, H. R. and Witz, B. W. Notes on the peninsula crowned snake, *Tantilla relicta*, in periodically burned habitat. J. Herpetol. 1993; 27(4):468-470.
Note: Research Note.
The authors compare standard morphological measures of the sexes, and present monthly patterns of activity (catch per unit effort) of a west-central Florida population of the peninsula crowned snake (*Tantilla relicta relicta*). Their findings suggest that fire periodicity has no influence on the local distribution of this burrowing species in the sandhills habitat. (extracted from paper by SWS).

56. Patterson, G. B. The effect of burning-off tussock grassland on the population density of common skinks. New Zealand Journal of Zoology. 1984; 11:189-194.
The density of a population of common skinks, *Leiolopisma nigriplantare maccanni*, in tussock grassland was measured before and after the vegetation was burnt. Population density declined 28% from 1 lizard per 24 m^2 before the fire, to 1 lizard per 33 m^2 after the fire. Skink survival is attributed to the low heat of the fire and to the possible use of crevaces for shelter.

57. Pearson, H. A.; Lohoefener, R. R., and Wolfe, J. L. Amphibians and reptiles on longleaf-slash pine forests in Southern Mississippi. Pages 157-165 *in* H. A. Pearson, F. E. Smeins, and R. E. Thill, Comps. Ecological, Physical, and Socioeconomic Relationships Within Southern National Forests. USDA For. Serv. Gen. Tech. Rept. SO-68. 1987.
Amphibians and reptiles were sampled during 1980-1982 on more than 20 square miles of the Biloxi Ranger District, DeSoto National Forest, in Southern Mississippi. Five stand classes or habitats (regeneration, saplings, poles, sawtimber, and bayheads) were sampled within each of four management units. The diverse fauna were measured by several survey methods, including active searches--both diurnal and nocturnal, permanent line transects, anuran calls after or during rainfall, pit-fall traps, and funnel trap stations. Highest numbers of salamander species and individuals were recorded on bayheads. Toad and frog species diversities were similar among all stand types, but numbers of individuals were higher on bayheads. Species diversities of turtles and lizards were also similar across stand types; highest individual counts of lizards occurred in poletimber stands, but relatively high counts occurred in all stands. Snake species diversity, individuals, and frequency were lowest on regeneration areas.

58. Phelps, J. P. and Lancia, R. A. ( ). Effect of timber harvest on the herpetofauna community of a bottomland hardwood ecosystem: preliminary results.Brissette, J. C., ed. Proc. seventh biennial southern

silvicultural research conference. USDA For. Serv. Gen. Tech. Rep. SO-93.; 1992 Nov 17-1992 Nov 19; Mobile, AL. 1993: 151-154.
Increasing recognition of the importance of bottomland hardwood ecosystems, both as natural systems and as sources of wood products, along with the concern that amphibian populations worldwide may be declining, led to the establishment of this study to document the impact of timber harvest on the herpetofauna community diversity of such a site. In addition to harvest and control treatments, treatments comparing the impact of skidder and helicopter logging were established. Reptiles and amphibians were collected using coverboards to simulate ground refugia, PVC pipes to simulate arboreal treefrog habitat, and the more established method of drift fences with pitfall traps. A total of 2880 captures, representing 26 species, were made from the three methods combined. The data indicate that beta diversity is probably increased by the presence of the clearcut. Differences in diversity between treatments within the clearcut are less clear. The results presented here are based on the first of two seasons of data collection. Eventually, a correlative model will be developed to predict diversity based on vegetative cover, site inundation, woody debris, and litter depth. All of these are significant to habitat and affected by logging.

59. Pough, F. Harvey; Smith, Ellen M., and Rhodes, Donald H. The abundance of salamanders in forests stands with different histories of disturbance. Forest Ecology and Management. 1987; 20:1-9.
Because of the importance of salamanders in forest food chains, the effects of forest management practices on populations of these animals warrant consideration. We compared the numbers and activity patterns of salamanders in areas of a deciduous forest in central New York State that had been selectively cut for firewood, or clear-cut, or planted with conifers. Numbers of salamanders were lower in three recently disturbed habitats than in adjacent old-growth control stands. The frequency of above-ground activity by both species of salamanders was positively correlated with the density of understory vegetation and depth of leaf litter. Small-scale habitat distruction associated with harvesting firewood increased the numbers of the terrestrial eft stage of the red-spotted newt (Notophtalmus viridescens) but had no effect on numbers of red-backed salamanders (Plethodon cinereus). A recently clearcut area had fewer red-backed salamanders than adjacent old-growth forest had, but the numbers of salamanders in a 60-year-old second-growth forest were indistinguishable from those in the adjacent old-growth forest. Populations of salamanders in a conifer plantation were low. Thus, salamanders seem to be resilient to limited disturbance of forests, but major changes are likely to affect populations of salamanders and, consequently, of birds and mammals that depend on salamanders for food.

60. Raymond, L. R. and Hardy, L. M. Effects of a clearcut on a population of the mole salamander, *Ambystoma talpoideum*, in an adjacent unaltered forest. J. Herpetol. 1991; 25(4):509-512.
Note: Research Note.
The authors conducted ecological studies of the amphibian and reptile community that used a temporary woodland pond in northwestern Louisiana from 1977 through 1982. During the fall and winter of 1978-1979, approximately 40.5 ha of mixed pine-hardwood forest west of their study area was clearcut and is being managed for commercial pine production. The edge of the clearcut was 156 m from the study pond. In this paper, the authors analyze the impact of clearcutting an adjacent site on a population of mole salamanders (*Ambystoma talpoideum*). They compared the number of adults immigrating from the west side (adjacent to the clearcut) to those immigrating from the east side (farthest from the clearcut) of the pond, using Chi-square 2×3 and 2×2 contingency tables to determine if the clearcut had any effect on their population. Survival, as a percent of total immigration, was higher for individuals immigrating from the clearcut side than for individuals immigrating from the unaltered side for 1978 and 1979, but lower for 1980, following a decline in survival for individuals immigrating from the clearcut. The survivorship of those individuals ($N =$ 102) that immigrated from the clearcut dropped from 28.4% in 1978 to 11.0% in 1979 and 3.5% in 1980. As the immigration percentage from the clearcut side decreased from 72.9% to 44.0%, the immigration percentage from the unaltered side increased from 23.6% to 38.3%. The authors expected more salamanders to move or to be displaced to the west side of the pond from the east side. However, the opposite occurred and indicated that the clearcut was affecting the spatial distribution of the population. If survivorship was higher on the west side, then the marked decline

might have been a significant factor in the population. This decline in survivorship corresponded to the clearcutting activities. It appears that the clearcut near the study pond affected the population of *Ambystoma talpoideum* by (1) lowering the survival of adults immigrating from the clearcut side of the pond, and (2) displacing adults to the terrestrial habitat on the east side of the pond, which appeared less suitable. (extracted from paper by SWS).

61. Russell, Kevin R.; van Lear , David H., and Guynn Jr., David C. Prescribed fire effects on herpetofauna: review and management implications. Wildlife Society Bulletin. 1999; 27(2):374-384.

62. Vogl, Richard J. Effects of fire on the plants and animals of a Florida wetland. American Midland Naturalist. 1973; 89(2):334-347.
A total of 754 birds were recorded on a portion of a pond shore line during 63 visits for 4 months following a controlled burn, while 236 birds were observed on an adjacent and comparable, but unburned, shore line. Only 5 of the 35 bird species encountered were seen more often on the unburned site. Fire-induced bird and mammal injury or mortality was unobserved even though the burn resembled a wildfire. Birds showed no fear of the fire and some were attracted to the smoking landscape. Although some cold-blooded vertebrate mortality occurred, other herptiles survived, and alligators used the burned shore line almost exclusively. Mammal populations of burned and unburned areas appeared similar 4 months after the fire.
Animal responses are considered related to the fire removal of the heavy grass mat that otherwise covered the water and soils and foods contained therein, and physically impared new plant growth. Burning also produced an earlier, and far more productive growth of wet-prairie plants.

63. Waldick, R. C.; Freedman, B., and Wassersug, R. J. The consequences for amphibians of the conversion of natural, mixed-species forests to conifer plantations in southern New Brunswick. Canadian Field-Naturalist. 1999; 113:408-417.
We examined amphibian abundance and species richness in stands of natural, mixed-species forest and in a chronosequence of Black Spruce (*Picea mariana*) plantations up to 16-years old in southern New Brunswick, Canada, during 1993 and 1994. We studied seven species of amphibians in 64 terrestrial sites of 10+ ha, and at 16 ephemeral ponds. Eggs, larvae, and adult numbers were estimated using a variety of sampling methods (visual pond surveys, night calling, pit-fall traps, and searches of coarse-woody debris). The low abundance of woody angiosperm vegetation in conifer plantations, particularly those with incomplete canopy closure, resulted in less leaf litter and drier coarse-woody debris than in natural forest. Amphibians were more abundant in natural forest than in plantations of any age. The most common terrestrial amphibian in natural forest was the Redback Salamander (*Plethodon cinereus*; average density 4/100 m2), but it occurred in only one of 33 plantations examined. Amphibians bred in all study ponds, including those in plantations, but only small numbers of American Toad (*Bufo americanus*), Yellow-spotted Salamander (*Ambystoma maculatum*), and Red-spotted Newt (*Notophthalmus viridescens*) were observed in terrestrial habitats of plantations outside of the breeding season. The densities of *A. maculatum* and Wood Frog (*Rana sylvatica*) breeding in ponds within plantations were most strongly related to the distance to the nearest natural forest. For Spring Peeper (*Pseudacris crucifer*) and *A. maculatum*, the high exposure and short hydroperiod of plantation ponds resulted in poor recruitment in both study years. Our study suggests that the conversion of natural, mixed-species forest into conifer plantations is most detrimental to *A. maculatum, P. cinereus, P. crucifer*, and *R. sylvatica*, and less-so for *B. americanus*.

64. Warrick, Gregory D.; Kato, Thomas T., and Rose, Barbara R. Microhabitat use and home range characteristics of Blunt-nosed Leopard lizards. J. Herpetol. 1998; 32(2):183-191.
We used radiotelemetry to determine habitat use and home range characteristics of 16 blunt-nosed leopard lizards (*Gambelia sila*) at two sites on the Naval Petroleum Reserves in California. Space use parameters of eight lizards occupying an area of relatively dense vegetation in 1982 and eight lizards inhabiting a sparsely vegetated site in 1984 were compared. Home range size, core area size, and amount of overlap of ranges did not differ significantly between sites. The difference in average home range size between males (4.24 ha) and females (2.02 ha) was borderline significant (P =

0.054). Female home ranges and core areas were overlapped extensively by male ranges (x = 79.8% and 50.3%, respectively). There was no evidence of intrasexual overlap of core areas. Male home ranges overlapped the ranges of up to four other males but female ranges did not overlap one another. At the more densely vegetated site, leopard lizards used washes significantly more than grassland, floodplain, and road habitats and they used grassland significantly less than other habitats. At the sparsely vegetated site, grassland was used more than wash habitat and hills were used less than all other habitats. Our data indicate that leopard lizard activity is concentrated in washes and other open areas when herbaceous cover is dense, but they are capable of utilizing the more extensive grassland habitat if vegetation is sufficiently sparse. Creating open space within the grassland habitat may have important management implications for this species in some areas.

65. Whiting, R. M., Jr.; Fleet, R. R., and Rakowitz, V. A. Herpetofauna in loblolly-shortleaf pine stands of east Texas. Pages 39-48 *in* H. A. Pearson, F. E. Smeins, and R. E. Thill, Comps. Ecological, Physical, and Socioeconomic Relationships Within Southern National Forests. USDA For. Serv. Gen. Tech. Rept. SO-68. 1987.
Amphibians and reptiles in seedling, sapling, pole and sawtimber pine stands were studied in the Angelina National Forest in eastern Texas. Amphibians (especially frogs and toads) were more abundant in winter while reptiles dominated in spring. Winter amphibians had a stronger relationship with the availability of ponds suitable for breeding than with stand age or vegetation structure. Spring amphibians were more dependent on vegetation structure. Lizards were the dominant reptile during winter. Spring reptile communities were evenly balanced between lizards and snakes. Generally, there were differences in species compositions between study areas in the amphibian and reptile communities.

66. Williams, K. L. and Mullin, K. Amphibians and reptiles of loblolly-shortleaf pine stands in central Louisiana. Pages 77-80 *in* H. A. Pearson, F. E. Smeins, and R. E. Thill, Comps. Ecological, Physical, and Socioeconomic Relationships Within Southern National Forests. USDA For. Serv. Gen. Tech. Rep. SO-68. 1987.
Amphibian and reptile species composition and abundance were surveyed on four study sites, each 2,000 acres, on the Catahoula Ranger District, Kisatchie National Forest, in central Louisiana, from August 1979 to May 1981. Four stand size classes (habitats) were sampled within each study area--regeneration, sapling, poletimber, and sawtimber. A variety of census methods were used, including walking transects and fence arrays with pitfalls and funnel traps. Sawtimber exhibited the most herpetofauna diversity. Amphibians were not abundant in any stand type. Reptiles were more abundant, but with the exception of three species of lizards, probably not abundant enough to serve as good indicators of habitat change resulting from grazing.

67. ---. Amphibians and reptiles of longleaf-slash pine stands in central Louisiana. Pages 116-120 *in* H. A. Pearson, F. E. Smeins, and R. E. Thill, Comps. Ecological, Physical, and Socioeconomic Relationships Within Southern National Forests. USDA For. Serv. Gen. Tech. Rep. SO-68. 1987.
Amphibians and reptile species composition and abundance were surveyed on four study areas, each 1,300-2,300 ac, on the Vernon Ranger District, Kisatchie National Forest, in central Louisiana, from August 1979 to May 1981. Four stand size classes (habitats) were sampled within each study area--regeneration, sapling, poletimber, and sawtimber. A variety of census methods were used, including walking transects and fence arrays with pitfalls and funnel traps. Sawtimber stands exhibited the most herpetofauna diversity. Amphibians were not abundant in any stand type. Reptiles were more abundant, but with the exception of three species of lizards, probably not abundant enough to serve as good indicators of habitat change resulting from grazing.

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Birds and reptiles were censused at two sites of contrasting soil texture (clay, loam) on pastoral land in the Victoria River District, Northern Territory. Both sites comprised 16 plots (each of 2.6 ha) subjected to seven different experimental fire regimes (unburnt, burnt in the early dry season at 2, 4,

and 6 year intervals, and burnt in the late dry season at 2, 4, and 6 year intervals) beginning five years before sampling (and thus, not all regimes had been operationally distinct between the onset of the experiment and this sampling). The regimes were deconstructed to four fire factors: the imposed regime, the time since last fire, the number of fires since the inception of the experiment, and the number of hot (=late dry season) fires. Of 30 species recorded from at least four plots, 12 were significantly associated with time since last fire. These responses were mostly to the extremes - some species were associated with the most recently burned areas, and others occurred mainly in the plots which had been unburnt the longest. longer-term responses to fire regimes were generally less clear-cut, possibly because the relatively short duration of the imposed experimental fire treatments had not yet brought about substantial environmental divergence.

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Keywords: restoration/ fire policy/ prescribed fire

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Keywords: flycatchers/ prescribed burn/ long leaf pine

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Keywords: fire regime

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Keywords: fire history

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Keywords: fire policy/ land management/ wilderness/ wildland fire

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Keywords: forest ecology/ forest management/ restoration/ prescribed fire

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Keywords: sediment yield, hydrologic response, fire, erosion control, log erosion barriers, upland watersheds, soil depth, water repellency

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Keywords: fire regime/ fire effects/ tropical savannas/ reptiles/ birds/ diversity

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Keywords: fire policy/ land management/ wilderness/ wildland fire/ prescribed fire

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Keywords: fire history

312. Young MK. Movement and Characteristics of Stream-Borne Course Woody Debris in Adjacent Burned and Undisturbed Watersheds in Wyoming. *Candadian Journal of Forest Research.* 1994;24(9):1933-1938.
Keywords: fire/ course woody debris/ stream

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Keywords: prescribed fire/ burn prescription

Support Provided By:

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PART 6

SECTION 2

Public Information and Outreach

Workshop Agenda

Presentations (abstracts)

Poster (reduced)

News Release

Fuels Reduction and Wildlife Workshop – Ellensburg, WA March 2004

Soc. Northwestern Vertebrate Biologists and Northwest Science Association

FIRE AND HAZARDOUS FUEL REDUCTION IN THE WEST: PERSPECTIVES AND CHALLENGES

R. Bruce Bury, USGS Forest and Rangeland Ecosystem Science Center, Corvallis, OR
David Pilliod, USFS Rocky Mountain Research Station, Missoula, MT
Evelyn Bull, USFS Pacific Northwest Research Station, LaGrande, OR

The National Fire Plan and the Healthy Forest Restoration Act are new national efforts to reduce catastrophic fire risk on federal lands, especially in the wildland-urban interface. Planned actions propose extensive use of prescribed fire, stand thinning and mechanical reduction (chippers). However, it is unclear how these programs may affect habitats and dependent vertebrates that include a diversity of fish, amphibians, birds, reptiles, and mammals. Western range and forest habitats have many endemic species and some are threatened or declining in numbers. Extensive loss and fragmentation of habitat resulted from past grazing and logging is a legacy overlaid on top of a complex landscape mosaic. The region experiences many low severity fires annually, punctuated by periodic, major fires. Now, what will happen to animal populations with removal of large amounts of coarse woody material from forests or alteration of rangelands? Today, the challenge is to maintain biodiversity in western forests and rangelands in the face of intense socio-economic pressures designed to "prevent" catastrophic fires. Better information on the effects of fire and fuels reduction on fish and wildlife will improve developing ecologically sound fire management policies. Thus, we propose a bold initiative: establish several research teams dedicated to understanding how fire affects biota in each major region, and to investigating outcomes of fuel reduction management on wildlife in different western forests and rangelands.

Keywords: fire, fuels reduction, wildlife
Format: Oral
Presenter: RB Bury
Audio-visual requirement: Powerpoint

Appendix

Fire and Fuel Reduction Effects on Wildlife (Special Session)
NW Scientific Association and Soc. for NW Vertebrate Biology, Ellensburg, WA.
26 March 2004. Organizers: David S. Pilliod, USFS; R. Bruce Bury, USGS, FRESC

INTRODUCTION: David S. Pilliod, USFS Rocky Mountain Research Station, Missoula, MT

FIRE AND HAZARDOUS FUEL REDUCTION IN THE WEST: PERSPECTIVES AND CHALLENGES
R. Bruce Bury, USGS Forest and Rangeland Ecosystem Science Center, OR
David Pilliod, USFS Rocky Mountain Research Station, Missoula, MT
Evelyn Bull, USFS Pacific Northwest Research Station, LaGrande, OR

FIRE EFFECTS ON PLANTS, ANTS, AND RODENTS IN THE MOJAVE DESERT
Todd Esque, USGS Western Ecosystem Science Center, Las Vegas, NV, & others

CHANGES IN FOREST RODENT COMMUNITIES AFTER FIRE: IMPLICATIONS FOR DISPERSAL AND REGENERATION OF PINE
Jennifer S. Briggs, Biological Res. Research Ctr., Univ. Nevada, Reno.
Stephen B. Vander Wall, Ecology, Evolution & Conserv. Biol, Univ. Nevada,Reno

USING TAXA-BASED CONSERVATIONS PLANS TO EVALUATE ECOLOGICAL EFFECTS OF FIRE MANAGEMENT: INSIGHTS FROM BIRD MONITORING IN OAK WOODLANDS
Nathaniel E. Seavy, Klamath Bird Observatory, Ashland, OR, and Dept. Zoology, Univ. Florida, Gainesville, FL
John D. Alexander, Klamath Bird Observatory, Ashland, OR
Paul E. Hosten, BLM, Ashland Field Office, Medford District, Ashland, OR

RESPONSES OF POND-BREEDING AMPHIBIANS TO WILDFIRE IN GLACIER NATIONAL PARK
Blake R. Hossack and P. Stephen Corn, USGS Northern Rocky Mountain Science Center, Missoula, MT

EFFECTS OF WILDLIFE FIRES ON STREAM AMPHIBIAN POPULATIONS IN THE GREATER NORTHWEST
David S. Pilliod, USFS Rocky Mountain Research Station, Missoula, MT
R. Bruce Bury and Erin Hyde, USGS Forest and Rangeland Ecosystem Science.
P. Stephen Corn, USGS Northern Rocky Mountain Science Center, Missoula, MT

DISCUSSION: How can we get wildlife resources better supported and protected?
R. Bruce Bury and David S. Pilliod.

1. What are the greatest risks to wildlife habitat from current and future fire management practices on federal lands?
2. What are the key research needs for protecting and managing habitat for sensutive wildlife in landscapes managed with prescribed fire, stand thinning or mechanical alteration (mastication)?
3. What are the challenges ahead for wildlife management and how might they be met more efficiently and effectively?

Fire Workshop – Arcata, California 5-6 November 2003

Wildfire and Fuels Reduction in Northwestern Forests: Responses of Amphibians and Reptiles.

R. BRUCE BURY

USGS Forest and Rangeland Ecosystem Science Center, 3200 SW Jefferson Way, Corvallis, OR 97331-8550, U.S.A.

email: buryb@usgs.gov

Abstract: The herpetofauna (amphibians and reptiles) of northwestern forests is diverse, has many endemics, and may be locally abundant. Most forest amphibians west of the Cascade Mountain crest are associated with cool, cascading streams or coarse woody material on the forest floor, which are characteristics of mature forests. Extensive loss and fragmentation of habitat resulted from logging 50-80% of old-growth forests in the Pacific Northwest. The region has a complex landscape mosaic overlaid with a mix of northern and southern biotic elements, especially in the Klamath-Siskiyou Region. This is a biodiversity "hot spot." The region experiences many low severity fires annually, punctuated by periodic, major fires including the Biscuit Fire—the largest in North America in 2002. In its north portion, severe fire occurred on >50% of young, managed trees but only about 25-33% of old-growth stands. This suggests that the legacy of timber harvest may produce fire-prone stands---but this needs more study. Calls for extensive use of prescribed fire and thinning to reduce fuel loads will remove large amounts of coarse woody material from forests. This will reduce cover for amphibians and alter nutrient inputs to streams. Our preliminary evidence in wildfire areas suggests no negative effects on terrestrial amphibians, but decreased stream amphibians in one area but not another. Studies are underway. Most reptiles are adapted to open terrain, and fire usually improves their habitat. Today, the challenge is to maintain biodiversity in western forests in the face of intense socio-economic pressures designed to "prevent" catastrophic fires. We need a dedicated research effort to understanding how fire affects biota, and to proactively investigate outcomes of fuel reduction management on wildlife in western forests.

Hyde, E.J., R.B. Bury, and D.J. Major. Fire, Fuel Loads, and Terrestrial Salamanders. 2002. Northwestern Naturalist 83(2):73.

Prescribed fire is increasingly being used as a management tool to reduce fuel loads in forests, in part because wildland fires have been suppressed for decades. Federal land managers are presented with conflicting priorities when dealing with fire. Current standards and guidelines of the Northwest Forest Plan require land managers to promote retention of dead and down wood as wildlife habitat, yet reduce high fuel loads through prescribed burning. Lack of information on how resident wildlife species respond to fire-induced changes in habitat availability and forest structure further complicates management decisions. We report preliminary findings on the physical structure of the forest floor and its use by terrestrial salamanders from two major wildland fires: Spring Fire, North Umpqua R., Southwest Oregon and Dillon Fire, Siskiyou Co., California. We also report on responses of salamanders to prescribed fire at sites in North Carolina. We found no significant decrease in salamander diversity or abundance in response to these wildland or prescribed fires, but noted measurable differences in habitat structure. However, we suspect that salamanders may be unequally sampled in burned and unburned habitat. We suggest that further testing of the bias and effectiveness of current sampling methods is required before sound conclusions can be reached.

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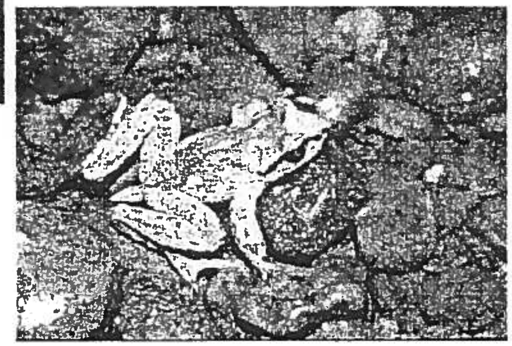

Fire Impacts on Amphibian Communities

Principal Investigators: Erin Hyde and Bruce Bury 541-758-7788, bbury@usgs.gov

In cooperation with: David Pilliod (USFS RMRS) and Steve Corn (USGS), Missoula MT

Joint Fire Science Program

BLM Medford and Roseburg Distracts and BLM OR/WA State Office

Objectives:

- Compare post-wildfire amphibian communities to those at unburned sites.
- Study amphibian populations and their habitat before and after prescribed burns.
- Identify changes in macroinvertebrate and periphyton biomass following wildland and prescribed fires.
- Monitor water chemistry in headwater streams following wildland and prescribed fires.
- Identify how critical amphibian habitat including downed woody debris is affected by fire.

Future Research Needs:

- Test for bias in terrestrial sampling effectiveness and detectability
- Large scale replication
- Increased geographic scope
- Multi-year pre-post manipulations
- Prescribed fire in riparian zones

WORKING AT A NATIONAL SCALE

	Upland 2000-2001	Aquatic 2002-2005
Wildfire ☐	OR, CA	OR, ID, MT
Prescribed ◯	OR, NC	OR, ID

Preliminary Results:

- Early work suggests that density of tailed frogs may be lower in streams burned by wildland fire.
- Tailed frog life stages may be impacted differently by wildland fire.
- Terrestrial amphibian surveys appear to overestimate abundance on burned landscapes compared to control areas.
- Positive sampling bias could lead to erroneous conclusions without further study.

Relevant Resources:

Bury, R.B., D.J. Major, and D.S. Pilliod. 2002. Responses of amphibians to fire disturbance in Pacific Northwest forests: A review. Pp. 34-42. *In* Ford, W.M., K.R. Russell, and C.E. Moorman (eds.). The role of fire in nongame wildlife management and community restoration: traditional uses and new directions. USDA, Gen. Tech. Report, NE-288.

Bury, R.B., D.J. Major. 2001. Annotated Bibliography: Fire effects on resident wildlife (amphibians, reptiles, and small mammals). http://fresc.fsl.orst.edu/Fuels/FuelsProject.html

Corn, P.S., R.B. Bury, and E.J. Hyde. *In Press.* Conservation of North American Stream Amphibians. In Semlitsch, R. (ed.). Conservation Biology of Amphibians. Smithsonian Inst. Press.

Pilliod, D., R.B. Bury, E.J. Hyde, C.A. Pearl, and P.S. Corn. *In Press.* Fire and amphibians in North America. Forest Ecology and Management. http://www.fs.fed.us/rm/boise/teams/fisheries/fire/firehome.htm

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News Release

Address
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U.S. Department of the Interior
U.S. Geological Survey

Release	**Contact**	**Phone**
6/23/2003	Robert Gresswell	541-750-7410
	Bruce Bury	541-758-7788

Frogs, Fish, and Fires: A New Look at Fire and Fuels Reduction Effects

NOTE TO NEWS EDITORS: Photos listed below can be downloaded.

(no photos available)

Frogs, salamanders and fishes are not exactly the first species one thinks about as wildlife affected by fire – after all, they live in water – but a special June issue of Forest Ecology and Management points out that the response of these species to habitat changes induced by fire and fuels reduction practices is highly variable.

The special issue, "The Effects of Wildland Fires on Aquatic Ecosystems of the Western USA," includes five overviews by U.S. Geological Survey (USGS) scientists of the known and possible effects of wildland fire and fuels management on amphibians and fish as well as their habitats. These overview papers are pieces within a larger framework regarding fire and fuels management that the journal issue focuses upon.

Amphibians are major parts of forest ecosystems, and many species are sensitive to habitat changes, including those that occur after a forest fire," said Bruce Bury, a USGS zoologist who co-authored a review paper on fire and amphibians. "For example, soil erosion increases after a fire. Sediment collects in streams filling in the area between rocks and stones so stream amphibians can no longer lay their eggs, forage and hide in these areas."

Although amphibians have evolved in the presence of wildfire, it is unclear at this time how the combination of fire and fuel-reduction management practices will affect them. Because of this, Bury says, policy makers and resource managers need to know how amphibians - many of which are declining in numbers - respond to wildfire and fuel-reduction management practices such as prescribed burning and reductions in fuel loads by thinning of forest stands.

Fire could affect each amphibian life stage differently, Bury noted, since amphibians often use different habitats as larvae and as adults. Some amphibians live their entire life in water, others breed in water but live on land as adults, and yet others spend their entire lives on land.

Fish populations can also be affected by fire, said USGS scientist Robert Gresswell, co-editor of the special issue. "A tremendous amount of debris can be dumped into streams following fires, and fish sometimes totally disappear following such an event. The good news is that even when fish populations are reduced, they usually manage to return from other unaffected areas." Within two years after a fire, fish numbers are often higher than before the fire. Furthermore, the wood and sediment that frequently enter the stream following fires are critical to maintaining good habitat for trout and salmon.

The real challenge is that fish have to be able to get back into affected areas when conditions improve. "The vulnerability of fish to fire is related to the type, amount, and quality of their habitat, and connections among areas in the stream network," Gresswell said. Because fires will occur regardless of efforts to prevent them, Gresswell suggests that resource managers address potential risk factors to prevent the decline of fish populations. "If we can build stronger populations by improving the habitat before a fire occurs and make sure that fish can move between areas with good habitat, fish will continue to thrive following fire."

Recent increases in the size and intensity of forest fires in the western United States appear related, in part, to accumulation of fuel loads from past forest practices including fire suppression. In response to these more severe fires and heavy fuel loads, current forest management policies call for a greatly expanded fuels reduction program.

Future climate change, however, may limit the effectiveness of fuel management activities. USGS scientist Sarah Shafer and her co-authors from the University of Oregon have examined long-term fire-regime patterns related to climate. Their simulations of vegetation and soil moisture under potential future climate scenarios indicate that future fire conditions could be more severe in some areas than they are today. Furthermore, management efforts to make forests look like they did 100 - 300 years ago may be extremely difficult because climate conditions have changed from those that occurred when most current forests were established.

The authors of the summary article emphasize that if resource managers want to combine fire and fuels management with aquatic ecosystem conservation, it is important to recognize that terrestrial and aquatic ecosystems are intimately linked and, in fact, fire can play a critical role in maintaining aquatic diversity. In the end, noted Gresswell, natural resource management always has a component of uncertainty. According to Gresswell and his co-authors, "The role of our research is to scientifically evaluate management activities that affect fire and aquatic ecosystems so that land managers can adjust when necessary."

USGS

U.S. Department of Interior, U.S. Geological Survey
Forest and Rangeland Ecosystem Science Center
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Last Update: February 27, 2003

PART 6

SECTION 3

USGS Web Page:
Exploring Fire Effects on Amphibian Communities

FRESC Web Page

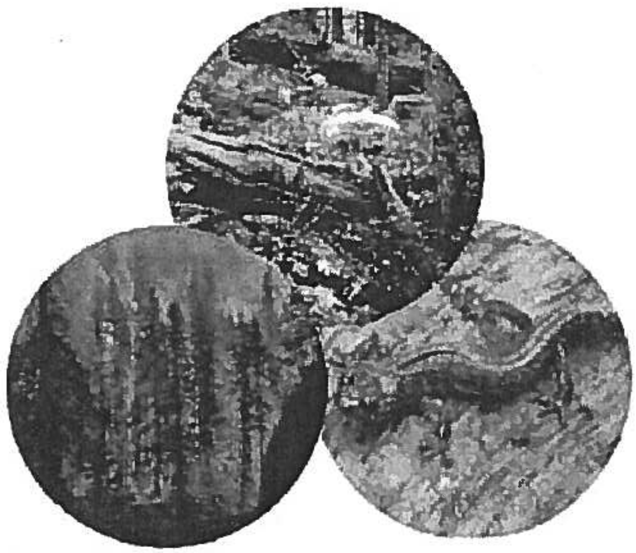
Geographic Coverage (map)

Samples of Recent Publications (with online access)

Study Description

Meet the Herp Lab (personnel)

Exploring Fire Effects on Amphibian Communities



In 2001 a National Fire Plan (NFP) was approved by Congress to reduce fire risk and to restore healthy fire-adapted ecosystems on federal lands through proactive fuel reduction (DOI/USFS 2001). One problem with proceeding with NFP objectives is that large information gaps exist regarding effects of proposed fuel-reduction practices (e.g., prescription burning, mechanical fuel reduction) on native flora and fauna. Amphibians are of particular conservation concern because many have restricted geographical ranges, occur only in localized microhabitats that may be vulnerable to management activities, or are listed (or candidates) under the Endangered Species Act. Many amphibian species have declined across large portions of their range throughout the United States (Corn, 2000; Semlitsch, 2000), and information on their responses to fire and fuel reduction practices is critically needed.

Our research is focused on determining the effects of wildland and prescribed fires on amphibian communities and habitat. Effects are likely to vary widely across habitat types and regions, species groups, and fire type, season, and severity. We seek to quantify this range of diversity through collaborative efforts, wide geographic scale, and long term research.

Click here for current research coverage

- Frogs, Fish, and Fires: A New Look at Fire and Fuels Reduction Effects
- Effects of Prescribed and Wildland Fires on Habitat Quality and Herpetofauna - Coming Soon
- Fire Effects on Aquatic Systems In Western Forests
- Select Publications
- Fire Bibliography: Citations With Abstracts For Literature Covering Fire Effects on Wildlife
- Meet the Herp Lab

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3200 SW Jefferson Way, Corvallis, OR 97331

Support Provided By:

Exploring Fire Effects on Amphibian Communities

Geographic Coverage

	Upland 2000-2001	Aquatic 2002-2006
Wildfire	OR, CA	OR, ID, MT
Prescribed	OR, NC	OR, ID

* ID and MT sites are part of a collaborative effort with David Pilliod and Stephan Corn of the Rocky Mountain Research Station.

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U.S. DEPARTMENT OF THE INTERIOR BUREAU OF LAND MANAGEMENT

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Exploring Fire Effects on Amphibian Communities

Sample of Recent Publications

Corn, P.S., R.B. Bury, and E.J. Hyde. 2003. Conservation of Stream Amphibians. In Semlitsch, R. (ed.). Amphibian Conservation. Smithsonian Inst. Press.

Pilliod, D., E.J. Hyde, R.B. Bury, and C.A. Pearl. 2003. Ecological effects of fire and fuel reduction practices on aquatic amphibians in the United States. Forest Ecology and Management 178 (1-2): 163-181.

Bury, R.B., D.J. Major, and D.S. Pilliod. 2002. Responses of amphibians to fire disturbance in Pacific Northwest forests: A review. Pp. 34-42. In Ford, W.M., K.R. Russell, C.E. Moorman (eds.). The role of fire in nongame wildlife management and community restoration: traditional uses and new directions. USDA, Genl. Tech. Report, NE-288.

Biek, R., L.S. Mills, and R.B. Bury. 2002. Terrestrial and stream amphibians across clearcut - forest interfaces in the Siskiyou Mountains, Oregon. Northwest Science 76:129-140.

Hyde, E.J., R.B. Bury, and D.J. Major. Fire, Fuel Loads, and Terrestrial Salamanders. 2002. Northwestern Naturalist 83(2):73.

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Study Description

Project No.7079

Fuels Management and Wildlife Habitat: BLM Fire Science

Our study will investigate the relations of fuels management to habitat quality for resident wildlife (terrestrial herpetofauna). Amphibians are highly sensitive to habitat change, in part because they have moist, permeable skin and restricted home ranges. Reptiles also require cover objects. Thus, herpetofauna are well suited as resident wildlife to measure for response changes. Specifically, our objectives are: 1)to compare structural components of the forest floor and their use by terrestrial herpetofauna in burned and unburned sites; 2) to determine the vulnerability of the structural components used by herpetofauna; and 3) to evaluate habitat quality by relating diversity and abundance of herpetofauna to available forest floor structure. We will examine changes in habitat quality resulting from both wildland fire and prescribed-burning. Our study will include two designs: retrospective (wildland fire) and experimental (pre-/post-treatment). Retrospective work will describe forest floor structure in burned and adjacent unburned sites of wildland fires. We will classify and quantify structural components of the forest floor in these two fire categories. We will also examine similar habitats immediately adjacent to the fire-affected sites (controls). We will then conduct terrestrial herpetofauna surveys at all sites to compare herpetofauna use of the various structural components across fire and no fire (wildland) and pre-/post-burn (prescribed).

Clients:
Interagency Joint Fire Sciences Program
Bureau of Land Management
USDA Forest Service

Locations:
Oregon
California

Field Stations:
USGS FRESC Corvallis Research Group

Collaborative Programs (i.e. CFER, ARMI):

USGS Programs:
Terrestrial, Freshwater and Marine Ecosystems
Wildlife and Terrestrial Resources Program

BASIS+ Project:
Understanding Fire in Ecosystems in the Western U.S.

Related Publications:

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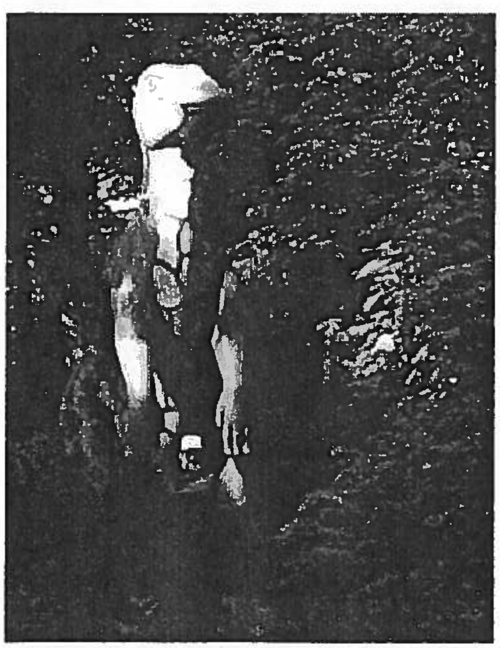
Exploring Fire Effects on Amphibian Communities

Meet the Herp Lab

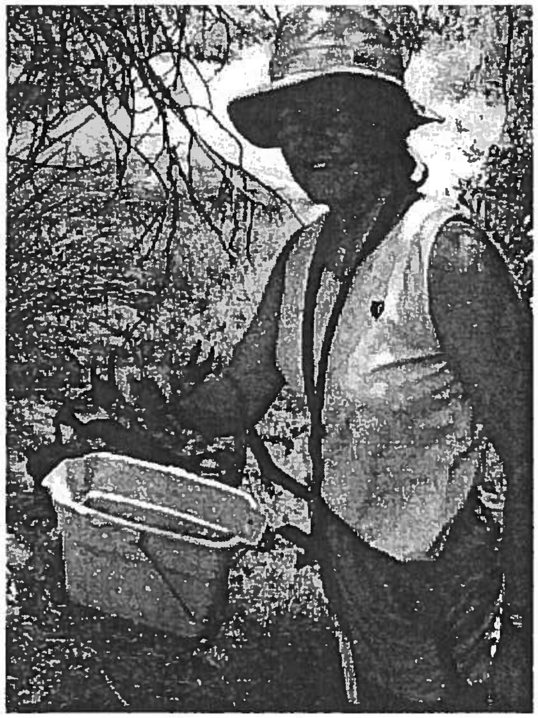
Erin Hyde, Fire Project Leader



Bruce Bury, Fearless Leader

Stephanie Galvan, Inventory & Monitoring

Chris Pearl, Spotted Frogs



Wendy Wente, ARMI

Mike Adams, Aquatic Ecologist