WORKPLAN REVISION:

EFFECTS OF SPLAT TREATMENTS ON SPOTTED OWL OCCUPANCY, SURVIVAL, AND REPRODUCTION

R. J. Gutiérrez, Principle Investigator
University of Minnesota

Douglas Tempel, Project Manager
University of Minnesota

Sheila Whitmore, Asst. Project Manager
University of Minnesota

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Project Narrative

- **Need for Revision**
- **Objectives**
- **Revised Methods**
- **Estimated Cost**
- **Recommended Course of Action**

Need for Revision

The Sierra Nevada Framework proposes to distribute Strategically Placed Land Allocation Treatments (SPLATs) across the landscape in order to reduce the rate of spread of wildfire. Because SPLATs require tree removal, they will affect ground vegetation, canopy closure, tree diameter distribution, and tree density, which could impact spotted owls and other forest wildlife. It is well known that California spotted owls are habitat specialists (Verner et al. 1992). They select habitats that have higher canopy closure, larger trees, more vertical structure, more mature/old forest, and larger patch sizes than what is generally available to them (e.g., Gutiérrez et al. 1992, Chatfield

2005). SPLATs will directly affect some of these elements by reducing canopy closure, tree density, vertical structure, and patch size. There is substantial uncertainty about the effect of SPLATs on California spotted owls in the Sierra Nevada. Thus, there is a need to estimate the chronic effects of SPLATs on owls in a formal, quasi-experimental manner under an adaptive management framework.

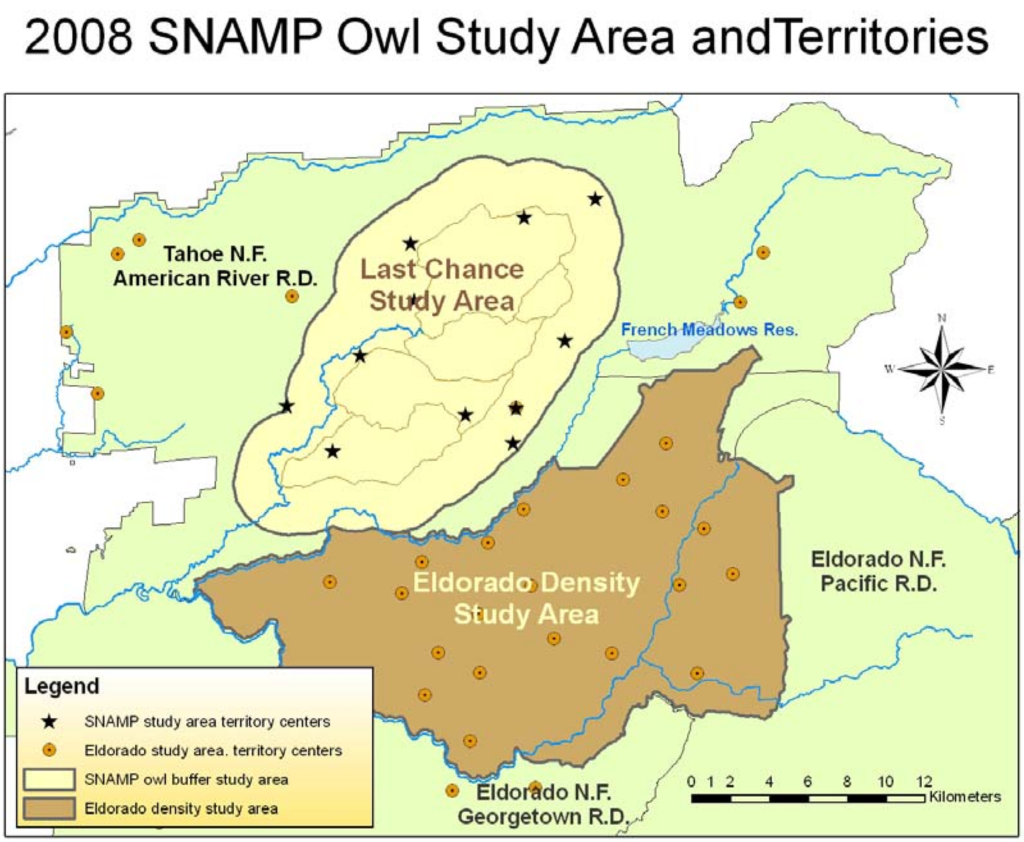
We recently completed a radiotelemetry study on the acute effects of canopy reduction treatments (i.e., SPLATS) on spotted owl movement patterns and habitat use (Gutiérrez et al. 2008). We conducted this experimental study by monitoring radio-marked owls on the Tahoe and Eldorado National Forests before and after SPLATs were conducted within their territories. Both treatment and control birds were randomly selected from the owl population following appropriate local control (e.g., owl territories contained sufficient habitat to allow treatment). This study was an experiment of the type that would be consistent with the adaptive management strategies proposed in the Sierra Nevada Framework because the results can be used to inform future management decisions. The study results were equivocal because there was substantial variation in the response of owls, which resulted in a "best" explanatory model that explained only a small amount of the total variation in owl responses to SPLATs. In addition, chronic (or long-term) effects of disturbance are more important when assessing the impacts of SPLATs on spotted owl populations. We propose to assess chronic effects of SPLATs by estimating territory occupancy rates and owl reproduction over the duration of SNAMP.

This work plan revision reflects the results of the first two field seasons (2007, 2008) conducted by the Owl Science Team for the Sierra Nevada Adaptive Management Project (SNAMP). We believe a new revision of the spotted owl work plan is necessary because the low number of owls found thus far on the Last Chance Study Area (LCSA) requires a change of design to examine owl responses to SPLAT treatments. Based upon the locations of territory centers (see Figure 1), we have found 1 occupied owl territory within a treatment fireshed, 3 territories within the control firesheds, and 6 territories within the owl buffer zone (i.e., 1/2-mile buffer around the treatment and control firesheds). We defined a territory center using the following criteria listed in order of relative importance: 1) the nest location for breeding owls; 2) the initial location that fledglings were found at (if the nest location was unknown); 3) the geometric mean of all known roost locations of non-breeding owls.

We believe this sample is not large enough to detect any effect of SPLATs on owl territory occupancy or reproductive output over the duration of SNAMP. After discussing this issue with participants at the Owl Integration Team meeting on July 25, 2009, we have adopted Option 2 from the previous work plan (dated November 13, 2007; see Appendix 1). Under this option, we will continue to monitor owl territories on the Eldorado Study Area (ESA) under our existing contract with the U.S. Forest Service (the Eldorado Population Monitoring Study) and will incorporate these territories into the SNAMP owl study design. The ESA is immediately adjacent to the LCSA and consists of both a Density and Regional Study Area (see Figure 1). We completely survey the Density Study Area each year, including the area between known owl territories. We survey additional owl territories on the Regional Study Area, which has owl territories on both the American River Ranger District (Tahoe N.F.) and the Pacific Ranger District (Eldorado N.F.). There are owl territories within the ESA that will receive SPLAT treatments within the next 2–3 years as part of normal implementation of the Sierra

Nevada Framework. Therefore we will use territories that experience SPLATs within their boundaries as treatment samples, and territories that do not receive treatments will be used as control samples.

Figure 1: Location of active spotted owl territory centers within Last Chance Study Area and Eldorado Study Area, 2008.



Objectives

We still propose to measure chronic effects (changes in occupancy rates and reproduction of owls) on owl territories as a function of SPLATS as part of the SNAMP owl study. Thus, we propose to increase the sample size by evaluating owl territory occupancy and reproduction on sites that are on the ESA (both Density and Regional territories) and on the LCSA. A number of SPLATs have been planned or recently conducted on the ESA including O'Leary's Cow, Hartless Ridge, Hey Joe, Misfire, Pine Nut, and Big Grizzly. By incorporating the ESA into our study design, we expect to sample approximately 20 treatment territories and 30 control territories. This expanded sampling scheme will assist the accomplishment of our original primary objective– the need to understand the potential longer-term effects of SPLATs on owls. We reiterate that because of limited sample sizes and funding levels allocated to the SNAMP owl study, our study design is contingent on continued funding of the Eldorado Population Monitoring Study.

Methods

Owl Sampling—As noted in previous work plans, there are two ways to examine the effect of SPLATS on spotted owls. The first is through radio-marking and tracking of individual owls. However, we believe that the use of radiotelemetry on owls is best suited to examining acute effects of disturbance rather than chronic effects. From our recent and past experiences, we believe that radiotelemetry monitoring of the same individuals will be difficult to conduct on a long-term basis, particularly where road access is limited, as it is on the LCSA and parts of the ESA. Additionally, the repeated capture of owls (necessary to periodically replace radios) makes the birds exceedingly wary over time and, therefore, difficult to capture. In areas where road access is good and birds can be easily found on a daily basis, recapture of birds becomes primarily a matter of probability. In areas where access is difficult, however, the probability of repeated recapture goes down dramatically. Limited road access also decreases both the amount and the reliability of collected data. Finally, whereas we believe the reduction of transmitter size and improvement in harness design has greatly reduced the potential negative effects of transmitters on owls (and the results of current radiotelemetry research supports this contention), chronic effects of SPLATS on owls may be confounded by possible adverse effects of transmitters on owls. Therefore, we propose to examine the chronic effects of SPLATS on owls using standard protocols for banding and recapturing (i.e., resighting) individual owls and determining reproductive output (Franklin et al. 1995). Our experience on the ESA suggests that banding has no short-term or long-term negative effect on owls and is a reliable way to estimate the key parameters of interest: territory occupancy and reproduction.

Vegetation Sampling—In 2008, we collected pre-treatment vegetation data in locations where proposed SPLAT projects intersect owl territories, within both the LCSA and ESA. We defined a territory as a circle around the territory center having a radius equal to 1/2 the mean nearest neighbor distance. A detailed description of our vegetation sampling protocol is found in Appendix 2. Upon completion of the SPLAT projects, we will resample the vegetation in the same locations to estimate SPLAT effects on habitat quality within owl territories.

We must also account for habitat change occurring within owl territories due to timber harvest on industrial private timber lands, which constitute nearly 40% of the Eldorado Density Study Area. We have identified the primary landowner, Lone Star Timber Inc. Lone Star owns >95% of the private land on the ESA and LCSA. The firm that manages the land (Mason, Bruce, and Girard Inc.) has provided us with GIS spatial data for timber harvest activities conducted during 2007 and 2008 and has agreed to provide this data in the future as needed.

At a larger scale, we are quantifying habitat quality in untreated portions of owl territories using remotely sensed data. The collection of fine-scale data using the methods developed to estimate SPLAT effects (see above) is not feasible at this time for all of the owl territories on the LCSA and ESA because of limited funding. We are currently constructing a habitat map for owl territories within the LCSA and ESA using Digital Orthophoto Quadrangles (DOQs) and will provide a detailed methodology in the upcoming months. We will test and fine-tune our habitat map by comparing our map with the LiDAR data collected on the LCSA by the SNAMP Spatial Team.

Estimated Cost

Using data collected on the ESA will not require additional funds to implement while greatly increasing the owl sample size.

Recommended Course of Action

Upon the study's conclusion, we will examine the relationships between spotted owl territory occupancy and reproduction and such factors as SPLAT effects (both as a categorical and continuous [i.e., changes in habitat composition] variable), pre-existing habitat conditions, and climate. Models representing hypothetical relationships between explanatory and response variables will be compared using either Akaike's Information Criterion (under a model-selection framework) or Bayes Information Criterion (under a

Bayesian framework). The final set of candidate models will be developed at future Integration Team meetings.

In summary, this revised design will be more in the framework of a quasi-experiment than a true experiment because treatment and "control" sites will not be selected at random, but the treatments will be similar across subjects. We believe that this revision provides the best alternative to meet the intent of the SNAMP, which is to evaluate the effect of SPLATS on key resources in the central Sierra Nevada, which in our case is the effect of SPLATS on spotted owls.

Literature Cited

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Gutiérrez, R.J., S. Whitmore, M. Seamans, G. Zimmerman, P. Stine, and P. Williams. 2008. Acute effects of canopy reduction on California spotted owls: challenges for adaptive management. Final report to U.S. Forest Service, Pacific Southwest Research Station, Davis, CA. 51 pp.

Verner, J., K. S. McKelvey, B. R. Noon, R. J. Gutiérrez, G. I. Gould Jr, and T. W. Beck. 1992. The California spotted owl: a technical assessment of its current status. General Technical Report GTR-PSW-133. U.S. Forest Service, Pacific Southwest Research Station, Berkeley, CA.

APPENDIX 1: Detailed Summary of Proposed Methods to Increase SNAMP Owl Sample Size (from Owl Science Team Work Plan, November 2007).

We have identified four methods to increase the SNAMP owl sample size. In this summary we have summarized each method and its strengths/weaknesses below. The methods are listed in order of the owl research team's preference.

OPTION 1—Determine if owl territories on the Eldorado Population Monitoring Study Area have experienced SPLAT or SPLAT-like treatments, and then use these territories as possible samples for inclusion in the SNAMP owl study.

Strengths

- No additional field effort is required (i.e., the data has already been collected). *As a result, this method will incur no additional fiscal costs for the owl portion of the SNAMP.*
- We have extensive pre- and post-treatment data on occupancy, survival, and reproduction of owls on these sites.

Weaknesses

- Because the treatments have already occurred, a confounding effect of time will be present. This is particularly critical for reproductive output, which has a large amount of annual variation due to climatic influences. The time effect will have far less importance for territory occupancy, which has lower annual variation than reproductive output. In addition, occupancy is conditional only on a bird having been present at a site prior to the treatment.
- Treatments (i.e., past fuels reduction projects on the Eldorado Study Area) may not be identical to treatments on SNAMP firesheds.

Important note: We caution that a confounding effect due to differences in time of treatment is a general concern for all aspects of the SNAMP. If SPLAT treatments for the SNAMP are applied sequentially over the course of several years (e.g., due to constraints encountered by the Forest Service during project implementation), we are concerned that treatment effects on a response variable could be confounded by time effects if significant annual variation exists in the response variable.

OPTION 2—Continue to monitor owl territories on the Eldorado Study Area and include in the SNAMP owl study any sites that receive SPLAT treatments within the same timeframe that treatments occur on the SNAMP study sites.

Strengths

- No additional field effort (i.e., no additional cost) is required beyond our ongoing effort on the Eldorado Study Area. *As a result, this method will incur no additional fiscal costs for the owl portion of the SNAMP.*
- There are no (or reduced) confounding effects due to time of treatment.

Weaknesses

- An insufficient number of SPLAT treatments may occur on the Eldorado Study Area during the timeframe of the SNAMP study.

OPTION 3—Determine if there are additional sites (i.e., outside of the SNAMP or Eldorado Study Area) on the Tahoe or Eldorado National Forests that: 1) are scheduled to receive SPLAT treatments during the same timeframe that treatments occur on the SNAMP, and 2) are near designated owl Protected Activity Centers (PACs). If so, survey and monitor these sites for possible inclusion in the SNAMP owl study.

Strengths

- There are no (or reduced) confounding effects due to time of treatment.

Weaknesses

- This approach will be logistically difficult because pre-treatment data (surveys, capture, banding, and monitoring of owls) will need to be collected. The Forest Service will need to provide the owl research team with sufficient notice of any planned SPLAT treatments.
- This approach has risk because planned SPLAT treatments may be delayed or prevented by logistic constraints or legal challenges. We may also fail to find an occupied owl territory within or near the treatment sites (despite the presence of a designated owl PAC in the area).
- *This method will incur additional (but unknown) costs for the owl portion of the SNAMP*. The amount of the additional cost will depend on several factors: 1) how far these sites are located from the SNAMP and Eldorado Study Areas, 2) the proportion of such sites that actually contain owl territories, and 3) the proportion of such sites in which the SPLAT treatments occur in a timely fashion, if at all (see note above).

OPTION 4—If we fail to find a sufficient sample size through approaches 1 – 3 above, determine if there are additional sites on the Tahoe or Eldorado National Forests that: 1) are scheduled to receive SPLAT treatments during the same

timeframe that treatments occur on the SNAMP, and 2) are *not* near designated owl Protected Activity Centers (PACs). If so, survey and monitor these sites for possible inclusion in the SNAMP owl study.

Strengths

- There are no (or reduced) confounding effects due to time of treatment.

Weaknesses

- This approach will be logistically difficult because pre-treatment data will need to be collected (initial owl surveys, capture, banding, monitoring), so the Forest Service will need to provide the owl research team with sufficient notice of any planned SPLAT treatments.
- This approach will be even riskier than the previous method. In addition to the risk of logistic constraints and/or legal challenges, we expect a lower probability of finding occupied owl territories at these sites (as compared to sites near owl PACs).
- *This method will incur additional (but unknown) costs for the owl portion of the SNAMP*. The amount of the additional cost will depend on several factors: 1) how far these sites are located from the SNAMP and Eldorado Study Areas, 2) the proportion of such sites that actually contain owl territories, and 3) the proportion of such sites in which the SPLAT treatments occur in a timely fashion, if at all.

APPENDIX 2: Vegetation Survey Instructions for SNAMP

***Equipment Needed*:**

1 GPS unit
Measuring tapes (at least 2 50-m tapes)
2 dbh tapes
1 densitometer
1 pole for measuring understory cover
1 compass
1 clinometer
1 range finder
Flagging
Hammer
Small nails
Numbered tree tags
Stakes (at least 5)
Clipboard
Data forms
Notebook
Pencils/pens
Map of plot locations
List of plot UTMs

Plot Layout (see Figure 1):

Placement of plot center:
Proceed to the assigned UTM coordinates for the plot number using the GPS unit, making sure that the GPS is obtaining 3D reception. Stop when the GPS unit indicates that you are 0.00 m away; this is the plot center. Record the UTM coordinates on the data form (in most cases, you will be within a few meters of the assigned coordinates).

Attach a numbered aluminum tree tag using aluminum nails to the tree nearest the plot center, on the side of the tree facing the plot center. The tag should be placed near the base (between ground level and 9 cm [~ 6 inches] above ground level) to avoid its loss if the tree is harvested during the treatment. Record the tag number, tree species, and tree dbh on the data form. Apply spray paint to the very base of the tree in four locations—uphill side, downhill side, and on each side facing along the slope contour.

Transect placement:
Establish the first transect in a random direction from the plot center. To get a random direction, spin your compass until your co-worker says "when." Then stop the compass and this will be your direction to orient the first 25-m transect. Next establish the second 25-m transect in the opposite direction. For the other 2 transects, orient them so that they

are perpendicular to the first 2 transects. You may want to flag the end of each transect, as well as the 12.5-m mark.

Plot placement:
We will collect vegetation data within 2 circular plots. The large plot will have a 25-m radius (the entire transect length), and the smaller plot will have a 12.5-m radius. We will measure all trees ≥15 cm dbh within the smaller plot (12.5-m radius), but only trees ≥75 cm dbh within the larger plot.

***Data Collection*:**

Aspect:
From the plot center, record the downhill direction in degrees using a compass. Pretend you are a stone, which way would you roll? If flat, record with a dash.

Slope:
From the plot center, record the % slope using the % scale on the clinometer (= the scale on the right hand side of the image viewfinder). You must sight on an object at the height of your eye (i.e., the same height as the clinometer). Take 2 readings—facing downhill (i.e. same direction as the aspect) and facing uphill (i.e. opposite direction as the aspect). Calculate the average of the two readings (all readings are positive numbers, regardless if facing downhill or uphill).

Trees within the 12.5-m plot:
Measure and record the dbh of all trees ≥15 cm dbh, record the species name using a 4-letter acronym (see list), and mark S for each snag (i.e. dead tree). Measure all stumps, and record the species name. If you are unsure of the species, mark "H" for hardwood and "C" for conifer.

Trees within the 25-m plot:
Measure and record the dbh of all trees ≥75 cm dbh, record the species name, and mark S for each snag (i.e. dead tree). Make sure that these data are recorded on the form in the separate column labeled "outside 12.5-m plot." The data for each plot must be kept separate, in order to calculate tree basal area per unit area.

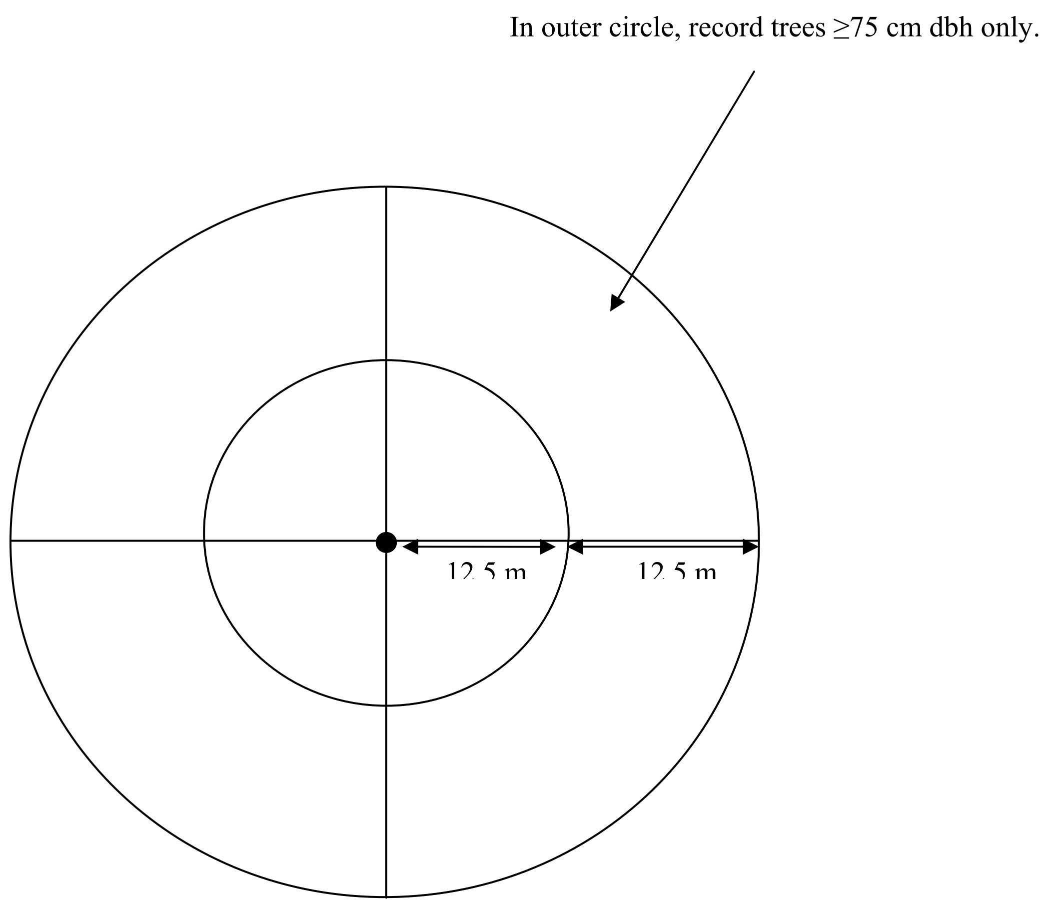
Canopy cover:
Take a reading every meter along two 25-m canopy cover transects, for a total of 50 readings. Your starting point will be the 12.5-m mark on one of the plot transects. Move one meter towards the plot center and repeat the process until you reach the 12.5-m mark on the opposite side. Note that you will not take a reading at the exact plot center. Repeat this procedure for the 25-m transect that is perpendicular to the initial transect.

Use the densitometer to measure canopy cover. While looking through the densitometer, balance the level bubbles inside the densitometer. Record whether or not the dot in the view frame contains canopy vegetation (= 1) or contains open sky (= 0). Count the number of 1's, and multiply ×2 to estimate the total % canopy cover at this plot.

Understory cover:
Plant the cover pole in the ground at the plot center. Standing at the 12.5-m mark on each of the plot transects, record how many of the 0.1-m bands on the cover pole (i.e. each red or white section) are obscured at least 25% by vegetation.

Downed logs:
Count the number of downed logs with a large end ≥25 cm dbh, and for which the large end lies inside the 12.5-m plot.

Figure 1. Plot layout for vegetation data collection by SNAMP Owl Team.



APPENDIX 3: Biographical Sketch of the Principal Investigator

RALPH J. GUTIIRREZ
Department of Fisheries, Wildlife, and Conservation Biology
University of Minnesota
St. Paul, MN 55108
612-624-2720 gutie012@tc.umn.edu

PROFESSIONAL PREPARATION

Colorado State University	Wildlife Biology	B.S., 1971
University of New Mexico	Biology	M.S., 1973
University of California, Berkeley	Zoology	Ph.D., 1977

POSITIONS AND ACADEMIC APPOINTMENTS

Professor and Gordon Gullion Endowed Chair in Forest Wildlife Research (2001-Present), *Department of Fisheries, Wildlife, and Conservation Biology, University of Minnesota, St. Paul, MN.*

Assistant to Professor (1979-2000), *Department of Wildlife, Humboldt State University, Arcata, CA.*

Assistant Professor, (1977-1979), *Department of Natural Resources, Cornell University, Ithaca, NY.*

PUBLICATIONS (TOTAL: 123 PEER-REVIEWED PAPERS; 8 EDITORSHIPS; 1 BOOK)

Recent Papers (last 5 years) Closely Related to the Project:

Anthony, R.G., E.D. Forsman, A.B. Franklin, D.R. Anderson, K.P. Burnham, G.C. White, C.J. Schwarz, J. Nichols, J.E. Hines, G.S. Olson, S.H. Ackers, S. Andrews, B.L. Biswell, P.C. Carlson, L.V. Diller, K.M. Dugger, K.E. Fehring, T.L. Fleming, R.P. Gerhardt, S.A. Gremel, R.J. Gutiérrez, P.J. Happe, D.R. Herter, J.M. Higley, R.B. Horn, L.L. Irwin, P.J. Loschl, J.A. Reid, and S.G. Sovern. 2006. Status and trends in demography of northern spotted owls, 1985-2003. Wildlife Monographs 163.

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Crozier, M. E. Seamans, R. J. Gutiérrez, P. J. Loschl, R. B. Horn, S. G. Sovern, and E. D. Forsman. 2006. Does the Presence of Barred Owls Suppress the Calling Behavior of Spotted Owls? Condor 108:760-769.

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Gutiérrez, R. J., M. Cody, S. Courtney, and Alan B. Franklin. 2007. The invasion of barred owls and its potential effect on the spotted owl: a conservation conumdrum. Biological Invasions 9:181-196.

Gutiérrez, R. J. 2008. Spotted Owl Research: a quarter century of contributions to education, ornithology, ecology, and wildlife management. Condor 110:792-798.

LaHaye, W. S., and R. J. Gutiérrez. 2005. The spotted owl in Southern California: ecology and special concerns for the maintenance of a forest dwelling species in a human dominated, desert landscape. In Kus, B. E., and J. L. Beyers (Technical Coordinators. Planning for biodiversity: bringing research and management together. U.S. Forest Service, Gen. Tech. Rep. PSW-GTR 195.

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Seamans, M. E., and R. J. Gutiérrez. 2006. Spatial dispersion of spotted owl sites and the role of conspecific attraction on settlement patterns**.** Ecology, Ethology, and Evolution 18:99-111.

Seamans, M. E., and R. J. Gutiérrez. 2007. Sources of variability in spotted owl population growth rate: testing predictions using long-term mark-recapture data. Oecologia 152:57-70.

Seamans, M.E., and R.J. Gutiérrez. 2007. Habitat selection in a changing environment; the relationship between habitat alteration and spotted owl territory occupancy and breeding dispersal. Condor 109:566-576.

Zimmerman, G. S., R. J. Gutiérrez, and W. S. LaHaye. 2007. Finite study areas and vital rates: sampling effects on estimates of spotted owl survival and population trends. Journal of Applied Ecology 44:963-971.

SYNERGISTIC ACTIVITIES

Workshops Organized to Integrate and Transfer Knowledge (1998-2001): Workshop on Analysis of Demographic Rates of California Spotted Owls (Colorado State University) and Northern Spotted Owls (Colorado State University; Oregon State University); Co-developed short course on "Applying remote sensing techniques to Wildlife Habitat analysis" (Humboldt State University).

Participation in Review Teams Applying Science to Conservation Problems: (1) Member, Scientific Review Panel for 5-year Review of Federal Listing Status of the Northern Spotted Owl (2003 - 2006), *Sustainable Ecosystem Institute, Portland, Oregon*; (2) Member, Congressional review of Heger-Feinstein Quincy Library Group Act, Gifford Pinchot Institute, Washington, D.C. (3) Member, Federal Advisory Team to review U.S. Forest Service Sierra Nevada Forest Management Strategy (1997), *Congressional Appointment through USDA Forest Service [Received Conservation Award 1997]*; (4) Member, California Spotted Owl Technical Assessment Team (1990-1992). *U. S. Forest Service, Sacramento, California [Received 3 Conservation Awards {1992, 1992, 1994} and 1 Publication Award {2001}]*; (5) Member, Northern Spotted Owl Recovery Team (1990 – 1992), *U. S. Fish and Wildlife Service, Portland, Oregon [Received Citation for Exceptional Service in 1992 from the Secretary of the Interior]*.

Contributions to Minority Participation in Science and University Education: (1) NIH Minority Representative from U.C. Berkeley to a national workshop on minority participation in Science (1975); (2) Development of biology teaching module in the College Enrichment Program for underrepresented students preparing for university life (1972; University of New Mexico); (3) Co-Director, CORE Student Affirmative Action Program to enhance minority participation in University education, particularly science (1981; Humboldt State University).

Service to Professional Scientific Organizations: (1) Humboldt Chapter of The Wildlife Society representative to the Western Section of the Wildlife Society (1981); (2) The Wildlife Society's Representative to The Nature Conservancy (1990-1998); (3) Associate Editor, *Wildlife Biology*; (4) Ad Hoc Associate Editor, Wildlife Monographs and Conservation Biology; (5) Rush Scholarship Committee, The Wildlife Society (2004-2007); (6) Caesar Kleberg Award Committee, The Wildlife Society (2007-2008).

COLLABORATORS & OTHER AFFILIATIONS

Collaborators During past 48 Months: David R. Anderson (Colorado State University), George F. Barrowclough (American Museum of Natural History), William M. Block (Rocky Mountain Research Station), Alan Franklin (USDA, APHIS), Jeffery G. Groth (American Museum of Natural History), Joshua J. Milspaugh (University of Missouri), Darryl Mackenzie (New Zealand), James D. Nichols (Patuxent Wildlife Research Center), Steven M. Redpath (Institute of Ecology and Hydrology, Banchory, Scotland), Brian Reilly (Tashwane University, South Africa), Peter Stine (PSW), Gary C. White (Colorado State University).

Graduate and Postdoctoral Advisors: A. Starker Leopold (Ph.D.; University of California, Berkeley), J. David Ligon (M.S.; University of New Mexico).

Graduate Students Advised (University of Minnesota 10) : Lorelle Berkeley, PhD., Andrea Chatfield, M.S. (2005), Jeremy Rockweit, M. S., Mark Seamans, PhD. (2005), Jonathan Slaght, PhD., Douglas Tempel, M.S. (2002), Douglas Tempel, PhD., Perry Williams, M.S., Guthrie Zimmerman, PhD. (2006), Meadow Kouffeld, M.S. (*Humboldt State University* 35) – Individuals not listed, but all M.S. [no PhD program at Humboldt State]

Undergraduate Research and Theses Advised (40+): not listed, 5 at University of Minnesota and remainder at Humboldt State University