Effects of Forest Biomass Removal on Bird and Small Mammal Communities in the Sierra Nevada

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Introduction

The montane mixed-conifer forests of the Sierra Nevada were historically characterized as being highly clustered with groups of trees separated by sparsely treed or open gap conditions (Lieberg 1902, Bonnickson and Stone 1982, North et al. 2007). Tree clustering has many beneficial ecological effects, including increasing plant diversity and shrub cover (North et al. 2005) and providing a variety of microhabitat conditions for birds (Purcell and Stephens 2005) and small mammals (Innes et al. 2007, Meyer et al. 2007). This forest structure was maintained primarily by fires that burned at intervals of a few years to decades (Biswell 1989, Agee 1993, Swetnam 1993)**.** However, a century of logging, fire suppression and other factors have disrupted these natural processes and resulted in forests that are unrepresentative of historical conditions (SNEP 1996) and prone to catastrophic wildfires.

The risk and costs associated with catastrophic wildfires has led to a more proactive approach to managing forests through fuels reduction treatments (e.g., HFRA 2003, USDA SNFPA 2004) in the last decade. In addition, the growing interest in domestically available, low-carbon fuel sources provides potential economic incentives for the wider implementation of fuels reduction treatments. These treatments aim to reduce surface fuels, remove midstory and understory vegetation (i.e. “ladder fuels”) and open the forest canopy, thereby reducing overall biomass (Agee and Skinner 2005, Stephens and Moghaddas 2005a, Collins et al. 2007). While fuels reduction treatments have been shown in models to reduce the risk of high-severity wildfires (Stephens and Moghaddas 2005a), there is limited information available on their impacts to wildlife.

Altering forest structure using fuels treatments will undoubtedly alter wildlife abundance and community composition. Increases in tree spacing, reductions in woody debris, and reductions in diversity or biomass of understory plants, truffles, and lichens can negatively affect canopy-associated species, such as northern flying squirrel (*Glaucomys sabrina*) and Douglas squirrel (*Tamiasciurus douglasii*) (Bull et al. 2004, Lehmkuhl et al. 2004, Meyer et al 2005). Understory-associated mammals, such as shrews, voles, and mice are vulnerable to changes in ground cover and truffle abundance (Campbell and Clark 1980; Bull and Blumton 1999), which can be highly altered where mastication or burns have taken place. Dead wood provides critical habitat for wildlife and logs are frequently lost through post-harvest slash treatments (Stephens and Moghaddas 2005b). Snags, important for nesting and foraging birds, are often lost because of their potential hazard to people during thinning and prescribed burn operations, thereby negatively impacting cavity nesting species (Scott and Oldemeyer 1983, Machmer 2002, Bull et al. 2005). However, few of these studies have focused on small mammal and bird communities within the Sierra Nevada, and prior research has generally focused on treatment regimes that differ significantly from those implemented in fuels reduction management. Existing results are mixed, necessitating further investigation. Furthermore, few studies have focused on multiple species/taxa responses and community dynamics.

Bird and small mammals comprise an important component of the vertebrate biomass and diversity of forests. Birds are readily detected and use multiple elements of forest structure. Small mammals influence forest vegetation structure through consumption and dispersal of seeds and hypogeous fungi (Tevis 1956, Gashwiler 1970, Maser et al. 1978, Price and Jenkins 1986). Furthermore, songbirds and small mammals are an important food source for forest carnivores (Koehler and Hornocker 1977) including special status species like Pacific fisher (*Martes pennanti*), American marten (*Martes americana*), California Spotted Owl (*Strix occidentalis*), and Northern Goshawk (*Accipiter gentilis*). Together, birds and small mammals are excellent indicators of forest ecosystem health because populations of both taxa can respond rapidly to changes in forest structure.

Objectives

Fuels reduction treatments can consist of a range of types and combinations of treatments, including different starting conditions (tree sizes and densities, fuel volumes by type), thinning prescriptions (the number, type, and location of trees removed and remaining), and reduction of remaining fuels (mastication, biomass removal, prescribed fire). All treatments involve the removal of biomass, but some treatment types result in greater biomass removal than others. This study will pursue the evaluation of fuels reduction treatments as a gradient of intensities of treatments to enhance the ability to predict the effects of various planned or considered treatments at site and the landscape scales. Responses can be most effectively and feasibly measured at the site scale, but cumulative effects at the landscape scale will ultimately drive the effects on biological diversity. The study will quantify site-scale responses of various treatment types and intensities and then use these results to predict the effects of various landscape-scale treatment scenarios.

In the current project, we are evaluating the effects of fuels-reduction treatments in Sierran conifer forests on vertebrate biological diversity. Our objectives are to (1) determine stand-scale responses of songbirds and small mammals to different intensities of fuels reduction treatments (2) compare responses of songbirds and small mammals with other forest management objectives, such as reducing surface and ladder fuels and the risk of crown fire and (3) determine how different landscape management scenarios would affect the proportion of the landscape that provides suitable habitat for various species of birds and small mammals that represent different life history characteristics and habitat needs. The results of this study will help land managers predict wildlife responses to various fuels reduction treatment scenarios at both the stand and landscape levels.

Declines in biomass and carbon are predicted to have variable effects on birds and small mammals, depending on residual forest structure. We predict that similar levels of biomass removal will have a lower impact on species associated with old-forest conditions when residual biomass is spatially heterogeneous such that pockets of old-forest conditions are retained. The size and density of old-forest pockets required to retain old-forest associates will vary with the home range size and environmental plasticity of individual species. Conversely, we predict that homogenous and/or simplified stand structure will favor species adapted to more disturbed environmental conditions, thereby resulting in more homogeneous, less diverse bird and small communities.

Study Design

Sugar Pine Study Area

This project is located on the western slope of the Sierra Nevada on the Sierra National forest in the 1350 – 1700 m elevational zone (montane conifer forests). A large scale study is currently being conducted at this site and is being led by the University of California, Berkeley, and it is designed to evaluate stand and landscape-scale ecological effects of fuels reduction treatments in the form of SPLATS (strategically placed area treatments). We will sample vertebrate biodiversity on these sites and work in collaboration with the science team to assess ecological responses – initial and modeled over time.

The United States Forest Service district personnel are implementing thinning treatments at the Sugar Pine site beginning fall 2010 and continuing into 2012. Three types of treatments are planned –mechanical thinning, tree mastication, and prescribed fire. Due to the scarcity of proposed burn areas in the landscape, we opted not to test the effects of this treatment. The Sugar Pine study area consists of two adjacent watersheds: one treatment and one control. However, the various thinning treatments are only being applied in select locations, leaving "controls" within the treatment watershed. As a result, grid points were designated treatment-commercial thin (T), treatment- mastication (M), control-treatment watershed (CT), or control-control watershed (CC). Points were also assigned to one of seven vegetation groups based on the dominant tree species. Points that fell into vegetation groups with very low representation (e.g., no trees, ponderosa pine, giant sequoia) were not sampled. A representative sample of points from each stratum was selected for bird surveys and mammal trapping. Vegetation and fuels data were collected from 2006 to 2008, and pre-treatment fire behavior modeling has been completed (e.g., Collins et al. 2010).

Field Sampling

Birds

Bird point count surveys will be conducted each year in each study area at all grid points for two years pre- and post-treatment. The two pre-treatment years may or may not be consecutive, depending on the timing of treatments; ideally, the second pre-treatment sampling event will occur no more than 1 yr prior to treatment. Post-treatment sampling will be conducted the 1st and 2nd years following treatment.

At each grid point, a 10-minute point count survey will be conducted with all individuals seen and heard recorded in 20-m distance intervals out to >100 m (Ralph et al. 1993), with three counts conducted at each point between May 15 and July 10. New species encountered while moving between point count stations also will be recorded. Counts will be conducted between 15-minutes after sunrise and 0930 hrs. Counts will not be conducted when precipitation is occurring or when winds exceed 5 mph. A cluster of point stations around each grid point was considered, but it was determined that greater benefit was derived from a larger sample of independent data points.

Small Mammals

Small mammal trapping will be conducted at a total of 60 points consisting of ~30 treatment sites and ~30 control sites. A subset of 10 control sites will be sampled each year to establish a record of annual variability, so the total sample effort sample each year will be ~15 treatment sites and ~20 control sites.

Small mammals will be sampled in a 6 x 8 trap grid with a 30-m distance (150 x 210-m grid; 3.1 ha area) centered on the point. Live-trap sampling methods target small mammal species presence and abundance. This spacing represents a balance between encountering a sufficient number of squirrel home ranges and obtaining a high enough recapture rate for chipmunks and mice to obtain reliable estimates of density (e.g., Jones et al. 1996, Converse et al. 2004). One Tomahawk trap (model 201; 12 x 12 x 40 cm) mounted in a tree and one extra-large (10 x 11 x 38 cm) Sherman trap will be placed at each trap station (n = 96 traps total). Tomahawk traps will be attached to trees 1.5-2.0 m above ground on the trunk of a tree > 20 in dbh that is not marked for removal. Sherman traps will be placed at the base of trees or along larger logs or under shrubs and covered with natural materials (or chloroplast if none are available) to insulate traps from the sun and rain, and polystyrene placed in the back of the trap for warmth. All traps will be baited with a mixture of oats, peanut butter, raisins, and molasses, following the general formula used by Carey et al. (1991): 12 parts oats, 4 parts peanut butter, 2 parts bird seed, 1 part molasses, 1 part raisins.

Traps will be pre-baited for 3 days, and then opened for 5 days and nights and checked twice per day. All individuals captured will be marked in a manner that minimizes cost, effort, and loss of marks over the life span of the animal. Members of the family Sciuridae will be marked with uniquely numbered eartag (model 1005-1) in each ear. Members of the genera *Peromyscus*, *Microtus* and *Thomomys* will get one ear tag. *Sorex* sp. will be marked by cutting a small patch of fur on the hind quarters (this mark is only effective within a sample year). The following data will be collected on each individual captured: age, sex, breeding status, and weight. Morphological measurements will be taken on individuals with questionable identify. All mortalities will be uniquely identified and donated to the University of California vertebrate museum collection.

Data Analysis

Stand-scale relationships between environmental conditions and birds and small mammals will be modeled using multiple regression analysis techniques. Bird and small mammal communities will be characterized by species richness, species dominance, and total abundance. In addition, the relative abundance and uncorrected density (based on area occupied by the grid plus a buffer of 20m) of individual species and ecological groups will be characterized. Density estimates corrected for probability of capture will be calculated for species with sufficient recapture rates.

Environmental variables will characterize a range of physical and biological conditions that are expected to influence the occurrence, abundance, and density of birds and small mammals. Vegetation data will quantify treatment effects on stand structure through the following variables: tree density by size class, sapling density, vertical vegetation diversity, horizontal tree distribution, snag density by size and decay class, coarse woody debris density by size and decay class, canopy closure, shrub and herbaceous ground cover, litter cover. Vegetation and fuels data will also be used to characterize fuels, biomass, and carbon to compare relative changes of biota and biomass to fuels reduction treatments. Abiotic and contextual characteristics will also be analyzed, including elevation, average precipitation, temperature, slope, aspect, and vegetation community types and stand structure classes around each sample point.

Multiple regression will be used to generate predictive models for abundance and richness measures at the stand scale based on observed changes in birds and small mammals in response to treatments. Logistic regression will be used to relate select habitat variables to the occurrence of key mature-forest associated species, such as northern flying squirrels. Akaike's Information Criterion (AIC) will be used to develop models of the association between species and community metrics and environmental conditions at each sample point (Burnham and Anderson 2002). Models will be used to test influential factors associated with various measures of diversity following fuels reduction treatments. Environmental relationships established based on stand-scale data will be used to model responses to landscape-scale treatments and compare them to responses to those of fire behavior, biomass, and carbon. Results will be compared across study areas to characterize variability in responses and relationships relative to larger-scale environmental influences. These analyses will inform the ecological trade-offs associated with site and landscape-scale fuels reduction treatments in terms of fire behavior, biomass generation, carbon sequestration, and biological diversity.

Literature Cited

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

Agee, J.K. and C.N. Skinner. 2005. Basic principles of forest fuel reduction treatments. Forest Ecology and Management. 211:83–96.

Biswell, H.H., 1989. Prescribed Burning in California Wildlands Vegetation Management. University of California Press, Berkeley.

Bonnicksen, T.M., and Stone, E.C., 1982. Reconstruction of a presettlement giant sequoia – mixed conifer forest community using the aggregation approach. Ecology 63:1134–1148.

Bull, E.L. and A.K. Blumton. 1999. Effect of fuels reduction on American Marten and their prey. Res. Note PNW-RN-539. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 10 p.

Bull, E.L., T.W. Heater, and A. Youngblood. 2004. Arboreal squirrel response to silvicultural treatments for dwarf mistletoe control in northeastern Oregon. Western Journal of Applied Forestry. 19:133-141.

Bull, E.L., A.A. Clark, and J.F. Shepherd. 2005. Short-term effects of fuel reduction on pileated woodpeckers in northeastern Oregon—a pilot study. Res. Pap. PNW-RP- 564. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 17 p.

Burnham, K.P. and D.R. Anderson. 2002. Model Selection and Multimodel Inference. Springer, New York, NY.

Campbell, T.M., III, and T.W. Clark. 1980. Short-term effects of logging on red-backed voles and deermice. Great Basin Naturalist. 40:183-189.

Carey, A. B., B. L. Biswell, and J. W. Witt. 1991. Methods for measuring populations of arboreal rodents. USDA Forest Service Gen. Tech. Rept. PNW-GTR-273. Pacific Northwest Research Station, Portland, OR.

Collins B.M., M. Kelly, J.W. van Wagtendonk, and S.L. Stephens. 2007. Spatial patterns of large natural fires in Sierra Nevada. Landscape Ecology. 22:545–557.

Collins, B.M., S.L. Stephens, J. Moghaddas, and J. Battles. 2010. Challenges and approaches in planning fuel treatments across fire-excluded forested landscapes. Journal of Forestry. 108:24-31.

Converse, S. J., B. G. Dickson, G. C. White, W. M. Block. 2004. Estimating small mammal abundance on fuels treatment unites in southwestern ponderosa pine forests. Pages 113-

120 *in* C. van Riper and K. L. Cole, eds. The Colorado Plateau: cultural, biological, and physical research. University of Arizona Press, Tucson, Arizona.

Gashwiler, J. S., 1970. Plant and animal changes on a clearcut in west-central Oregon. Ecology. 51:1018-1026.

HFRA, 2003. Healthy Forest Restoration Act of 2003. Public Law 108-148. Statutes at Large 117, 1887-1887.

Innes, R.J., D.H. van Vuren, D.A. Kelt, M.L. Johnson, J.A. Wilson, and P.A. Stine. 2007. Habitat associations of dusky-footed woodrats (*Neotoma fuscipes*) in mixed-conifer forest of the northern Sierra Nevada. Journal of Mammalogy. 88:1523-1531.

Jones, C., W.J. McShae, M.J. Conroy, and T.H. Dunz. 1996. Capturing mammals. Pages 115–155 *in* D.E. Wilson, F.R. Cole, J.D. Nichols, et al., eds. Measuring and monitoring biological diversity: standard methods for mammals. Washington, DC: Smithsonian Institution Press.

Koehler, G.M. and M.G. Hornocker. 1977. Fire effects on marten habitat in the Selway-Bitterroot wilderness. Journal of Wildlife Management. 41:500-505.

Lehmkuhl, J.F., L.E. Gould, E. Cazares, and D.R. Hosford. 2004. Truffle abundance and mycophagy by northern flying squirrels in eastern Washington forests. Forest Ecology and Management. 200:49-65.

Lieberg, J.B. 1902. Forest conditions in the northern Sierra Nevada, California. US Geological Survey Prof. Pap. 8, Series H, Forestry 5, Government Printing Office, Washington, D.C.

Machmer, M. 2002. Effects of ecosystem restoration treatments on cavity-nesting birds, their habitat, and their insectivorous prey in fire-maintained forests of southeastern British Columbia. In: Proceedings of the symposium of the ecology and management of dead wood in Western forests. Gen. Tech. Rep. PSW-GTR-181. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station: 121-133.

Maser, C., J.M. Trappe, and R.A. Nussbaum. 1978. Fungal-small mammal interrelationships with emphasis on Oregon coniferous forests. Ecology. 59:799-809.

Meyer, M.D., M.P. North, and D.A. Kelt. 2005. Short-term effects of fire and forest thinning on truffle abundance and consumption by *Neotamias speciosus* in the Sierra Nevada of California. Canadian Journal Forest Research. 35:1061-1070.

Meyer, M.D., D.A. Kelt, and M P. North. 2007. Effects of burning and thinning on lodgepole chipmunks (*Neotamias speciosus*) in the Sierra Nevada, California. Northwestern Naturalist. 88:61-72.

North, M.P., B. Oakley, R. Fiegener, A. Gray, and M. Barbour. 2005. Influence of light and soil moisture on Sierran mixed-conifer understory communities. Plant Ecology. 177:13–24.

North, M.P., R.J. Innes, and H. Zald. 2007. Comparison of thinning and prescribed fire restoration treatments to Sierran mixed-conifer historic conditions. Canadian Journal of Forest Research. 37:331–342.

Price, M. V. and S. H. Jenkins. 1986. Rodents as seed consumers and dispersers. Pages 191-235 *in* D.R. Murray, ed.. Seed dispersal. Academic Press, Sydney, Australia.

Purcell, K. and S.L. Stephens. 2005. Changing fire regimes and the avifauna of California oak woodlands. Studies in Avian Biology. 30:33–45.

Ralph C.J., G.R. Geupel, P. Pyle, T.E. Martin, and D.F. DeSante. 1993. Handbook of field methods for monitoring landbirds. Pacific Southwest Research Station, Albany, CA.

Scott, V.E. and J.L. Oldemeyer. 1983. Cavity-nesting bird requirements and response to snag cutting in ponderosa pine. Pages 19-23 *in* Davis, J.W., G.A. Goodwin, and R.A.

Ockenfels, tech. coords. Snag habitat management: proceedings of the symposium. Gen. Tech. Rep. RM-GTR-99. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station.

Sierra Nevada Ecosystem Project (SNEP). 1996. Sierra Nevada Ecosystem Project: Final Report to Congress. Wildland Resources Center Report No. 37. Centers for Water and Wildland Resources, University of California, Davis.

Stephens, S.L. and J.J. Moghaddas. 2005a. Experimental fuel treatment impacts on forest structure, potential fire behavior, and predicted tree mortality in a California mixed conifer forest. Forest Ecology and Management. 215:21–36.

Stephens, S.L. and J.J. Moghaddas. 2005b. Fuel treatment effects on snags and coarse woody debris in a Sierra Nevada mixed conifer forest. Forest Ecology and Management. 214:53–64.

Swetnam, T.W. 1993. Fire history and climate change in giant sequoia groves. Science. 262:885–889.

Tevis, L., Jr. 1956. Responses of small mammal populations to logging of Douglas-fir. Journal of Mammalogy. 37:189-196.

USDA SNFPA. 2004. USDA Forest Service. Sierra Nevada Forest Plan Amendment: Final Supplemental Environmental Impact Statement, Record of Decision. January 2004.