Small Mammals of the Bitterroot National Forest: Ecological Significance and Guidelines for Management

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Abstract—Small mammal literature was reviewed to assess the ecological role of small mammals on the Bitterroot National Forest of western Montana. Small mammals fulfill numerous important roles in forest ecosystems by supporting a wide range of predators, dispersing seeds and mycorrhizal spores, altering vegetation through herbivory and seed predation, and preying on insects. Coarse woody debris (CWD) is among the most important habitat components for forest small mammals. Guidelines are suggested for managing CWD for small mammal populations with an emphasis on CWD recruitment.

The Bitterroot National Forest (Bitterroot Forest) initiated the Bitterroot Ecosystem Management Research Project (BEMRP) to develop an ecosystem-level approach to restoring forests altered by fire suppression and timber harvest. Low- to mid-elevation habitats on the Bitterroot Forest were historically dominated by park-like ponderosa pine (*Pinus ponderosa*) and ponderosa pine-western larch (*Larix occidentalis*) cover types, which were maintained by frequent, low-intensity fires (Arno 1976). Fire suppression and timber harvest have encouraged the encroachment of dense stands of Douglas-fir (*Pseudotsuga menziesii*) and grand fir (*Abies grandis*). Overcrowded stands and ensuing competition for limited resources has increased the susceptibility of these forests to disease, insect infestations, and high intensity, stand-replacing fire. By reintroducing periodic, low intensity fire in conjunction with thinning methods, researchers and managers seek to reestablish fire-dependent communities to pre-settlement conditions, thereby increasing forest health.

Literature was reviewed to develop a small mammal species list for the Bitterroot Forest and assess potential effects of proposed Ecosystem Management (EM) on small mammal communities, the predators they support, and the roles they play in forest ecosystems (Pearson 1999a). I sought distribution records from the Montana Natural Heritage Program Element Occurrence database, and reviewed published species' distributions and surveys conducted within the Bitterroot Valley for those families most commonly recognized as comprising the North American small mammals. Those families are shrews (Soricidae); moles (Talpidae); pikas (Ochotonidae); squirrels (Sciuridae); pocket gophers (Geomyidae); heteromyids (Heteromyidae); mice, rats, and voles (Muridae); and jumping mice (Zapodidae). I also included all families of bats (Order Chiroptera) and one species from the rabbit family (Leporidae), the snowshoe hare (*Lepus americanus*).

Forty-one species of small mammals were identified as occurring on, or likely to occur on, the Bitterroot Forest. Four species of bats, two species of shrews, and the northern bog lemming (*Synaptomys borealis*) were ranked by the Montana Natural Heritage Program as species of special concern at the state level. Pearson (1999a) reviewed the conservation status and provides brief management guidelines for each species of special concern.

Although early research on forest small mammals arose from concerns over the potentially deleterious impacts of small mammals' seed predation (Tevis 1956), researchers now recognize that small mammals play significant positive roles in forest ecosystems such as dispersers of seeds (Abbott and Quink 1970) and mycorrhizal spores (Maser and others 1978), predators of important forest insect pests (Holling 1959; Smith 1985; Andersen and Folk 1993), and prey base for rare and sensitive forest carnivores (Ruggiero and others 1994).

Insectivory is an important, but often overlooked role that small mammals play in ecosystems. For instance, deer mice (*Peromyscus maniculatus*), white-footed mice (*P. leucopus*), and shrews may help control important forest pests such as pine sawflies (*Neodiprion sertifer*), gypsy moths (*Lymantria dispar*), and acorn weevils (*Curculio* spp.) (Holling 1959; Smith 1985; Andersen and Folk 1993), and cinereus shrews (*Sorex cinereus*) can function as keystone predators that increase arthropod diversity by depredating dominant insects (Platt and Blakley 1973). However, small mammals can also heavily depredate beneficial insects such as the gall flies (*Urophora* spp.) released for the biological control of spotted knapweed (*Centaurea maculosa*) (Pearson and others 2000; Pearson 1999b). Based on laboratory feeding trials, Pearson and others (2000) showed that deer mice could consume nearly 1,200 larvae/mouse/day, illustrating the great predatory potential of small mammals on insects.

In addition to functioning as prey for sensitive species of forest carnivores and raptors, some small mammals also play important indirect roles in supporting some of these species. For instance, red squirrel middens provide rest sites (Buskirk 1984) and den sites (Ruggiero and others 1998) for American martens (*Martes americana*), and martens use middens to access subnivean prey at times when winter snows would otherwise prevent predators from reaching small mammals (Sherburne and Bissonette 1993). Yet red squirrels generally comprise <10 percent of marten diets (Buskirk and Ruggiero 1994). This situation has prompted

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researchers to suggest that a symbiotic relationship may exist between these species in western North America (Buskirk and Ruggiero 1994; Buskirk 1984).

Small mammals clearly play important roles in forest ecosystems. As a result, if "Ecosystem Management" is to succeed as such, the potential effects of management practices on small mammals and the processes dependent upon them must be considered. Since wildlife management is habitat management, we must first understand small mammal habitat associations in order to understand potential effects of EM on small mammal communities.

Because fire and timber harvest function as forms of disturbance in forest communities that generally reinitiate succession, habitat alterations resulting from EM can best be thought of as degrees of movement along the successional gradient. For instance, a clearcut or stand-replacing fire will completely reinitialize the process of secondary succession whereas selective cutting or a windstorm causing sporadic blowdown will initiate fine-scale succession within canopy openings. In the Northern Rocky Mountains, secondary succession progresses from grasses and forbs, to shrubs, saplings, young forest, and mature forest. If the stand continues to mature without disturbance, old-growth characteristics such as large diameter trees and snags and large diameter logs will develop.

Small mammals can also be tied to stages of plant succession to develop a Small Mammal Succession Model (SMSM). For instance, montane (*Microtus montanus*), long-tailed (*M. longicaudus*), and meadow (*M. pennsylvanicus*) voles associate primarily with the earliest grass and forb stages, whereas red-backed voles (*Clethrionomys gapperi*) and northern flying squirrels (*Glaucomys sabrinus*) reside within climax and old-growth forest. Chipmunks (*Tamias* spp.) favor shrubs that dominate early seral stages, red squirrels (*Tamiasciurus hudsonicus*) are linked to mature forest, and deer mice occur anywhere along the gradient.

As vegetation predictably responds to the successional process at multiple spatial scales, so do small mammals. For example, if we apply our understandings of forest succession and the SMSM to EM in ponderosa pine stands heavily invaded by Douglas-fir, we might expect low densities of grasses, forbs, and shrubs due to excessive shading beneath Douglas-fir thickets. At the microhabitat scale, small mammals may be depauperate within such Douglas-fir thickets. Deer mice may use these habitats by foraging for seeds and insects, red-backed voles may survive on truffles and seeds, and shrews may forage for insects in the litter, but the habitat will not be highly productive. Within the landscape, such thickets may actually add to the overall species richness because red-backed voles and shrews are rare to absent from the dry ponderosa pine parks without the input of these shady, moist habitats. Removal of Douglas-fir thickets would therefore probably increase small mammal abundance and diversity within the former thicket due to the increased use by deer mice and addition of chipmunks, golden-mantled ground squirrels (*Spermophilus columbianus*), and possibly *Microtus* resulting from increased grasses, forbs, and shrubs. In contrast, the potential loss of red-backed voles and shrews could decrease diversity at the stand level.

Although the Small Mammal Successional Model may provide a good rule of thumb for the direct effects of management on small mammals, managers must keep in mind that indirect effects may disassociate small mammals from their expected habitats through complex interactions. For instance, if opening of the canopy through selective cutting increases the presence of generalist predators such as coyotes (*Canus latrans*) and great-horned owls (*Bubo virginianus*), such sights could become sink habitats (e.g., Van Horne 1983) or predator pits for small mammal populations that might otherwise be expected to increase in response to treatment. This is especially true if features such as logs that can mediate predation by providing hiding and escape cover are also removed or destroyed in the process of timber harvest.

The Small Mammal Successional Model also highlights the fact that many small mammal habitat features are ephemeral. For instance, meadow voles are associated with grass and forb habitats, which can easily be generated by timber harvesting, but disappear rapidly as trees regenerate. To the extent that much of the current focus of EM within the Bitterroot Forest is on reestablishing park-like ponderosa pine and western larch forests by reinstating high frequency, low intensity fire, such ephemeral habitats can be maintained and small mammals are likely to respond to these treatments in a manner predicted by the Small Mammal Succession Model. However, more persistent features of small mammal habitats may be easier to manage successfully.

Coarse woody debris, primarily logs, is a persistent feature in forest systems that is important to many forest small mammals for hiding and escape cover, den sites, travel corridors, and feeding areas (Pearson 1999a). Coarse woody debris is also at the heart of many forest-floor ecosystem functions. It facilitates predator-prey interactions in winter by providing predators such as martens and weasels (*Mustela* spp.) access to subnivean small mammals. At other times, CWD functions to mediate predator-prey interactions by providing small mammals with hiding and escape cover, thereby potentially dampening small mammal population cycles and stabilizing predator communities (Pearson 1999a). Coarse woody debris provides midden sites for red squirrels, which in turn provide critical den sites and resting sites for marten. Coarse woody debris functions more directly in nutrient cycling and soil development (Harmon and others 1986), as nurse logs in moist forest systems (Harmon and others 1986), and possibly as fruiting sites for hypogenous mycorrhizal fungi (Amaranthus and others 1994). Therefore, CWD management supports not only small mammal communities, but processes integral to forest ecosystems.

Although CWD guidelines have been proposed for conservation of mycorrhizal fungi, cavity nesting birds, and small mammals (Carey and Johnson 1995; Harvey and others 1987; Thomas and others 1979), guidelines developed to date are subject to the following criticisms: (1) they do not address CWD recruitment; (2) they do not take into account CWD productivity based on the cover type, aspect, temperature, moisture, and other site-specific determinants; and (3) they do not provide for a diverse array of CWD size classes, decay classes, and other attributes important to small mammals and other CWD-associated wildlife.

In response to these shortfalls, I have proposed a relatively simple "within-treatment" coarse filter approach that could be developed to manage for CWD on the Bitterroot

Forest and in the Northern Rockies, based on an understanding of the site-specific nature of CWD recruitment. The logic is as follows. In natural systems, dead trees become CWD. Many become snags first. The amount of CWD on a site is determined by the number and size of trees produced there, which is a function of temperature, moisture, soils, and other site-specific factors. A ponderosa pine savanna will have fewer stems, but of larger diameter, than a dry-site lodgepole pine stand (Harris 1999). Moist-site lodgepole pine will produce more stems of larger diameter, than dry-site lodgepole, but logs may decay faster. Therefore, production of CWD is cover-type- and site-specific (Harris 1999; Brown and See 1981). Rates of transfer from trees to snags and CWD are also site-specific, being a function of probabilities of mortality events on a site.

An effective long-term management strategy should generate CWD based on cover type and local conditions. Furthermore, distributions for CWD attributes (diameter, decay, etc.) should reflect natural distributions. These goals could be achieved by randomly assigning a portion of each tree species/cohort combination in a treatment unit to CWD recruitment. Proportions could reflect current tree composition or future tree composition based on long-term goals. For instance, in a stand of 30 ponderosa pine and 70 Douglas-fir trees a goal of 20 percent CWD recruitment would result in 20 trees being assigned to CWD recruitment. These 20 trees could be assigned to species classes based on their proportional occurrence (in other words, 30 percent ponderosa pine, 70 percent Douglas-fir) or all 20 could be assigned to ponderosa pine if the long-term objective is to reestablish a ponderosa pine-dominant overstory. In this manner, species composition of CWD would more quickly come to reflect that of the overstory species. Coarse woody debris recruitment must be applied to each cohort in multistory stands to provide for continuous recruitment as occurs in natural systems. Ideas of CWD dispersion and management priority areas can also be built into this approach, and adaptive management should guide a CWD management strategy so it can mature over time based on new research information.

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