
Conservation Assessment for the Red-Tailed Chipmunk (*Tamias ruficaudus simulans*) in Washington

Jennifer Gervais

May 2015



Oregon
Wildlife
Institute

Disclaimer

*This Conservation Assessment was prepared to compile the published and unpublished information on the red-tailed chipmunk (*Tamias ruficaudus simulans*). If you have information that will assist in conserving this species or questions concerning this Conservation Assessment, please contact the interagency Conservation Planning Coordinator for Region 6 Forest Service, BLM OR/WA in Portland, Oregon, via the Interagency Special Status and Sensitive Species Program website at <http://www.fs.fed.us/r6/sfpnw/issssp/contactus/>*

U.S.D.A. Forest Service Region 6 and U.S.D.I. Bureau of Land Management
Interagency Special Status and Sensitive Species Program

Executive Summary

Species: Red-tailed chipmunk (*Tamias ruficaudus*)

Taxonomic Group: Mammal

Management Status: The red-tailed chipmunk is considered abundant through most of its range in western North America, but it is highly localized in Alberta, British Columbia, and Washington (Jacques 2000, Fig. 1). The species is made up of two fairly distinct subspecies, *T. r. simulans* in the western half of its range, including Washington, and *T. r. ruficaudus* in the east (e.g., Good and Sullivan 2001, Hird and Sullivan 2009).

In British Columbia, *T. r. simulans* is listed as Provincial S3 or of conservation concern and is on the provincial Blue List (BC Conservation Data Centre 2014). The Washington Natural Heritage Program lists the red-tailed chipmunk's global rank as G2, "critically imperiled globally because of extreme rarity or because of some factor(s) making it especially vulnerable to extinction," and its state status as S2 although the S2 rank is uncertain. This rank is defined as "imperiled in the state because of rarity or other factors making it very vulnerable to extirpation from the state" (Washington Natural Heritage Program 2014, http://www1.dnr.wa.gov/nhp/refdesk/lists/stat_rank.html).

Range: The range is centered on the central Rockies, extending from southwestern Alberta and southern British Columbia south through northeast Washington, northern Idaho, and western Montana except for the Flathead Lake valley, which was the site of Lake Missoula (Fig. 1). The subspecies *T. r. simulans* occupies the western half of the range including Washington, whereas *T. r. ruficaudus* is found in the eastern half with minimal overlap (e.g., Best 1993). They do not appear to extend west of the Columbia River in Washington (Johnson and Cassidy 1997).

Specific Habitat: Red-tailed chipmunks are found in rocky, brushy habitat in dense coniferous forests and at forest edges. They may also be found in open, brushy habitat created by fire if snags and downed wood are present. Where their range overlaps with the yellow pine chipmunk, *T. amoenus*, they may occur at relatively higher elevations than the yellow pine chipmunk (Orr 1943) or in wetter, denser forest conditions (Beg 1969, Shepherd 1994, Fenneman and Hawkes 2010).

Threats: Fire suppression was suggested as a potential issue in Alberta, because it reduces disturbance needed to maintain forest openings favored by the chipmunks (Bennett 1999). However, populations of chipmunks have been documented in closed forests elsewhere in their range (e.g., Beg 1969).

Management Considerations: This species occupies a variety of mesic forest types and is a generalist in its diet. Little is known about its dispersal capabilities or response to large-scale disturbance such as fire. The red-tailed chipmunk is genetically differentiated into two distinct subspecies, although only one of these, *T. r. simulans*, occurs in Washington.

Inventory, Monitoring, and Research Opportunities: The species' range in Washington is not well-defined, and nothing is known of its population status or trends. Determining the extent of *T. r. simulans*' distribution and general abundance may be useful first steps in assessing its status in Washington, although it appears to be abundant in appropriate habitat in the rest of its range.

Table of Contents

Executive Summary	2
I. INTRODUCTION	5
Goal	5
Scope	5
Management Status	5
II. CLASSIFICATION AND DESCRIPTION	6
Systematics	6
Figure 1. General range of <i>Tamias ruficaudus</i>	7
Figure 2. Reports of <i>T. r. simulans</i> in Washington	8
Species Description	9
Comparison with Sympatric Species	10
III. BIOLOGY AND ECOLOGY	10
Range, Distribution, and Abundance	10
Habitat	11
Diet	14
Life History and Breeding Biology	14
Movements and Territoriality	16
Population Trends	17
IV. CONSERVATION	17
Ecological and Biological Considerations	17
Threats	18
Management Considerations	19
V. INVENTORY, MONITORING, AND RESEARCH OPPORTUNITIES	20
Data and Information Gaps	20
Inventory and Monitoring	20
Research	20
Acknowledgements	21
VI. LITERATURE CITED	22

I. INTRODUCTION

Goal

The red-tailed chipmunk, *Tamias ruficaudus*, is confined to the northern Rocky Mountains of the US and the southern edges of Alberta and British Columbia. The goal of this Conservation Assessment is to summarize existing knowledge of the ecology of red-tailed chipmunks to better inform management of the subspecies *T. r. simulans* and its habitat in the westernmost edge of its distribution in northeastern Washington.

Scope

I found only limited information regarding the distribution and ecology of red-tailed chipmunks in Washington. Therefore, I draw on accounts of the species from its entire range. There is no information regarding differences in ecology between the two subspecies. This work should not be considered complete, as unpublished reports of occurrence or ecological information are very likely to exist beyond what was found for this Assessment, and new information will hopefully become available with time.

Management Status

The red-tailed chipmunk is broken into two distinct subspecies that make up the western (*T. r. simulans*) and eastern (*T. r. ruficaudus*) portions of its distribution. The species is generally considered abundant throughout its range. Although the red-tailed chipmunk is classified as of Least Concern by the International Union for Conservation of Nature (IUCN, <http://www.iucnredlist.org/details/42577/0>), its range barely enters the provinces of British Columbia and Alberta and the state of Washington, and it thus ranks as of greater conservation concern at the more localized level.

In Alberta, where only *T. r. ruficaudus* occurs, red-tailed chipmunks are on the Province's Blue List¹ because of its extremely localized distribution and concerns about potential habitat loss (Bennett 1999). In British Columbia, both subspecies occur although their ranges are disjunct. The subspecies *T. r. simulans* is on the Blue List and is given the rank of S3 for the province, a species of conservation concern. The

¹Blue List "Includes any ecological community, and indigenous species and subspecies considered to be of special concern (formerly vulnerable) in British Columbia. Elements are of special concern because of characteristics that make them particularly sensitive to human activities or natural events. Blue-listed elements are at risk, but are not Extirpated, Endangered or Threatened". From <http://www.env.gov.bc.ca/atrisk/red-blue.htm>

subspecies *T. r. ruficaudus* is of greater concern, with a place on the Red List² and a rank of S2, or imperiled within British Columbia (BC Conservation Data Centre 2014).

In Washington, *T. r. simulans* is ranked in Category S2 by the Washington Natural Heritage Program, which considers it “at high risk of extirpation in the state due to restricted range, few populations or occurrences, steep declines, severe threats, or other factors” (Washington State Department of Natural Resources 2014). Specimens have been reported from the mountains of Stevens, Pend Oreille, and Spokane counties (Burke Museum of Natural History and Culture 2014).

Some researchers have called for the two subspecies to be considered separate species based on bacular morphology (Nagorsen et al. 2000), but the existence of hybrid zones does not support this reclassification (Hird et al. 2010, Reid et al. 2010). Red-tailed chipmunks have also hybridized with yellow pine chipmunks (*T. amoenus*, Good et al. 2003, Good et al. 2008). Bacular morphology is insufficient to guarantee reproductive isolation, and hybridization can occur between members of otherwise distinctly different species. The two subspecies have become a model of speciation and the generation of genetic variability in the absence of reproductive isolation. The hybridization issue will be dealt with in more detail below.

II. CLASSIFICATION AND DESCRIPTION

Systematics

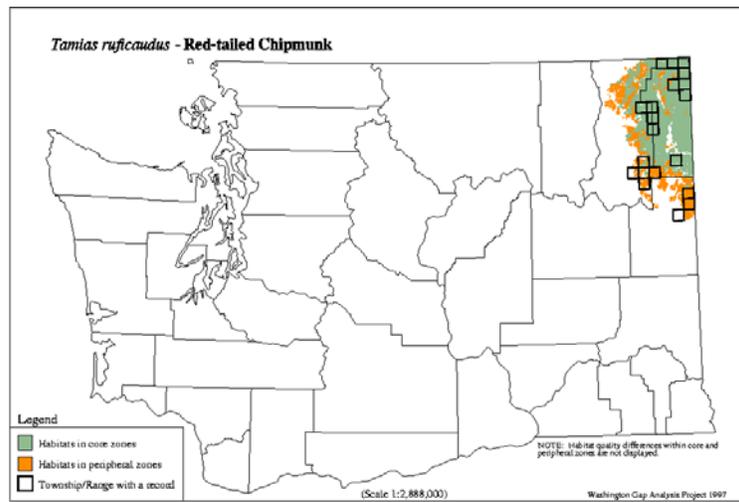
The systematics of the subgenus *Neotamias* are considered an example of rapid radiation, resulting in 23 species in the subgenus *Neotamias* versus one species within the subgenus *Tamias*, the eastern chipmunk (Hird et al. 2010). Species have traditionally been differentiated in part by their bacular morphology, which is distinct among species but shows little variation within them (e.g., White 1953, Sutton and Patterson 2000). In addition, other morphological measurements, external characteristics, and genetics have been used to classify the group. Overall, the classification and systematics of western chipmunks has posed an ongoing puzzle for systematists (e.g., Sutton and Nadler 1974, Levenson and Hoffman 1984, Levenson et al. 1985, Patterson and Heaney 1987, Good et al. 2003).

² Red List “Includes any ecological community, and indigenous species and subspecies that is extirpated, endangered, or threatened in British Columbia. Extirpated elements no longer exist in the wild in British Columbia, but do occur elsewhere. Endangered elements are facing imminent extirpation or extinction. Threatened elements are likely to become endangered if limiting factors are not reversed. Red-listed species and sub-species may be legally designated as, or may be considered candidates for legal designation as Extirpated, Endangered or Threatened under the *Wildlife Act* (see <http://www.env.gov.bc.ca/wld/faq.htm#2>). Not all Red-listed taxa will necessarily become formally designated. Placing taxa on these lists flags them as being at risk and requiring investigation.” From <http://www.env.gov.bc.ca/atrisk/red-blue.htm>



Figure 1. General range of *Tamias ruficaudus*. *T. r. ruficaudus* occupies the eastern half of the range, and *T. r. simulans* occupies the western half including WA with small zones of overlap in ID and MT. (Source: <http://maps.iucnredlist.org/map.html?id=42577>)

A.



B.

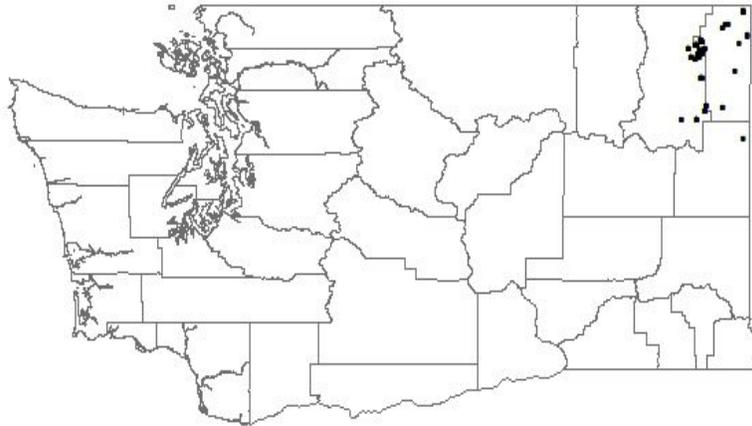


Figure 2. Reports of *T. r. simulans* in Washington. A. Squares are townships in which museum specimens have been collected. Shading refers to modeled habitat suitability based on Washington GAP Analysis Project, 1997 (figure from <http://wdfw.wa.gov/conservation/gap/gapdata/mammals/gifs/taru.gif>). B. Captures of *R. t. simulans* reported in Hawkes 2010, <http://www.vertnet.org>, and <http://arctos.database.museum/>. These data should not be considered comprehensive.

The red-tailed chipmunk is comprised of two distinct subspecies, each with its own distinctive bacular morphology, and some researchers have proposed breaking the two subspecies into two species based in part on this characteristic (Patterson and Heaney 1987, Nagorsen et al. 2000). However, the subspecies have hybridized where they overlap at the northern edge of their range near Whitefish, Montana and 200 km to the south, in the Lochsa River drainage in the Clearwater Mountains of Idaho (Hird et al. 2010). Bacular characteristics are not as conservative as once thought, nor are they a mechanism of complete reproductive isolation (e.g, Good et al. 2003).

There is considerable genetic structuring within each subspecies of *T. ruficaudus* as well (Hird et al. 2010). It appears that the complex genetics are a result of repeated range contractions and expansions as a result of glaciation and other events. The Whitefish contact zone is much more recent than the Lochsa contact zone (Hird et al. 2010).

There is also evidence of hybridization between red-tailed chipmunks and yellow pine chipmunks (*T. amoenus*), whose range almost completely encompasses that of *T. ruficaudus*. A phylogenetic analysis of the subspecies *T. amoenus canicaudus* suggested that it is the result of hybridization between *T. r. simulans* and *T. amoenus* (Good et al. 2003). Further research suggested that the hybridization events occurred repeatedly but there was no current gene flow (Good et al. 2008). Chipmunk species may hybridize far more readily than originally thought (Good et al. 2008), creating an even greater challenge to systematists and conservationists.

Species Description

The red-tailed chipmunk is generally larger and darker than other species within their geographic range.

“The general tone of the back is deep orange brown, the five dark stripes are black to fuscous, and the four pale stripes are grayish to tawny and creamy white. The underparts of the body are creamy white and washed with pale pinkish-buff. The underside of the tail is brilliant rufous and bordered with black and pale pinkish-cinnamon. The top of the head is cinnamon and fuscous sprinkled with grayish white.” (Best 1993).

The pelage of *T. r. simulans* is considered similar to *T. r. ruficaudus*, although in winter pelage it is paler (Howell 1929).

Females are slightly larger than males, but the differences are only significant for breeding females (Beg 1972). The head-body lengths of males from two populations in Montana were measured as 122.30 mm (SE = 0.66, range = 114-136 mm, n = 57) and 123.57 mm (SE = 1.26, range=110-143 mm, n = 61) respectively. Females from those populations measured 125.01 mm (SE = 0.95, range = 105-138 mm, n = 49) and 126.04 mm (SE = 1.15, range= 105-140 mm, n = 80, Beg and Hoffman 1977; see also Orr 1943).

Body weights of males ranged from 53.65 g (SE = 0.94, n = 13) for males trapped in April, to 59.43 g (SE = 0.93, n = 15) for those trapped in October in Montana (Beg 1972). Similarly, non-breeding females ranged from 53.84 g (SE = 0.54, n = 9) in May to 61.46 g (SE = 1.26, n = 13) in October. Breeding females were the heaviest, ranging from 69 to 78 g (SE = 1.29, n = 17) in June to 62.18 g (SE = 1.83, n = 4) in August. After that they could not be distinguished from the non-breeding females (Beg 1972).

Comparison with Sympatric Species

Species of chipmunks can be highly variable in their pelage characteristics across their range and overlap extensively in appearance with other species (e.g., Patterson 1984, Sutton and Patterson 2000). According to Best (1993), who in turn relied on Howell's work (Howell 1920, 1922, 1929) describing the type specimens of this species, the comparisons are as follows:

“Compared with *T. amoenus ludibundus*, *T. r. simulans* is larger, the tail and ears are longer, and the upperparts, especially the head, shoulders, and rump, are more tawny in summer (Howell, 1929). *T. amoenus felix* of the coastal region of British Columbia is similar to *T. r. simulans*, but may be distinguished from that taxon by its larger size, larger skull, longer and paler tail, whiter underparts, paler sides of the body and face, and more tawny head (Howell 1922, 1929). *T. r. ruficaudus* can be distinguished from *T. a. felix* by its whiter belly, more reddish tail, more whitish dorsal stripes, and particularly by its larger skull and longer rostrum (Howell 1929).”

III. BIOLOGY AND ECOLOGY

Range, Distribution, and Abundance

The species' range extends in a broad ring around the Flathead Valley of Montana. In the eastern half, *T. r. ruficaudus* extends north into the southernmost part of Alberta on the British Columbia border, into British Columbia in the East Kootenay Valley, west to the edge of the Rocky Mountains in Montana, south through the Bitterroot Mountains, and east to the south riverbank of the Lochsa River in the Clearwater River drainage. *T. r. simulans* is found west of the Flathead Valley, extending north into British Columbia, west into the northeastern mountains of Washington, and south to the north bank of the Lochsa River in the Clearwater River drainage in Idaho. This subspecies occupies the Idaho panhandle (Best 1993).

Red-tailed chipmunks are found at elevations of 800 to 1,800 m, or 2,700 to 6,000 feet (Bennet 1999 and references therein, Hawkes 2010) in coniferous forests. They have been recorded as high as 7,000 feet elevation in Idaho (Orr 1943). This species often overlaps in its distribution with the yellow pine chipmunk (*T. amoenus*) and the least chipmunk (*T. minimus*), although the red-tailed chipmunk typically is found in wetter forest and at higher elevations where it overlaps with *T. amoenus* (Orr 1943, Beg 1969,

Best 1993, but see Shepherd 1994). It occupies more xeric habitats at the periphery of its range (Best 1993).

Red-tailed chipmunks were considered the most abundant of four species of chipmunks in Idaho (Rust 1946). It was considered “very abundant” in the Clearwater Mountains of Idaho (Orr 1943). No more recent assessments of abundance were found.

Habitat

Red-tailed chipmunks are found in a wide variety of coniferous forest types although typically with a well-developed understory layer. They frequently inhabit forest edge in clearings, next to rockslides, and other openings. They have been described as more arboreal than other chipmunk species (Orr 1943), although tree foraging appeared to be most prevalent in fall and made up less than 20% of foraging observations relative to ground or shrub substrate (Beg 1969). This species uses both underground dens and tree nests, and has also been reported to use rock crevices and log piles for den sites (Orr 1943, Rust 1946, Broadbooks 1974).

In Idaho, *T. ruficaudus* were frequently encountered in ponderosa pine (*Pinus ponderosa*) clearings, whereas in Washington they have been found in mixed second-growth stands of Douglas- fir (*Pseudotsuga menziesii*), western larch (*Larix occidentalis*), grand fir (*Abies grandis*), Englemann spruce (*Picea englemanni*), lodgepole pine (*Pinus contorta*), and aspen (*Populus* spp., Jacques 2000).

In the Clearwater Mountains of Idaho, red-tailed chipmunks were found in spruce and fir forests, which included “alpine” fir (presumably sub-alpine fir, *Abies lasiocarpa*), western redcedar (*Thuja plicata*), Englemann spruce, grand fir, and some Douglas-fir with a thick understory of western yew (*Taxus brevifolia*). They were also seen in brushy clearings at high elevations where fires had burned 10 and 30 years previously. This brushy habitat was composed of Sitka alder (*Alnus sinuata*), maple (*Acer glabrum*), mountain ash (*Sorbus sitchensis*), willow (*Salix* spp.), and bracken (*Pteridium aquilinum*, Orr 1943).

In western Montana north of Missoula, *T. ruficaudus* was found in mature Douglas-fir forests, and was positively associated with the presence of western larch 10-20 cm dbh, negatively associated with other conifers in that size class, positively associated with forbs, but negatively associated with woody debris and short shrubs <30 cm in height. However, the species was captured in Douglas-fir forest with a preponderance of grasses in the understory, suggesting tolerance of more xeric conditions (Shepherd 1994).

In northeastern Washington, a study examined three different riparian-zone management strategies on wildlife by comparing the captures of small mammals. Control zones of unlogged, 65-75 year old second-growth coniferous forests were compared to two different logging regimes within the riparian zone, one based on the Washington Forest Practices Rules of 1988, the other a modified buffer treatment. Riparian zone was defined as within 8 m of ordinary high water level, the upland as 100 m upslope. Fenneman and

Hawkes (2010) found that although *T. ruficaudus* was found in both upland and riparian zones, it was twice as abundant in upland plots as in riparian plots, and the greatest densities occurred after logging. Dominant tree species included Douglas-fir, lodgepole pine, western redcedar, western hemlock, western larch, and grand fir. The understory plants included Oregon grape, red-osier dogwood (*Cornus stolonifera*), mallow ninebark (*Physcarpus malvaceus*), spirea, *Amelanchier alnifolia*, and huckleberry (Fenneman and Hawkes 2010).

In a study of small-mammal response to logging of spruce-fir forest in the Clearwater National Forest of Idaho, red-tailed chipmunks were found in all four stand age-classes studied (≤ 10 , 33-39, 40-79 and 80+ years post-harvest), although they were most commonly trapped in the two mid-successional stands in one area. In the other area, the highest number of captures occurred in the 40-79 years post-logged stand in year 1 and the most recently logged stand in year 2 (Scrivner and Smith 1984). Grand fir was the dominant tree species on all study plots.

Where *T. ruficaudus* co-occurs with *T. minimus* and *T. amoenus*, it is reportedly restricted to subalpine forest (Best 1993). However, in the presence of just *T. amoenus*, it is not so restricted (e.g., Beg 1969, Shepherd 1994, Fenneman and Hawkes 2010). *T. amoenus* and *T. ruficaudus* occur in many of the same habitats in the absence of the other species, suggesting some level of competitive exclusion (Beg 1969). In the presence of *T. ruficaudus*, *T. amoenus* appears to be restricted to open, dry pine forests. In the presence of *T. amoenus*, *T. ruficaudus* was not found in ponderosa pine and Douglas-fir forests, but was restricted to more mesic Douglas-fir and larch forest (Beg 1969). In another study, such habitat segregation became more apparent following logging (Shepherd 1994).

Shepherd (1994) evaluated habitat use of small mammals in Douglas-fir forests following overstory removal and a “new forestry” treatment that left a specified number of large trees per hectare. He found that while *T. amoenus* increased in treated plots and in the overstory-removal plots in particular, *T. ruficaudus* showed the greatest declines in numbers from pre-treatment captures in those plots (Shepherd 1994). These results suggest that the more xeric habitat conditions found after overstory removal in particular are more favorable to *T. amoenus* than *T. ruficaudus*.

However, another study of effects of logging found no difference in *T. ruficaudus* abundances between control plots and clear-cut plots that had been only partially burned (Halvorson 1982). Halvorson speculated that the statistically significant increase in abundances of *T. ruficaudus* on the lightly burned plot was a result of the abundant forb-shrub layer that developed following breakdown of the slash provided plentiful food and cover. In this study, no other chipmunk species were reported as present. Trap grids were 61-92 m from the forest edge (Halvorson 1982).

A study conducted in northeastern Washington comparing logging treatments in riparian buffer zones using a discriminant function analysis found that *T. ruficaudus* and *T. amoenus* were associated with many of the same riparian-zone forest characteristics, but

not all of them (Fenneman and Hawkes 2010). Both species were found in maturing conifer forest with increasing open habitat, increasing canopy stratification, and decreasing canopy cover. However, *T. amoenus* was positively associated with increasing herbaceous cover, large snags, large cedar and hemlock trees, decreasing shrubs, decreasing numbers of regenerating conifers, small hardwoods, and understory canopy, whereas *T. ruficaudus* showed a strong negative association to these characteristics in the riparian zone (Fenneman and Hawkes 2010). In upland logged plots, *T. ruficaudus* showed a weak positive response to increases in tree size, numbers of hemlock and cedar, increasing large coarse woody debris, and understory cover that included regenerating conifers. *Tamias amoenus*, however, was strongly associated with increasing small trees, coarse woody debris of all sizes, decreased overstory canopy cover and large trees, and decreased herbaceous cover and small hardwoods (Fenneman and Hawkes 2010). Both species were negatively associated with habitat with a well-developed, diverse shrub and herbaceous layer, increasing canopy cover, large conifers, small deciduous trees, and fewer regenerating conifers. However, while *T. amoenus* was strongly negatively associated with this forest type, *T. ruficaudus* was only moderately so (Fenneman and Hawkes 2010).

Overall, chipmunks appear to have broad ecological niches that overlap extensively across species. Although *T. ruficaudus* has been the subject of only limited research with regard to community ecology, other chipmunk assemblages have been extensively studied. In the Snake Mountain Range of Nevada, Brown (1971) explored the potential mechanisms behind the narrow range of overlap between two species of chipmunks, *T. umbrinus* (Uinta chipmunk) and *T. dorsalis* (cliff chipmunk). He concluded that *T. umbrinus* occurred at slightly greater elevations where trees were denser because *T. dorsalis*, although competitively dominant, could not successfully pursue *T. umbrinus* nor exclude it from food resources in more dense vegetation. Instead, *T. dorsalis* dominated interactions in sparse piñon-juniper habitat where escape options for the more arboreal *T. umbrinus* were more limited. However, *T. umbrinus* was able to overwhelm *T. dorsalis* at an experimental feeder, because it was impossible for *T. dorsalis* to exclude the more numerous *T. umbrinus* despite being the victor in every interspecific encounter.

In another study of community ecology, researchers examined the factors behind altitudinal zonation among four species of chipmunks in the eastern Sierra Nevada of California, where four species of chipmunks are each associated with specific plant life zones (Heller 1971). Using both field observations and a combination of field and laboratory experiments, Heller (1971) and Heller and Gates (1971) determined that *T. alpinus* (alpine chipmunk), *T. speciosus* (lodgepole chipmunk), *T. amoenus*, and *T. minimus* had very broad overlap in their fundamental niches, but their realized niches were the result of a combination of competitive exclusion and physiological constraints.

In laboratory encounters, both *T. alpinus* and *T. amoenus* were found to be dominant over *T. speciosus*, and *T. amoenus* was dominant over *T. minimus*. In general, females were also more aggressive than males of the same species. Although the physiological tolerances of the four species were broadly similar, *T. minimus* was able to survive in hotter, drier conditions of lower elevations than the other three species (Heller and Gates

1971). Heller (1971) and Brown (1971) suggested that aggression in some species could be explained by the profitability of defending food resources, whereas habitat conditions prevented successful defense for other species of chipmunk.

Further community ecology work performed in California with *T. minimus*, *T. amoenus*, and *T. speciosus* concluded that the separation among these three species could be explained by habitat selection, competitive exclusion, and physiological limits (Chappell 1978). *Tamias speciosus* was the most aggressive of the three species, and kept the other two species out of its more heavily forested habitat. Although *T. minimus* would expand into the arid woodland habitat occupied by *T. amoenus* when *T. amoenus* was removed, the converse was not true, suggesting that the boundary between *T. amoenus* and *T. minimus* was in part based on physiological limitations in *T. amoenus* (Chappell 1978).

Other community-level interactions also may be at play. In a study of ecological partitioning of habitat among *T. quadrivittatus*, *T. umbrinus*, and *T. minimus*, Bergstrom (1992) suggested that parasitism by the botfly (*Cuterebra foninella*) prevented *T. umbrinus* from competitively excluding the ecologically very similar *T. quadrivittatus* at elevations where the botfly occurred (below 2200 m). Interestingly, *T. minimus* was apparently unaffected by botflies (Bergstrom 1992). Disease and parasitism are often overlooked as factors affecting vertebrate species distribution, but their impacts may become more prominent as climate change allows range expansion.

Thus, although limited studies have been conducted to date on the ecology of chipmunk communities that include *T. ruficaudus*, it seems likely that similar mechanisms may be operating behind the apparent elevational separation among *T. minimus*, *T. ruficaudus*, and *T. amoenus* (e.g., Best 1993).

Diet

Like other species of chipmunk, *T. ruficaudus* feeds widely on seeds and fruits of trees, shrubs, and forbs. Tree seeds include Englemann spruce (Broadbooks 1974), Douglas-fir, ponderosa pine, and fir. Shrubs and small trees used for food include currant (*Ribes inerme*), Pacific nine-bark (*Physocarpus capitatus*), snow bush (*Ceanothus sanguineus*), serviceberry (*Amelanchier alnifolia*), buckbrush (*Symphoricarpos rivularis*), cranberries (*Vaccinium oxycoccus*) and huckleberry (*V. ovalifolium*). Forbs and grasses include Douglas knotweed (*Polygonum douglasii*, Orr 1943), bull thistle (*Cirsium vulgare*), balsam-root (*Balsamorhiza* sp.), glacier lily (*Erythronium* sp.), oyster plant, willow herb (*Epilobium* spp), and tarweed (*Madia glomerata*, Best 1993). In addition to seeds and buds of woody plants, flowers, and foliage, chipmunks may also consume mushrooms, bulbs, insects and birds' eggs and nestlings (Beg 1969, Nowak 1999).

Life History and Breeding Biology

The life history of *T. ruficaudus* is like that of other species of chipmunk in the subgenus *Neotamias* (Nowak 1999). Activity above ground ceases in October in Montana, coincident with snowfall, although individuals may appear during warm spells in the

middle of winter (Beg 1971a, 1972). *T. ruficaudus* spends the winter months in short bouts of torpor, relying on stored food rather than body fat to survive the period of inactivity. The animals emerge at snowmelt and begin their breeding season (Beg 1969).

The sexually active males appear to emerge first based on capture data; nearly all individuals caught in April and early May were sexually active males, whereas sex ratios were balanced later in the season (Beg 1971a).

The breeding season has been given as January-July (Jacques 2000), but in Montana breeding peaked in late April and early May (Beg 1971b). The timing of reproduction seems to be a function of elevation and latitude. The length of gestation isn't known but is estimated at about 31 days (Beg 1971b, Best 1993); the known range in gestation times for species within the subgenus *Neotamias* is 28-36 days (Nowak 1999). The duration of lactation is also not known for *T. ruficaudus*, but for other species of *Tamias* it has been estimated at 30 to 60 days (Nowak 1999). Young *T. r. ruficaudus* in Montana are born in June and appear above ground in mid-July at an approximate age of 39-45 days old (Beg 1971b). The permanent molars have erupted by 45 days of age (Beg 1969); presumably the acquisition of adult dentition would coincide with weaning. In Montana, young recruit into the population in July and August (Beg 1971a). In Washington, there is one record of a juvenile chipmunk being captured in mid-June, suggesting that the phenology may be somewhat advanced relative to Montana (Washington Department of Natural Resources, trap records submitted by LGL Limited).

The mother may move the brood to a tree nest partway through their dependency period, although the same brood was observed using both a ground nest and a tree nest on the same day (Broadbooks 1974). Tree nests may occur in hollows within the main stem or under projections such as witches' brooms, and have been found at varying heights above ground (5.8-18.3 m, Broadbooks 1974). Young have also been found in grass nests placed in shrubs (Rust 1946).

Red-tailed chipmunks are sexually mature at one year of age, although relatively few females (11-15%) were found to breed as yearlings in a study conducted in Montana (Beg 1971b). Females gave birth to one litter per year in July, comprised of 4.85 (\pm 0.04 SE) young. In any given year, 50-73% of all females bred. If only animals older than first-year individuals were considered, pregnancy rates ranged from 68-83% (Beg 1971b). The largest litters were born to females approximately 46-52 months of age (5.3 ± 0.7 , $n = 16$), whereas the smallest were born to females aged 10-16 months (4.0 ± 0.13 , $n = 4$, Beg 1971b).

Young achieved nearly adult weights by September. Young-of-the-year males in Montana weighed 56.1 g (SE = 0.76, $n = 13$) in September, and 58.7 g (SE = 1.17, $n = 18$) in October. Similarly for females, September weight was measured as 56.7 g (SE = 0.94, $n = 25$) and their body mass in October was 55.1 g (SE = 1.79, $n = 13$, Beg 1972). More juveniles than adults were caught in traps in October in Montana. Young animals may require an extended activity period to store the necessary food for the winter period (Beg 1971a).

The longevity record for a red-tailed chipmunk in the wild is 8 years (Beg 1971a). The majority of the populations studied in Montana were made up of first-year individuals, with decreasing percentages of second- and third-year animals. However, 8-13% of captured animals were estimated to be 58 months or older (Beg 1971a). Survivorship curves reflected these proportions, with the most rapid decline in survivorship occurring during the first 16 months, then declining steadily at a slightly less rapid rate to 52 months of age (Beg 1971a).

Numbers of red-tailed chipmunks varied seasonally. In Montana, the population was at its lowest in late March and April, when survivors of the winter appeared as snow melted. Populations grew in June, presumably from immigration (Beg 1971a). Numbers of adult animals began to fall in July, although the reason was not identified. Despite that trend, overall numbers peaked in August when young animals were recruited into the population. Following the August peak, overall numbers declined. Presumably, some young animals emigrated and other individuals were lost to predation. Increasing numbers of animals would also be entering torpor as colder weather became prevalent in the fall (Beg 1971a).

Movements and Territoriality

Chipmunks are generally not territorial with conspecifics, although they do appear to defend their dens from conspecifics (Yahner 1978). Interspecific territoriality varies by species and community (e.g., Brown 1971, Heller 1971, Chappell 1978). Despite substantial interspecific aggression, Brown (1971) witnessed individuals of both *T. dorsalis* and *T. umbrinus* feeding under the same tree at the same time when a particularly abundant cone crop was available. *Tamias ruficaudus* and *T. amoenus* were also observed feeding in the same vicinity and sometimes even within the same bush (Beg 1969).

In one study, eastern chipmunks (*T. striatus*) overlapped extensively in their home ranges, and they did not seem to maintain core areas of exclusive use (Getty 1981). However, other research revealed that adult *T. striatus* did defend core areas and their dens, although juvenile and subadult chipmunks would tolerate some intraspecific intrusion (Yahner 1978). It is not clear whether these behaviors apply to western chipmunks. Wolff (1993) argued that females of small mammals would be expected to defend their nests with young against possible infanticide by other females, but not food supply. He reasoned that food supply should not be limiting during lactation and that therefore, food should be defended less vigorously. This is supported by the findings of Heller (1971), who observed in laboratory and field encounters that females were found to be more aggressive than males in *T. alpinus*, *T. speciosus*, *T. minimus*, and *T. amoenus*. No information was found regarding territoriality in *T. ruficaudus*. However, Orr (1943) reported that in September, he observed six individuals of *T. ruficaudus* occupying separate holes in the same broken dead fir trunk that was 6 m tall.

Daily movements have been estimated from a trapping grid in western Montana with traps spaced at 50-foot intervals (approximately 15 m) and dimensions of 1,450 feet (442 m) by 200 feet (61 m, Beg 1969). Mean distance between captures in May-August was 266 ± 26.3 feet (81 ± 8 m) for males, which was nearly fifty percent greater than that of breeding females (187 ± 15.7 feet, or 57 ± 4.8 m) and one-third greater than nonbreeding females (199 ± 30.9 feet or 61 ± 9.4 m, Beg 1969).

Males also made the greatest mean movements between captures, averaging 886 feet (270 m) versus 800 feet (244 m) for females and 650 feet (198 m) for juveniles. Overall, animals typically moved 300-500 feet on a daily basis. Maximum distances moved were 1,500 feet (457 m) for males, 950 feet (290 m) for juveniles, and 850 feet (259 m) for females (Beg 1969). In Montana, adult chipmunks tended to move shorter distances after the juveniles emerged from natal nests, such that movements were inversely proportional to density in July (Beg 1969).

No information was found regarding dispersal of either adults or juveniles, or home range size estimates for *T. ruficaudus*. Studies have noted that adding food greatly increased chipmunk densities generally (e.g., Brown 1971, Sullivan et al. 1983), suggesting that resource limitation may have a major role in spacing behavior.

Population Trends

The only population-level work located for this species was carried out in Montana 1966-1968 (Beg 1969, 1971a, 1971b, 1972). Although monthly fluctuations in numbers were noted, there did not appear to be any overall trends in population size (Beg 1969). The number of chipmunks estimated to be present on a trapping grid of 200 x 1450 feet (61 by 442 m) ranged from 11-30 in May, 18-36 in June, 25-42 in July, 30-47 in August, 25-41 in September, and 12-37 in October (Beg 1969). These numbers translate into 4-11 individuals/ha in May, 7-13 animals/ha in June, 9-16 animals/ha in July, 11-17 animals/ha in August, 9-15 animals/ha in September, and 4-14 animals/ha in October.

Red-tailed chipmunks have been described as “abundant” in Idaho (Orr 1943, Rust 1946), but no other density estimates were found in the literature.

IV. CONSERVATION

Ecological and Biological Considerations

The red-tailed chipmunk has a relatively restricted range in both geographic extent and possibly in elevation (Fig. 1). However, it has been described as abundant within that range (Orr 1943, Rust 1946), although more recent assessments were not found. From what is known about *T. ruficaudus*, it is capable of inhabiting a range of habitat types and eats a wide variety of foods. It reproduces only once annually, but reproductive rates are well within those reported for other *Tamias* species (Beg 1971b). Although it is far from

the most widely distributed species within *Tamias*, it is still present over a relatively broad geographic region that includes part of two provinces and three states (Best 1993).

There are numerous studies suggesting that the ranges of different species of chipmunk are determined at least in part by interspecific interactions (e.g., Brown 1971, Heller 1971, Sheppard 1971). Interspecific dynamics may be particularly important in a group whose general ecological niches overlap very broadly.

Threats

Because of the relatively broad use of coniferous forests of many age-classes, and their extent within the range of this species, one of the greatest threats to *T. ruficaudus* is likely to be from climate change. Changing rainfall and temperature regimes could alter forest species composition and structure, rendering current habitat unsuitable. In addition, changing ecological interactions resulting from climate change could also have major impacts. These could arise from altered community dynamics among co-occurring species of chipmunk, range expansion by disease organisms or parasites, and altered disturbance regimes that simplify or otherwise alter necessary habitat structure. Any of these could alter the range of *T. ruficaudus*. Currently, ecological interactions are too poorly known to identify which factors might be particularly relevant.

Fire has already increased in severity and intensity in western North America (e.g., Westerling et al. 2006, Littell et al. 2009, Marlon et al. 2012). Severe fires may lead to the loss of all understory vegetation and destruction of the duff layer. On the other hand, this species is frequently found on the edges of gaps, and such edges and gaps are also created by disturbance such as fire and logging, so smaller-scale fires may not be a threat to *T. ruficaudus* (e.g., Halvorson 1982).

Loss of forests from insect pests such as the mountain pine beetle (*Dendroctonus ponderosae*) could potentially destroy red-tailed chipmunk habitat, either directly by killing large swaths of trees or by increasing severe fire risk.

Roads pose a potential dispersal barrier and risk of mortality to chipmunks and other small mammals (e.g., Oxley et al. 1974, Mader 1984, Merriam et al. 1989, Ford and Fahrig 2008, McGregor et al. 2008). However, it is not clear that narrow, gravel roads that are only lightly traveled will discourage movement, particularly if the verges are brushy rather than mowed or devoid of vegetation (Oxley et al. 1974, Getty 1981, Richardson et al. 1997). Although road mortality can be substantial for some vertebrates in some circumstances, speed was found to be one of the greatest predictors of vertebrate mortality in southern Ontario (Farmer and Brooks 2012). The graveled surfaces of most forest roads will by default decrease traffic speed and hence the risk of mortality. In addition, it appears that narrow openings of less than 20 m between forest margins are less of a barrier to crossings by small mammals (Oxley et al. 1974). Amount of traffic also influenced the crossing rate of voles and mice in Great Britain (Richardson et al. 1997).

Management Considerations

Before management actions are undertaken, the ecological context of this species should be considered. Co-occurring chipmunk species can have a profound influence on the local distribution of any one species, in addition to interspecific differences in physiological constraints. Parasitism may also be a limiting factor. A major challenge in management will be anticipating and responding to changes in the community context as climate change resulting from global warming leads to shifts in ranges of competitors, parasites, disease, fire regimes, and consequently, vegetation.

There are some data available regarding the effects of timber harvest on red-tailed chipmunks. Halvorson (1982) found that a lightly burned clear-cut in Douglas-fir forest supported an increase in abundance several years post-burn and was indistinguishable from an unlogged control site in the same forest type, whereas a more heavily burned clear-cut in grand fir (*Abies grandis*) and western redcedar (*Thuja plicata*) did not yield as many captures as a control plot in that forest type. Unfortunately there was no replication; burn intensity and forest type are therefore confounded. Halvorson (1982) speculated that the abundant forb-shrub layer in the lightly burned clear-cut provided plentiful food and cover. This observation could be further tested in future work.

Another study of harvest effects on small mammals compared abundances on control plots, overstory-removal plots, and plots that were logged but retained a mean of 7.5 trees >30 cm dbh per hectare (“new forestry” plots, Shepherd 1994). No statistically significant differences were found. However, red-tailed chipmunk abundances remained stable in the control plots, but showed declining trends in the “new forestry” plots and in particular the overstory-removal plots, although no clear habitat associations were found following logging treatments (Shepherd 1994).

Finally, work conducted in northeastern Washington found that *T. r. simulans* was more abundant in upland sites than directly adjacent to riparian areas, and that abundances were greatest following partial logging (Fenneman and Hawkes et al. 2010).

Taken together, what is currently known of the ecology of red-tailed chipmunks suggests the following habitat management actions may be helpful in its conservation. Given the uncertainty, however, an adaptive management framework will be critical in gaining the most knowledge possible about actual consequences of management decisions, which in turn can be used to guide future actions.

- If prescribed fire is planned for a unit, timing and intensity of fire can be managed to increase regrowth of the shrub and forb layers, which can increase habitat suitability for red-tailed chipmunks.
- Retaining mature trees in logged areas may help maintain more mesic conditions and provide more food resources from seed crops.
- Maintaining brushy openings in closed stands will retain habitat complexity. These may be provided by periodic fire or mechanical conifer removal.

- Retaining slash piles and large-diameter downed wood in particular following timber harvest may provide cover for red-tailed chipmunks and ultimately nutrients for the forb/shrub layer.
- Reduce forest fuels to prevent catastrophic fires and restore historic fire regimes to the extent possible. This can be accomplished with timber harvest, mechanical site preparation, and prescribed fire.
- Promote habitat complexity by managing for a mosaic of dense, mixed second-growth stands with small canopy gaps, mature trees, and brushy openings in closed stands.
- Maintaining dense vegetation on the edge of natural openings such as rock slides will help maintain food resources and cover.

V. INVENTORY, MONITORING, AND RESEARCH OPPORTUNITIES

Data and Information Gaps

Despite the interest this species has received from geneticists and researchers interested in evolution, even basic information regarding *T. ruficaudus*' biology and ecology is lacking. The boundaries of *T. r. simulans*' range in Washington are not well-described, particularly in reference to the ranges of other chipmunk species. Understanding potential interspecific interactions may be crucial to understanding the range boundaries of *T. r. simulans*.

Most of what is known about the basic reproductive biology and ecology of *T. ruficaudus* is from a very small handful of studies carried out in a restricted portion of the species' range and is focused on *T. r. ruficaudus*, the subspecies not found in Washington. Even basic information regarding reproduction such as the duration of pregnancy and lactation are unknown. Nothing is known of its population dynamics other than some basic static life-table data drawn from two study sites (Beg 1971a).

Understanding basic population dynamics such as the relative magnitude of population fluctuations and what factors are associated with those fluctuations will also be valuable in evaluating the likelihood of population persistence in the face of threats such as climate change. Although some movement data are available, a greater understanding of possible metapopulation dynamics will aid in evaluating likelihood of persistence in the face of environmental change. Such gaps in data on population ecology, especially dispersal, are typical for most small mammal species.

Inventory and Monitoring

Obtaining a better understanding of the distribution and abundance of *T. r. simulans* in Washington will be crucial to evaluating the extent of risks to the subspecies' persistence in the state.

Research

Research on the impacts of management activities, such as harvest and salvage prescriptions, that could affect *T. r. simulans* may help managers better understand responses of *T. r. simulans* to changing environmental conditions.

Chipmunks interact in complex communities, which have the potential to limit any one species' distribution. No such research has yet included *T. ruficaudus*, which overlaps with several other chipmunks throughout its range. A better understanding of the community ecology of *T. r. simulans* in Washington may allow a more nuanced approach to management and conservation.

Acknowledgements

I thank Chris Loggers, West Zone Wildlife Biologist, Colville National Forest, Michael A. Borysewicz, East Zone Wildlife Biologist, Colville National Forest, USFS, John Fleckenstein, zoologist, WA Natural Heritage Program, for their editorial comments and help in locating additional sources of information. I also thank Kayce Bell, Department of Biology, University of New Mexico, who pointed me in the direction of databases of specimen locations and helped compile that information.

VI. LITERATURE CITED

BC Conservation Data Centre. 2014. BC Species and Ecosystem Explorer. BC Ministry of the Environment, Victoria, BC. Available: <http://a100.gov.bc.ca/pug/eswp/> (Accessed August 18, 2014).

Beg, M. A. 1969. Habitats, food habits, and population dynamics of the red-tailed chipmunk, *Eutamias ruficaudus*, in western Montana. Dissertation. University of Montana, Missoula.

Beg, M. A. 1971a. Population dynamics of the red-tailed chipmunk (*Eutamias ruficaudus*) in western Montana. *Pakistan Journal of Zoology* 3:133-145.

Beg, M. A. 1971b. Reproductive cycle and reproduction in Red-Tailed Chipmunk, *Eutamias ruficaudus*. *Pakistan Journal of Zoology* 3:1-13.

Beg, M. A. 1972. Seasonal changes in body weight of the red-tailed chipmunk, *Eutamias ruficaudus*. *Pakistan Journal of Zoology* 4:13-16.

Beg, M. A., and R. S. Hoffman. 1977. Age determination and variation in the red-tailed chipmunk, *Eutamias ruficaudus*. *Murrelet* 58:26-36.

Bennett, R. 1999. Status of the Red-Tailed Chipmunk (*Tamias ruficaudus*) in Alberta. Alberta Environmental Protection, Fisheries and Wildlife Management Division, and Alberta Conservation Association. Wildlife Status Report No. 19, Edmonton, AB. 15 pp.

Bergstrom, B. J. 1992. Parapatry and encounter competition between chipmunk (*Tamias*) species and the hypothesized role of paratism. *American Midland Naturalist* 128:168-179.

Best, T. L. 1993. Mammalian Species No. 452, *Tamias ruficaudus* (Nov. 15, 1993), pp. 1-7. American Society of Mammalogists.

Broadbooks, H. E. 1974. Tree nests of chipmunks with comments on associated behavior and ecology. *Journal of Mammalogy* 55(3):630-639.

Brown, J. H. 1971. Mechanisms of competitive exclusion between two species of chipmunk. *Ecology* 52:305-311.

Burke Museum of Natural History and Culture. 2014. Mammals of Washington: red-tailed chipmunk. http://collections.burkemuseum.org/mamwash/rodentia.php#Red_tailed_Chipmunk (Accessed April 17, 2014).

- Chappell, M. A. 1978. Behavioral factors in the altitudinal zonation of chipmunks (*Eutamias*). *Ecology* 59:565-579.
- Farmer, R. G., and R. J. Brooks. 2012. Integrated risk factors for vertebrate roadkill in southern Ontario. *Journal of Wildlife Management* 76:1215-1224.
- Ford, A. T., and L. Fahrig. 2008. Movement patterns of eastern chipmunks (*Tamias striatus*) near roads. *Journal of Mammalogy* 89:895-903.
- Fenneman, J. D., and V. C. Hawkes. 2010. Chapter 8: Eastern Washington small mammals. Pp. 8.1-8.41 in Hawkes, V. C., editor. Effectiveness of riparian management zones in providing habitat for wildlife: resampling at the 10-year post-treatment interval. Cooperative Monitoring, Evaluation, and Research Committee Report CMER 02-215. Department of Natural Resources, Olympia, WA.
- Getty, T. 1981. Territorial behavior of eastern chipmunks (*Tamias striatus*): encounter avoidance and spatial time-sharing. *Ecology* 62:915-921.
- Good, J. M., J. R. Demboski, D. W. Nagorsen, and J. Sullivan. 2003. Phylogeny and introgressive hybridization: chipmunks (genus *Tamias*) in the northern Rocky Mountains. *Evolution* 57(8):1900-1916.
- Good, J. M., S. Hird, N. Reid, J. R. Demboski S. J. Stepan, T. R. Martin-Nims and J. Sullivan. 2008. Ancient hybridization and mitochondrial capture between two species of chipmunks. *Molecular Ecology* 17: 1313-1327.
- Good, J. M., and J. Sullivan. 2001. Phylogeny of the red-tailed chipmunk (*Tamias ruficaudus*), a Rocky Mountain endemic. *Molecular Ecology* 10:2683-2695.
- Hawkes, V. C., editor. 2010. Effectiveness of riparian management zones in providing habitat for wildlife: resampling at the 10-year post-treatment interval. Cooperative Monitoring, Evaluation, and Research Committee Report CMER 02-215. Department of Natural Resources, Olympia, WA.
- Halvorson, C. H. 1982. Rodent occurrence, habitat disturbance, and seed fall in a larch-fir forest. *Ecology* 63:423-433.
- Heller, H. C. 1971. Altitudinal zonation of chipmunks (*Eutamias*): interspecific aggression. *Ecology* 52:312-319.
- Heller, H. C., and D. M. Gates. 1971. Altitudinal zonation of chipmunks (*Eutamias*): energy budgets. *Ecology* 52:424-433.
- Hird, S., N. Reid, J. Demboski, and J. Sullivan. 2010. Introgression at differentially aged hybrid zones in red-tailed chipmunks. *Genetica* 138:869-883.

- Hird, S., and J. Sullivan. 2009. Assessment of gene flow across a hybrid zone in red-tailed chipmunks (*Tamias ruficaudus*). *Molecular Ecology* 18(14):3097-3109.
- Howell, A. H. 1920. Description of a new chipmunk from Glacier National Park, Montana. *Proceedings of the Biological Society of Washington* 33:91-92.
- Howell, A. H. 1922. Diagnoses of seven new chipmunks of the genus *Eutamias*, with a list of the American species. *Journal of Mammalogy* 3:178-185.
- Howell, A. H. 1929. Revision of the American chipmunks (genera *Tamias* and *Eutamias*). U.S. Department of Agriculture, Bureau of Biological Survey, North American Fauna 52:1-256.
- Jacques, K. 2000. "*Tamias ruficaudus*" (On-line), Animal Diversity Web. Accessed April 17, 2014 at http://animaldiversity.ummz.umich.edu/accounts/Tamias_ruficaudus/
- Johnson, R. E. and K. M. Cassidy. 1997. Washington Gap Project Mammal Distribution Models, version 5. Washington Cooperative Fish and Wildlife Research Unit, Seattle, WA. http://naturemappingfoundation.org/natmap/maps/wa/mammals/WA_red-tailed_chipmunk.html, accessed May 5, 2015.
- Levenson, H., and R. S. Hoffman. 1984. Systematic relationships among taxa in the Townsend chipmunk group. *Southwestern Naturalist* 29:157-168.
- Levenson, H., R. S. Hoffman, C. F. Nadler, L. Deutsch, and S. D. Freeman. 1985. Systematics of the Holarctic chipmunks (*Tamias*). *Journal of Mammalogy* 66:219-242.
- Littell, J. S., D. McKenzie, D. L. Peterson, and A. L. Westerling. 2009. Climate and wildfire area burned in western U.S. ecoprovinces, 1916-2003. *Ecological Applications* 19:1003-1021.
- Mader, H. J. 1984. Animal isolation by roads and agricultural fields. *Biological Conservation* 29:81-96.
- Marlon, J. R., P. J. Bartlein, D. G. Gavin, C. J. Long, R. S. Anderson, C. E. Briles, K. J. Brown, D. Colombaroli, D. J. Hallett, M. J. Power, E. A. Scharf, and M. K. Walsh. 2012. Long-term perspectives on wildfires in the western USA. *Proceedings of the National Academy of Sciences* 109:E535-E543.
- McGregor, R. L., D. J. Bender, and L. Fahrig. 2008. Do small mammals avoid roads because of the traffic? *Journal of Applied Ecology* 45:117-123.
- Merriam, G., M. Kozakiewicz, E. Tsuchiya, and K. Hawley. 1989. Barriers as boundaries for metapopulations and demes of *Peromyscus leucopus* in farm landscapes. *Landscape Ecology* 2:227-235.

- Nagorsen, D. W., M. A. Fraker, and N. Panter. 2000. Conserving mammals at risk: the role of taxonomy. Pp. 41-48 in L. M. Darling, editor. Proceedings of the Biology and Management of Species and Habitats at Risk, Kamloops, BC, 15-19 February 1999. Volume 1. BC Ministry of Environment, Lands and Parks, Victoria, BC, and University College of the Cariboo, Kamloops, BC. 490 pp.
- Nowak, R. M. 1999. Walker's Mammals of the World, Sixth Edition, volume II. Johns Hopkins University Press, Baltimore MD.
- Orr, R. T. 1943. Mammals of the Clearwater Mountains, Idaho. Proceedings of the California Academy of Science 23(35):511-536.
- Oxley, D. J., M. B. Fenton and G. R. Carmody. 1974. The effects of roads on populations of small mammals. Journal of Applied Ecology 11:51-59.
- Patterson, B. D. 1984. Geographic variation and taxonomy of Colorado and Hopi chipmunks (genus *Eutamias*). Journal of Mammalogy 65:442-456.
- Patterson, B. D., and L. R. Heaney. 1987. Preliminary analysis of geographic variation in red-tailed chipmunks (*Eutamias ruficaudus*). Journal of Mammalogy 68(4):782-791.
- Reid, N., S. Hird, A. Schulte-Hostedde and J. Sullivan. 2010. Examination of nuclear loci across a zone of mitochondrial introgression between *Tamias ruficaudus* and *T. amoenus*. Journal of Mammalogy 91(6):1389-1400.
- Richardson, J. R., R. F. Shore, J. R. Treweek, and S. B. C. Larkin. 1997. Journal of Zoology 243:840-846.
- Rust, H. J. 1946. Mammals of northern Idaho. Journal of Mammalogy 27(4):308-327.
- Scrivner, J. H., and H. D. Smith. 1984. Relative abundance of small mammals in four successional stages of spruce-fir in Idaho. Northwest Science 58:171-176.
- Shepherd, J. F. 1994. Initial response of small mammals to new forestry and overstory removal timber harvests. M.Sc. thesis, University of Montana, Missoula.
- Sheppard, D. H. 1971. Competition between two chipmunk species (*Eutamias*). Ecology 52:320-329.
- Sullivan, T. P., D. S. Sullivan, and C. J. Krebs. 1983. Demographic responses of a chipmunk (*Eutamias townsendii*) population with supplemental food. Journal of Animal Ecology 52:743-755.
- Sutton, D. A., and C. F. Nadler. 1974. Systematic revision of three Townsend chipmunks (*Eutamias townsendii*). Southwestern Naturalist 19:199-212.

Sutton, D. A., and B. D. Patterson. 2000. Geographic variation of the western chipmunk *Tamias senex* and *T. siskiyou*, with two new subspecies from California. *Journal of Mammalogy* 81:299-316.

Washington State Department of Natural Resources 2014. Animal List from the Washington Natural Heritage Program, accessed August 19, 2014.
http://www1.dnr.wa.gov/nhp/refdesk/lists/animal_ranks.html#key

Westerling, A. L., H. G. Hildago, D. R. Cayan and T. W. Swetnam. 2006. Warming and earlier spring increase western U.S. forest wildfire activity. *Science* 313:940-943.

White, J. A. 1953. The baculum in the chipmunks of western North America. University of Kansas Publications, Museum of Natural History 5:611-631.

Wolff, J. O. 1993. Why are female small mammals territorial? *Oikos* 68:364-370.

Yahner, R. H. 1978. The adaptive nature of the social system and behavior in the eastern chipmunk, *Tamias striatus*. *Behavioral Ecology and Sociobiology* 3:397-427.