Appendix A.7

Habitat Connectivity for Least Chipmunk (*Neotamias minimus*) in the Columbia Plateau Ecoregion

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Introduction

Least chipmunk, photo by Kelly McAllister

This account describes components of least chipmunk (*Neotamias minimus*) life history, ecology and behavior that are relevant to an analysis of the size and connectivity on habitat blocks on the Columbia Plateau. This analysis started with the *Washington Connected Landscapes Project: Statewide Analysis* (WHCWG 2010) which modeled connectivity for 16 focal species within Washington State. The statewide analysis incorporated data layers such as land cover/land use, elevation, slope, housing density, and roads at a 100-meter scale of resolution. This relatively coarse-scale analysis is the basis for a finer scale connectivity assessment of the Columbia Plateau Ecoregion. The Columbia Plateau comprises much of southeast Washington. It is an arid area with several ecological systems and a number of species that are declining in distribution and abundance. Human activities have, and are continuing to, reduce and fragment the cover of native vegetation in the area. Less than 50% of the historical shrubsteppe remains in Washington. Most of it is within the Columbia Plateau (Schroeder & Vander Haegen 2011).

To define important wildlife corridors and habitat blocks more precisely than was done in the statewide analysis, we used additional data layers, better defined habitat variables, and a finer scale of resolution—a 30 m scale—to examine connectivity issues for 11 focal species, including the least chipmunk.

Justification for Selection

The least chipmunk utilizes a wide variety of woody and shrubby habitats across its range. In Washington, it is restricted largely to shrubsteppe and shrub habitats. It is found on the edge of woodlands and will use grasslands, but these are not preferred types. It is also found in dunes habitat, but only where pockets of denser soil support burrows or rock outcrops provide escape cover.

Among the threats considered in the species selection process, land clearing, development, and fire have the greatest impact on chipmunks because they remove the shrub cover that the species depends on. People and domestic animals are direct threats through predation by domestic dogs,

and especially cats. Roads and traffic also cause mortality, but chipmunks tend to dart across roads, rather than lingering, so the threat posed by roads and traffic is relatively less. Energy development has not been shown to pose a threat, except through direct habitat destruction that takes place on a small scale on wind and solar farms. The impact of climate change is speculative, but if it leads to increased fire intensity and a shorter fire return interval, the impact will be negative.

We have less information on distribution and abundance of the least chipmunk than we have for other focal species such as the Greater Sage-Grouse (*Centrocercus urophasianus*), Sharp-tailed Grouse (*Tympanuchus phasianellus*), and the mule deer (*Odocoileus hemionus*). However, we have sufficient range and habitat information to model habitat connectivity. The chipmunk is not a migratory species, nor is it a long-distance disperser. Its dispersal distance is short enough at two kilometers that it can be considered a linkage dweller, able to live and reproduce within dispersal corridors.

As a small, relatively sedentary species, the least chipmunk may be a good representative for the sagebrush vole (*Lagurus curtatus*) or, where their ranges overlap, the sagebrush lizard (*Sceloporus graciosus*). Most Columbia Plateau species represent different habitats or are much more mobile than the chipmunk.

The least chipmunk is not listed by or a species of concern for any federal, state or local agency. It is ranked G5 (demonstrably widespread, abundant, and secure across its range) by NatureServe, S4 (apparently secure) by the Washington Natural Heritage Program (WANHP 2011) and Oregon Biodiversity Data Center (Oregon Wildlife Explorer 2011), and S5 (secure) by the Idaho Natural Heritage Program (2011) and the British Columbia Conservation Data Centre (2011).

Distribution

Least chipmunks have the widest distribution of North American chipmunks. They are found from the upper Midwest, north into northern British Columbia and Yukon Territory. In the western U.S., they occur from the western Great Plains, through the Rockies, Basin and Range, Sierras and Cascades from northern Arizona, New Mexico, and southern California through Montana, southern Idaho, Oregon, and Washington (Verts & Carraway 2001; NatureServe 2011).

Within the project area, least chipmunks are found only in Washington, on the Columbia Plateau. Historically, they were found from Turnbull National Wildlife Refuge and on the Palouse near Steptoe Butte, west to the Columbia River near Wenatchee and Bridgeport, and south to the Yakima Training Center. They were found west of the Columbia from Ahtanum Ridge, south of Yakima north to Lookout Mountain at the west end of the Kittitas Valley. This is the range mapped by Johnson and Cassidy (1997; See Habitat Modeling and Habitat Concentration Areas). The current range, where the species has been found in the last 20 years appears to be much smaller. The eastern-most recent records are near Swanson Lakes in Lincoln County. They are found west and north within the Columbia River loop to Bridgeport and Badger Mountain, near Wenatchee. West of the Columbia River they have only been found between the Columbia River and Ellensburg. The species has never been found on the Hanford Reservation (Hanford Site) or

surrounding public lands, despite many surveys. Shrubsteppe east and north of Hanford has not been thoroughly surveyed.

Dalquest (1948) recorded least chipmunks only in the east Cascade Range and the western part of the Columbia Plateau [Basin]. They have since been found in Lincoln and Adams counties and an old record exists for Whitman County. No recent records are known from Whitman County and Johnson and Cassidy (1997) believe them to be gone from this area. They also reported no recent records below 300 m and believe them to be gone below this elevation.

Washington is isolated from the remainder of the range of the species. Least chipmunks are not in the project area in Oregon (Oregon Wildlife Explorer 2011) or Idaho (Groves et al. 1997).

The range of the yellow-pine chipmunk (*N. amoenus*) encircles that of the least chipmunk. The yellow-pine chipmunk is found in more heavily wooded habitat and may exclude the least chipmunk from those areas.

Limiting factors are not well defined for this species. Elsewhere in their range, least chipmunks occupy a broader range of habitats than in this project area. In particular, a range of forest types are occupied elsewhere, but not here (summarized in Verts & Caraway 2001).

Habitat Associations

Across their broad geographic range, least chipmunks inhabit a wide ecological range, reaching from dense boreal forest to semi-desert to alpine meadows. In the project area, they are a species of the shrubsteppe and forest edge (Dalquest 1948; Johnson & Cassidy 1997). They are most common in sagebrush (*Artemisia* spp.) but also use antelope bitterbrush (*Purshia tridentata*) and greasewood (*Sarcobatus vermiculatus*; Larrison 1947; Feldhammer 1979). In Washington, they are found only rarely in grassland or closed forest. They will use these habitats when adjacent to shrubsteppe or open forest. They do not reach alpine meadows in Washington. They use agricultural habitat types including cropland and pasture (Larrison 1947) and developed habitats such as open space and low-density housing where these are adjacent to shrubsteppe.

In the shrubsteppe, least chipmunks prefer habitat that has relatively dense shrub cover but is open below 15 cm. (Feldhammer 1979). Overhead shrubs probably provide cover from predators while an open ground layer provides visibility and free movement. Page et al. (1978) found that in California, grazing on wet sites allowed use by chipmunks probably by opening dense habitat while grazing on drier sites reduced use, possibly because habitat was then too open. Chipmunks will use Conservation Reserve Program (CRP) fields, but only where shrubs were included in the planting mix or have invaded the site (Schroeder & Vander Haegen 2006). Impact of cheatgrass (*Bromus tectorum*) has not been assessed, but in some situations, it may grow densely enough to provide a structural barrier to chipmunks. Cliff and talus are used when adjacent to shrubsteppe.

Least chipmunks are burrowing animals but do not appear to be dependent solely on deep soils. While Feldhammer (1979) found higher density on deep soils with higher clay content, he also found them on rocky areas where they can live in the spaces among the rocks. They are not found in sandy soils that will not support burrows. Laundré (1989) excavated five burrows and found them to range from 17 to 31 cm below the surface and from 0.4 to 3.5 m long.

Least chipmunks are omnivorous. They eat plant material all year. Insects are eaten when available in large numbers, usually in spring and early summer (Carleton 1966; Vaughn 1974). Chipmunks do not put on additional weight in late summer, suggesting that they do not hibernate (Verts & Carraway 2001). They probably spend most of the winter in torpor, waking occasionally to feed on stored food.

Sensitivity to Traffic

Traffic has less impact on chipmunks than on some other species. In eastern forested habitat, striped chipmunks (*Tamias striatus*) were not seen to cross roads of 19 m or more in width (Oxley et al. 1974). No similar studies have been done on the least chipmunk in shrubsteppe, but in Idaho they were apparently able to cross barren lava flows up to several 10s of meters wide (Hanser & Huntly 2006). Direct mortality on roads is a factor, but chipmunk behavior of darting across open habitat reduces the chances of being hit by a vehicle.

Sensitivity to Development

Housing and other forms of development destroy the least chipmunk's preferred habitat of shrubland and shrubsteppe. While chipmunks will use the habitat around buildings, it is not entirely suitable and is much more likely to host predators.

Sensitivity to Energy Development

Chipmunks are probably not very sensitive to energy development. The amount of habitat destroyed by completed powerline or wind power projects is relatively small. Slight impacts might be expected from direct habitat loss tower and roadway footprints. Other impacts would be related to general habitat fragmentation; increased road traffic, fire frequency, weed introduction, and predation. Impact of the energy development process is greater, but assuming developers are sensitive to general wildlife needs, chipmunk populations should survive the construction process.

Sensitivity to Climate Change

Impact of climate change is hard to predict. Direct impacts are not likely to be great. Indirect effects are most likely to result from changes in vegetation. Anything that would increase fire frequency and intensity would result in destruction of shrub cover and reduction of habitat suitability. Several climate change models support this possibility through a wetter spring followed by a hotter, dryer summer (Mauer et al. 2007). The chipmunk is at the northern edge of its range in the project area. An overall warming of climate might enable it to expand to the north.

Other Factors

No chipmunks have been recorded below an elevation of 300 m since 1930 (Johnson & Cassidy 1997). The reason for this is unknown, but there is no evidence to suggest that elevation forms a barrier to dispersal or that it defines suitable habitat.

Dispersal

Home range estimates range from 0.2 to 5.5 ha (Martinsen 1968; Sheppard 1972; Larrison & Johnson 1973; Chappell 1978). Density estimates range from 0.9 to 22.2 chipmunks/ha (Fautin

1946; Vaughn 1974; Feldhammer 1979; Converse et al. 2006). This wide range of home-range size and density represents a wide range of habitat, from sagebrush (Fautin 1946; Feldhammer 1979) to forest edge and alpine meadow (Vaughan 1974). Home range size changes seasonally (Martinsen 1968), and males use a larger area than females (Sheppard 1972). Population density may follow a five to seven year cycle (Erlien & Tester 1984). Density is also affected by food availability (Morrison et al. 1989) and probably by weather conditions.

Little information is available on dispersal. Within suitable habitat, dispersal movements of 130–200 m have been recorded by Martinsen (1968) in a lodgepole pine (*Pinus contorta*) system in Montana (Table A.7.1). This is a small sample size and does not include radio-tracking studies. It may, therefore, underestimate actual dispersal distances (NatureServe 2011). NatureServe (2011) estimates dispersal distance at 5 km.

Little information is available on barriers to dispersal. In eastern forested habitat, striped chipmunks were not seen to cross roads of 19 m or more (Oxley et al. 1974). No similar studies have been done of the least chipmunk in shrubsteppe. In Idaho, Hanser and Huntly (2006) assessed small mammal communities in patches of shrubsteppe isolated in agricultural landscapes or lava flows recent enough to be almost barren. They found least chipmunks in shrubsteppe habitat patches isolated by lava flows 39–422 m in width. No chipmunks were found in patches isolated by 800 m or more. Suitable habitat patches isolated by agriculture 83 and 141 m wide hosted chipmunks. Chipmunks were not present in patches isolated by 180 m or more.

Table A.7.1. Movement distances for the least chipmunk.

Habitat/location	*n*	*Distance*	*Movement type*	*Method*	*Source*
Lodgepole pine/MT	8	73–335 m	Exploratory[a]	Mark/recapture	Martinsen 1968
Lodgepole pine/MT	2	128–201 m	Dispersal[b]	Mark/recapture	Martinsen 1968
		5 km			NatureServe

[a]*Returned to original home range.*
[b]*Relocated to new area.*

Conceptual Basis for Columbia Plateau Model Development

Overview

Two habitat models have been developed for the least chipmunk in the project area. Johnson and Cassidy (1997) attribute the least chipmunk to big sagebrush (*Artemisia tridentata*), greasewood, and antelope bitterbrush habitats with firm or rocky soils. They attribute it to all steppe zones except the Palouse, canyon grassland, and wheatgrass/fescue zones. This encompasses most of the Columbia Plateau within Washington. Bare ground and non-forested habitats were noted as good. All other habitats including forested types were excluded. The current project agrees with the GAP model except on the use of forest types. We have included aspen and woodland types as good habitat (0.80 habitat value, see Table A.7.2) because the species is found in these types elsewhere and old records north of Ellensburg are in an area where woodland types are closely intermixed with shrubsteppe.

Modeling by O'Neil et al. (2001) also has results similar to this project. They associated the least chipmunk with eight habitat types. The types with which the least chipmunk is closely associated are shrubsteppe, desert playa and salt-scrub shrublands, and upland aspen forest. The first two

types are the highest value habitat types used by this project (Table A.7.2). Salt-scrub does not occur in the project area. Aspen types comprise only 450 ha of the project area. Other types with which the least chipmunk had a weaker association were dwarf shrubsteppe, agriculture, urban and mixed environments, riparian and wetlands, and ponderosa pine (*Pinus ponderosa*) forest and woodland (O'Neil et al. 2001). These results agree with this project (Table A.7.2).

The least chipmunk occurs in Oregon, but not within the Columbia Plateau Ecoregion. Oregon Wildlife Explorer (2011) attributes the least chipmunk to sagebrush and rarely, to timber or other habitats.

Previous models and this connectivity model are based on relatively few detailed field studies. Dalquest (1948) and Verts and Caraway (2001) summarize what is known for Washington and Oregon, respectively, and Larrison (1947) reports a little anecdotal information. Some trapping information is available from Schroeder and Vander Haegen (2006) and from records collected by ReGAP (unpublished). ReGAP found 100 verified records of the least chipmunk in Washington. Only 20 of these are from the last 20 years. These locations were plotted on the habitat map developed by this project (See Habitat Modeling and Habitat Concentration Areas). Habitat types likely to be used by the least chipmunk were selected based on these locations. Additional types were added based on personal observations of J.W.F. Results were reviewed by others on the connectivity project knowledgeable on the species.

The foundation for the habitat map is records collected in the last 20 years. Added areas are shrubsteppe, which is believed to be appropriate habitat that has not been surveyed recently. Excluded areas are those where the species likely would have been reported if present. These are areas with records older than 20 years, and areas where biologists or the public likely would have reported the species, such as around Spokane.

The species is under-surveyed, so these boundaries may not be accurate. In particular, the GAP project (Johnson & Cassidy 1997) mapped a much more extensive range west of the Columbia River and east of the range used in this project (See Distribution).

(continued on page A.7-8)

Table A.7.2. Landscape features and resistance values used to model habitat connectivity for least chipmunk.

Spatial data layers and included factors	*Resistance values*	*Habitat values*
Landcover/Landuse		
Grassland_Basin	3	0.40
Grassland_Mountain	3	0.40
Shrubsteppe	0	1.00
Dunes	2	0.20
Shrubland_Basin	0	1.00
Shrubland_Mountain	0	1.00
Scabland	1	0.80
Introduced upland vegetation_Annual grassland	3	0.40
Cliffs_Rocks_Barren	1	0.60
Meadow	3	0.40
Herbaceous wetland	22	0.20
Riparian	22	0.20
Introduced riparian and wetland vegetation	22	0.20
Water	66	0.00
Aspen	3	0.80
Woodland	4	0.80
Forest	9	0.60
Disturbed	22	0.20
Cultivated cropland from RegapNLCD	9	0.20
Pasture_Hay from CDL	2	0.40
Non-irrigated cropland from CDL	9	0.30
Irrigated cropland from CDL	22	0.20
Highly structured agriculture from CDL	5	0.20
Irr Not Irr Cult Ag buffer 0 - 250m from native habitat	15	0.20
Irr Not Irr Cult Ag buffer 250 - 500m from native habitat	15	0.20
Pasture Hay Ag buffer 0 - 250m from native habitat	2	0.40
Pasture Hay Ag buffer 250 - 500m from native habitat	2	0.40
Slope (degrees)		
Gentle slope Less than or equal 20 deg	0	1.00
Moderate slope Greater than 20 less than equal to 40 deg	0	1.00
Steep slope Greater than 40 deg	2	0.40
Ruggedness		
Very gentle terrain (or surface water)	0	1.00
Gentle terrain	0	1.00
Moderate terrain	0	1.00
Rough terrain	0	1.00
Very rough terrain or escarpment	0	0.80
Housing Density Census 2000		
Greater than 80 ac per dwelling unit	0	1.00
Greater than 40 and less than or equal 80 ac per dwelling unit	3	0.80
Greater than 20 and less than or equal 40 ac per dwelling unit	6	0.60
Greater than 10 and less than or equal 20 ac per dwelling unit	9	0.40
Less than or equal 10 ac per dwelling unit	12	0.10
Roads		
Freeway Centerline	16	0.00
Freeway Inner buffer 0 - 500m	0	0.80
Freeway Outer buffer 500 - 1000m	0	1.00
Major Highway Centerline	12	0.00
Major Highway Inner buffer 0 - 500m	0	0.80
Major Outer buffer 500 - 1000m	0	1.00

Spatial data layers and included factors	*Resistance values*	*Habitat values*
Secondary Highway Centerline	9	0.00
Secondary Highway Inner buffer 0 - 500m	0	1.00
Secondary Highway Outer buffer 500 - 1000m	0	1.00
Local Roads Centerline	2	0.00
Local Roads Inner buffer 0 - 500m	0	1.00
Local Roads Outer buffer 500 - 1000m	0	1.00
Railroads Active		
Railroads Active Centerline	1	0.80
Railroads Active Inner buffer 0 - 500m	0	1.00
Railroads Active Outer buffer 500 - 1000m	0	1.00
Irrigation Infrastructure		
Irrigation canals	66	0.80

To produce useful cost-weighted distance and linkage maps, habitat values for habitat connectivity maps were set at 0.95, a very high value. Habitat value of roadway centerlines was set at zero but increases rapidly with distance from the centerline. Resistance values were set high for roadway centerlines and low or zero for roadway buffers. Active Railroads have little effect on habitat quality and form only a weak barrier to dispersal. Inactive Railroads do not affect habitat quality or dispersal. Resistance increases and habitat suitability decreases with rising density of housing. Elevation was not considered in modeling and for the most part, Soil Texture and Depth to Restrictive Layer were not considered. The scale of soil mapping used in this project is coarse enough that areas mapped as unsuitable for chipmunks actually include small areas of soil suitable for them. These areas can be sufficient to support a population of chipmunks. Exceptions are the categories of No Soil which are somewhat less suitable as habitat and somewhat more resistant to dispersal. Slope, Ruggedness, and Landform are largely not relevant to chipmunks. The exceptions are Steep Slopes and Very Rough Terrain or Escarpment which are probably somewhat less suitable as habitat and more resistant to dispersal. Steep Slope is less suitable and more resistant than Very Rough Terrain or Escarpment because it is usually mapped in larger units and consists of poorer habitat. Neither Compound Topo Index nor Insolation appears to affect chipmunk distribution.

Movement Distance

Documented movement distances for the least chipmunk are relatively short. Home ranges of 0.2 and 5.5 ha represent the extreme values (See Dispersal). These extremes have radii of less than 10 m and 130 m. Recorded dispersal distances are up to 335 m. These values represent mark/recapture studies that probably underestimate dispersal distance (NatureServe 2011). The small size of least chipmunk home ranges means that they are able to live in very small habitat patches, such as might be found in a corridor. So dispersal between larger habitat patches could be a multi-year event.

For these reasons, a dispersal distance of 12 km was used in modeling dispersal through suitable habitat.

Few field data are available on which to base maximum cost-weighted distance (Table A.7.2). Most resistance values are estimates, based on J.W.F.'s field experience and reviewed by other connectivity project biologists. Based on these estimates and the possibility of the least chipmunk being a linkage dweller, a maximum cost-weighted distance of 20 km was selected.

Habitat Concentration Areas

Draft habitat concentration areas (HCAs) for the least chipmunk were modeled using habitat values ranging from 0.75 to 0.95 and home range radii of 130 m and 600 m. After review of the draft HCAs, acceptable habitat value was set at 0.95 or higher, and habitat radius was set at 600 m or larger.

Resistance and Habitat Values for Landscape Features

Data layers (Table A.7.2) used to model resistance and habitat for the least chipmunk include:

1) Land cover/Land use
2) Slope
3) Soil Depth to First Restricted Layer
4) Housing Density Census 2000
5) Roads
6) Railroads Active
7) Irrigation Infrastructure

Modeling Results

Resistance Modeling

Resistance is mapped in Figure A.7.1. Areas of low resistance are blocks of shrubsteppe through which chipmunks can move freely. These form networks of low resistance in coulee systems such as Moses Coulee, Grand Coulee, and Upper Crab Creek on the northern part of the Columbia Plateau and large blocks on the Hanford Site and the Yakima Training Center. Bodies of water such as Banks Lake, the Columbia River, and Potholes Reservoir appear as high resistance, as do areas of irrigated agriculture. Built up areas like Moses Lake, Walla Walla, and the Tri-Cities are also highly resistant.

Habitat Modeling and Habitat Concentration Areas

Suitable habitat is mapped in Figure A.7.2. This figure is a good representation of the distribution of remnant shrubsteppe, a logical result since least chipmunks are largely a shrubsteppe species. Low quality habitat includes areas of irrigated agriculture such as that in south-central Grant County and the Yakima Valley in east-central Yakima and west-central Benton County. The distinctive area of low quality habitat on the Hanford Site, in northern Benton County is a large sand deposit, a feature of low habitat quality. This sandy area is not, however, very resistant to movement. While the soil is too sandy to support burrows, and there is no rock to provide protection the area supports a good cover of shrubs through which chipmunks can move freely.

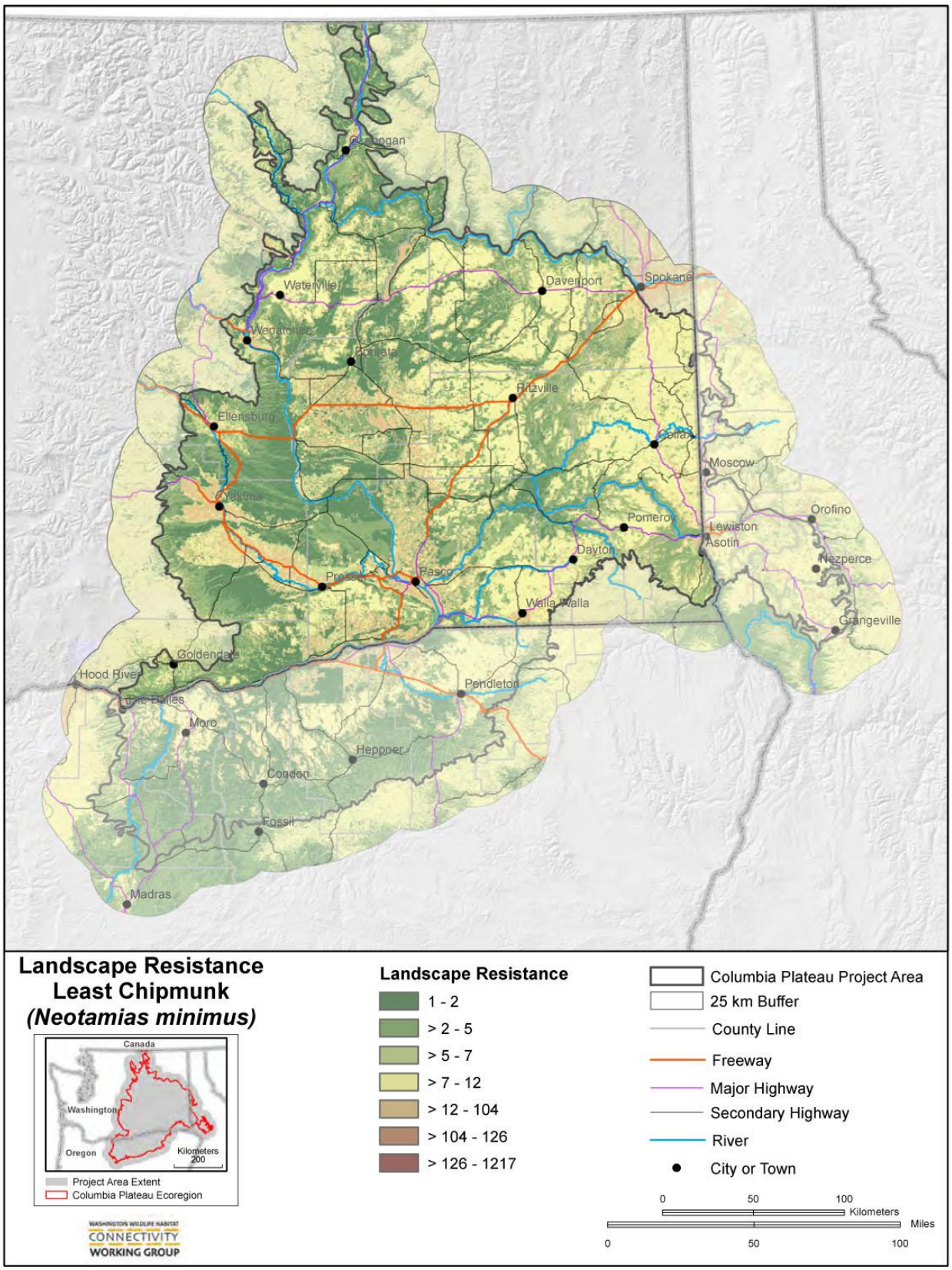

Figure A.7.1. Resistance map for least chipmunk in the Columbia Plateau Ecoregion.

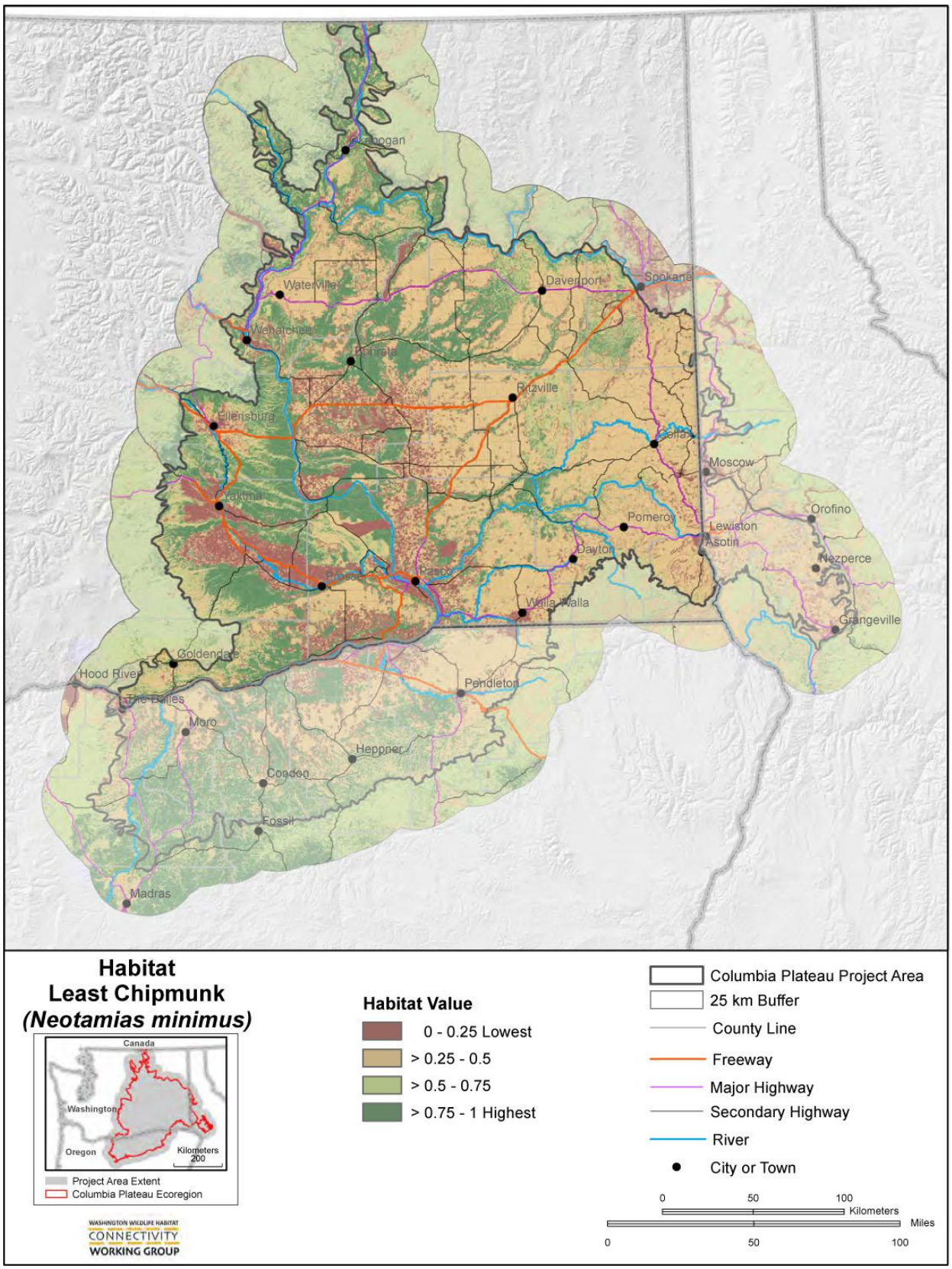

Figure A.7.2. Habitat map for least chipmunk in the Columbia Plateau Ecoregion.

There are 47 HCAs totaling 270,600 ha (Fig. A.7.3; see also Fig. A.7.4 for HCA identification). These are the result of relatively high values for habitat (0.95) and home range radius (600 m). The home range radius is higher than any in the literature. The habitat value excludes quite a bit of habitat that appears to be suitable (J.W.F., personal observation). These values were used because lower values resulted in much larger HCAs and left no room for linkages. For instance, HCAs 5, 9 and 10 are expressed in the model using 0.95 habitat value and home range radius of 130 m. These three HCAs become a single HCA in a model using a habitat value of 0.85 and a home range radius of 600 m. HCAs 8, 11, 12, 13, 16, and 19 also become a single HCA when habitat value is lowered to 0.85 and home range radius increased to 600 m. The areas between these groups of HCAs are shrubsteppe but of a lower quality than the sites delineated as HCAs by the selected model.

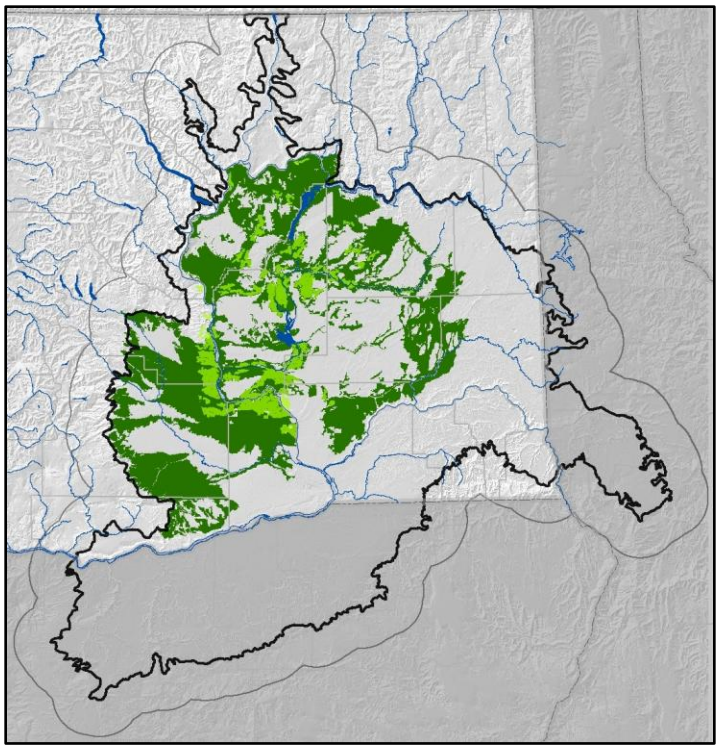

Figure A.7.3. Least chipmunk HCAs (light green) and GAP distribution (dark green) in the Columbia Plateau Ecoregion.

Cost-Weighted Distance Modeling

Much of the potentially adequate habitat that is not included in HCAs is used by the linkages developed by cost-weighted distance (CWD) modeling (Fig. A.7.5). For instance, HCAs 5, 9, and 10 and HCAs 8, 11, 12, 13, 16, 19 link through areas included by the more liberal habitat model discussed above.

Euclidean path length of 12 km and CWD length of 20 km were selected to drive definition of valid paths. Within the model, these distances appear to have been largely successful. CWD routes through landscapes that are highly resistant show high CWD values. Even with Euclidean distance as short as 0.4 km, routes that cross the Columbia River have CWD values greater than 20 and are assumed, therefore to be resistant to passage.

There are two exceptions to the 12 and 20 kilometer rule. Between HCAs 10 and 15 (See Appendix B), Euclidean length is 7.7 km and CWD is 24.4 km. This CWD is higher than expected. Shrubsteppe is almost uninterrupted in this area (J.W.F., personal observation), and a linkage was, therefore, inserted here manually. Between HCAs 10 and 20, Euclidean distance is 10.9 and CWD is 19.4. This CWD is lower than expected. This area is in highly developed agriculture, and least chipmunks are not likely to use this linkage. It was, therefore, manually removed.

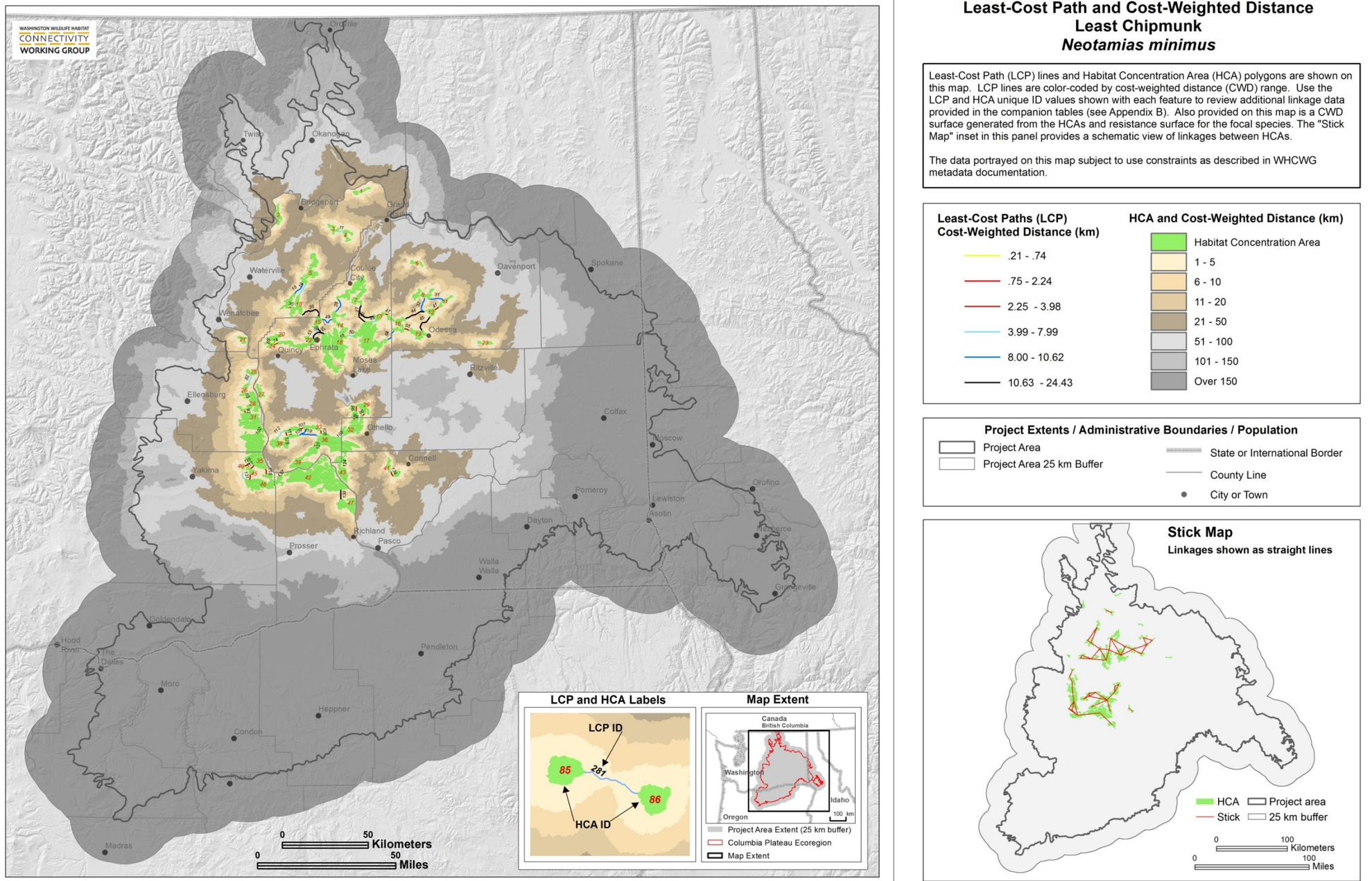

Figure A.7.4. Cost-weighted distance map with numbered HCAs (green polygons labeled with red numerals) and least-cost paths (lines labeled with black numerals) for least chipmunk. Linkage modeling statistics provided in Appendix B.

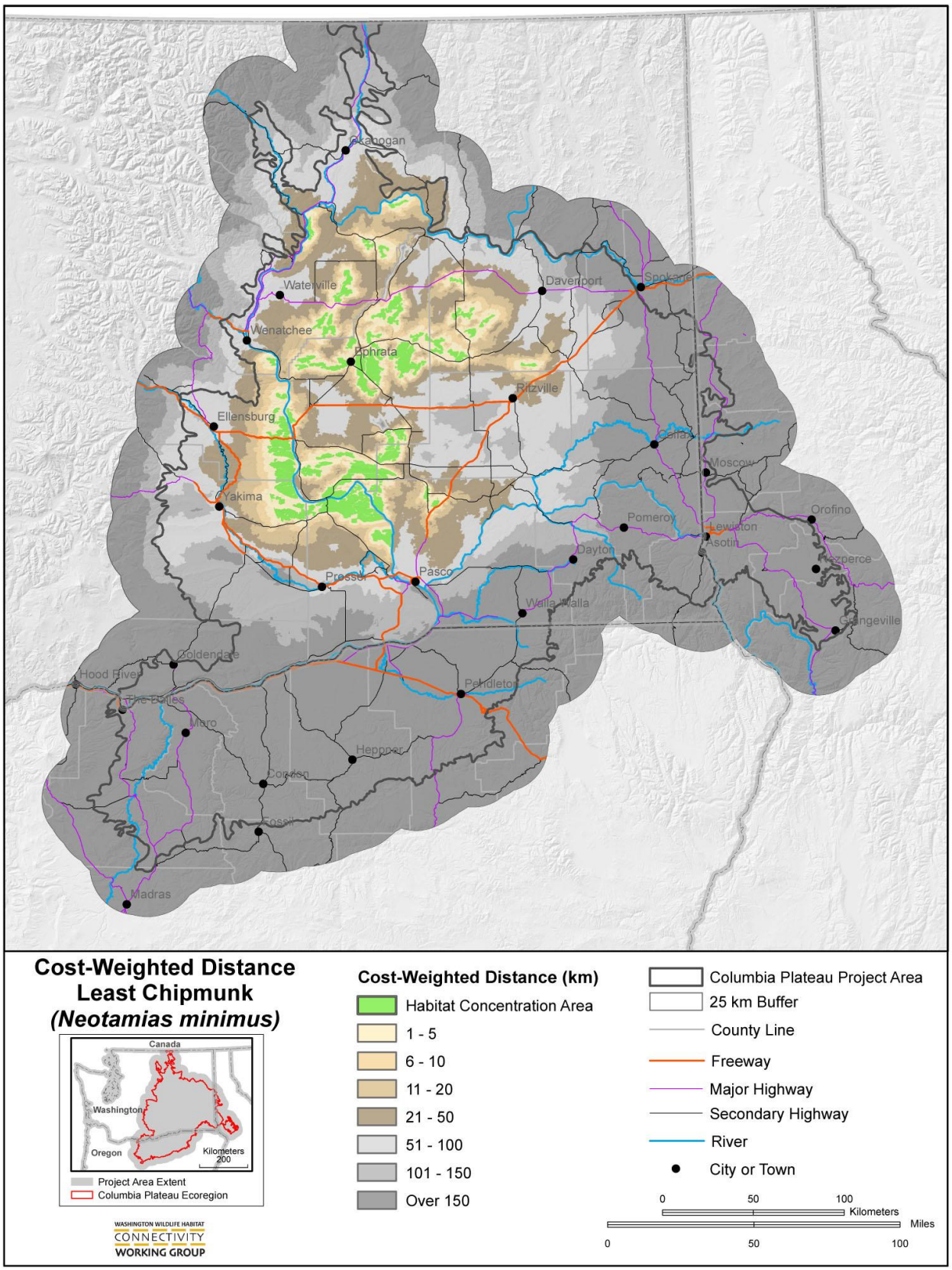

Figure A.7.5. Cost-weighted distance map for least chipmunk in the Columbia Plateau Ecoregion.

Linkage Modeling

The 47 HCAs modeled by this project are joined by 52 links into 11 sets (Fig. A.7.6; see also Fig. A.7.4). Links face varying levels of threat depending on pressure in the particular area from residential and agricultural development, road construction, and other factors. All links are threatened by fire. The shrubsteppe community that provides the best habitat and lowest resistance to movement is often destroyed and usually damaged when burned.

Six HCAs are too distant in either Euclidean or cost-weighted distance to link to other HCAs. Four HCAs are linked in pairs. The remaining HCAs are linked into three large groups. The Columbia River forms an impenetrable barrier. One single HCA and one large group are on the west side of the River. Among these HCAs, important linkages join HCA 47 and HCA 42, in the southern part of the Hanford Site. This link crosses the sandy area discussed above and should be relatively strong and secure. Likewise, linkages from the west end of HCA 42, reaching west and north to HCA 35 are relatively secure. Most are on the Yakima Training Center, and therefore protected from most development. Linkages north from this area to HCA 25 are through land that is relatively undeveloped and faces few current threats. HCA 21 is isolated from all other HCAs, and no potential linkage is apparent.

East of the Columbia River, in this southern area, HCAs 41 and 44 connected, but isolated from other HCAs in a landscape fragmented by irrigated agriculture. The linkage between them will be difficult to maintain. HCAs west of these, from 29 and 43 to 38 are also separated by corridors of agriculture. As agriculture continues to grow in this area, pressure on these linkages and the HCAs will grow. North of this area, HCA 21 is isolated in a block of relatively high quality shrubsteppe with little hope of connecting to another HCA.

Around the northern and eastern part of the ecoregion, four single HCAs; 1, 2, 6, and 23, and one pair of HCAs, 3 and 4, are isolated from other HCAs. The western of these; 1, 2, 3, and 4, are each within large blocks of shrubsteppe. These blocks either are not interconnected or only connect over distances greater than those permitting movement of chipmunks under this model. These areas would be interesting to survey for chipmunk distribution and to measure dispersal. HCAs 23 and 6 are isolated by long distances. Habitat between them and other HCAs is somewhat fragmented and not of pristine quality. It may, however, be populated by chipmunks and would be interesting to survey.

A large block of interconnected HCAs runs from 11 and 19 to 5, 9, 20, and 24. Some of these linkages are secure, such as among 5, 9, and 10. Others are at risk from continuing agricultural and recent housing development. These include links between HCA 10 and HCA 15; among 22, 15, and 18; 18 and 14; 14 and 17; and most linkages north of HCA 14 and HCA 17. In these areas, HCAs are at risk as are linkages.

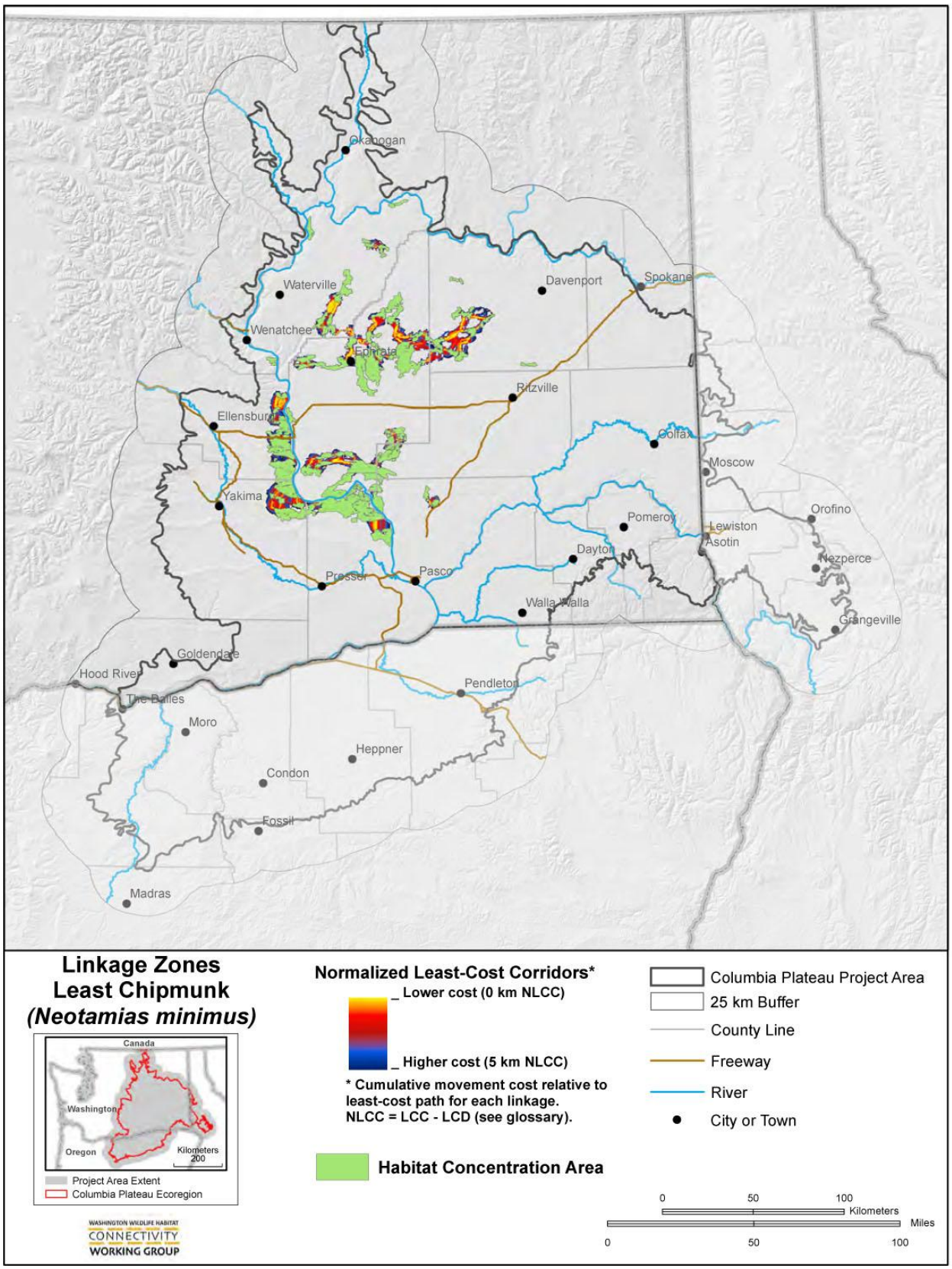

Figure A.7.6. Linkage map for least chipmunk in the Columbia Plateau Ecoregion.

Key Patterns and Insights

Key patterns and insights for our connectivity analysis of the least chipmunk in the Columbia Plateau Ecoregion include:

- Least chipmunks are widespread across the western part of the Columbia Plateau. They are able to use lower quality habitat than was used to create HCAs.
- Least chipmunks are under-surveyed. This project is based on few recent records, and large areas of potential habitat have not been surveyed.
- HCAs are restricted largely by agricultural development. Irrigated agriculture has an especially large impact. Residential and industrial development and transportation corridors are also restrictive. The chipmunk does not require shrub cover, but it is a powerful positive influence and the habitat value of burned areas is reduced.
- These same factors increase the resistance of linkages.
- Fire may pose the greatest large-scale, short-term threat.
- Development may pose the greatest small-scale, long-term threat.

Considerations for Future Modeling

The least chipmunk is the least studied of the focal species in the Connectivity project. It is probably more widely distributed than other focal species. Its habitat requirements are not well known in Washington, nor is its dispersal capability. Reassessment of its distribution, dispersal capabilities, and habitat needs are badly needed before management can be successful.

Opportunities for Model Validation

The greatest knowledge gap for the least chipmunk is its current range in the state. It is relatively common and widespread and of limited conservation concern (NatureServe 2011). It is noted where collected, but is not a target for intensive survey. Detailed study of range, distribution, habitat, and dispersal are needed. Cheatgrass has spread through much of the project area. Its impact on habitat suitability has not been assessed and could be powerful.

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Literature Cited

British Columbia Conservation Data Centre (BCCDC). 2011. Status of least chipmunk. Available from http://www.env.gov.bc.ca/cdc/ (accessed December 2011).

Carleton, W. M. 1966. Food habits of two sympatric Colorado sciurids. Journal of Mammalogy 47:91–103.

Chappell, M. A. 1978. Behavioral factors in the altitudinal zonation of chipmunks (*Eutamias*). Ecology 59:565–579.

Converse, S. J., G. C. White, and W. M. Block. 2006. Small mammal responses to thinning and wildfire in ponderosa pine-dominated forests of the southwestern United States. Journal of Wildlife Management 70:1711–1722.

Dalquest, W. W. 1948. Mammals of Washington. University of Kansas Publications, Museum of Natural History. Erlien, D. A., and J. R. Tester. 1984. Population ecology of sciurids in northwestern Minnesota. Canadian Field Naturalist 98:1–6.

Fautin, R. W. 1946. Biotic communities of the northern desert shrub biome of western Utah. Ecological Monographs 16:251–310.

Feldhammer, G. A. 1979. Vegetative and edaphic factors affecting abundance and distribution of small mammals in southeast Oregon. Great Basin Naturalist 39:207–218.

Groves, C. R., B. Butterfield, A. Lippincott, B. Csuti, and J. M. Scott. 1997. Atlas of Idaho's Wildlife. A. Lippincott (editor). Idaho Department of Fish and Game, The Nature Conservancy, Idaho Gap Analysis Project. Available from http://imnh.isu.edu /digitalatlas/bio/mammal/mamfram.htm (accessed May 2011).

Hanser, S. E., and N. J. Huntly. 2006. Biogeography of small mammals of fragmented sagebrush-steppe landscapes. Journal of Mammalogy 87:1165–1174.

Idaho Natural Heritage Program. 2011. Status of least chipmunk. Available from http://fishandgame.idaho.gov/ifwis/taxonomy/viewer/ (accessed December 2011).

Johnson, R .E., and K. M. Cassidy. 1997. Terrestrial mammals of Washington State: Location data and predicted distributions. Volume 3 in Washington State Gap Analysis – Final Report. K. M. Cassidy, C. E. Grue, M. R. Smith, and K. M. Dvornich (editors). Washington Cooperative Fish and Wildlife Research Unit, University of Washington. Seattle.

Larrison, E. J. 1947. Notes on the chipmunks of west-central Washington. The Murrelet 28:23–30.

Larrison, E. J., and D. R. Johnson. 1973. Density changes and habitat affinities of rodents of shadscale and sagebrush associations. The Great Basin Naturalist 33:255–264.

Laundré, J. W. 1989. Burrows of least chipmunks in southeastern Idaho. Northwestern Naturalist 70:18–20.

Martinsen, D. L. 1968 Temporal patterns in the home ranges of chipmunks (*Eutamias*). Journal of Mammalogy 49:83–91.

Maurer, E. P., L. Brekke, T. Pruitt, and P. B. Duffy. 2007. Fine-resolution climate projections enhance regional climate change impact studies. EOS Transactions, AGU 88:504. Available from http://www.climatewizard.org/ (accessed October 2011).

Morrison, M. L., M. L. Morton, L. S. Hall, J. L. Harner, and J. J. Keane. 1989. Population biology of small mammals in the White-Inyo mountains, California. Pages 246–255 in C. A. Hall Jr., V. Doyle-Jones, and B. Widawski, editors. WMRS Symposium Volume 3: Natural History of Eastern California and High-Altitude Research, September 21–24, 1989. University of California White Mountain Research Station. Available from http://www.wmrs.edu/resources/reference%20documents/Natural%20History%20EC/TOC.htm (accessed April 2011).

NatureServe. 2011. NatureServe Explorer: *Neotamias minimus* account. An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available from http://www.natureserve.org/explorer (accessed March 2011).

O'Neil, T. A., D. H. Johnson, C. Barrett, M. Trevithick, K. A. Bettinger, C. Kiilsgaard, M. Vander Heyden, E. L. Greda, D. Stinson, B. G. Marcot, P. J. Doran, S. Tank, and L. Wunder. 2001. Matrixes for Wildlife-Habitat Relationship in Oregon and Washington. Northwest Habitat Institute. In D. H. Johnson, and T. A. O'Neil, managing directors. Wildlife-Habitat Relationships in Oregon and Washington. Oregon State University Press, Corvallis, Oregon.

Oregon Wildlife Explorer. 2011. Status of the least chipmunk in Oregon. Available from http://oe.oregonexplorer.info/Wildlife/ (accessed May 2011).

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.

Page, J. L., N. Dodd, T. O. Osborne, and J. A. Carson. 1978. The influence of livestock grazing on non-game wildlife. Transactions of the Western Section of The Wildlife Society. Available from http://www.tws-west.org/transactions (accessed October 2011).

ReGAP (Regional GAP Analysis). Data collected as part of the Northwest Regional Gap Analysis Program and held by the Washington Natural Heritage Program.

Schroeder, M. A., and W. M. Vander Haegen. 2006. Use of Conservation Reserve Program fields by greater sage-grouse and other shrubsteppe-associated wildlife in Washington state. Technical report prepared for U.S. Department of Agriculture Farm Service Agency. Washington Department of Fish and Wildlife, Olympia, Washington.

Schroeder, M. A., and W. M. Vander Haegen. 2011. Response of greater sage-grouse to the Conservation Reserve Program in Washington State. Pages 517–529 in S. T. Knick and J. W. Connelly (editors). Greater Sage-Grouse: ecology and conservation of a landscape species and its habitats. Studies in Avian Biology Series (vol. 38), University of California Press, Berkeley, California.

Sheppard, D. H. 1972. Home ranges of chipmunks (*Eutamias*) in Alberta. Journal of Mammalogy 53:379–380.

Vaughan, T. A. 1974. Resource allocation in some sympatric, subalpine rodents. Journal of Mammalogy 55:764–795

Verts, B. J., and L. N. Carraway. 2001. *Tamias minimus*. Mammalian Species Number 653.

WANHP (Washington Natural Heritage Program). 2011. Status of least chipmunk in Washington. Available from http://www1.dnr.wa.gov/nhp/ (accessed December 2011).

WHCWG (Washington Wildlife Habitat Connectivity Working Group). 2010. Washington Connected Landscapes Project: Statewide Analysis. Washington Departments of Fish and Wildlife, and Transportation, Olympia, Washington.