Appendix A.8

Habitat Connectivity for Rocky Mountain Mule Deer (*Odocoileus hemionus hemionus*) in the Columbia Plateau Ecoregion

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Introduction

Mule deer, photo by Woodrow Myers

This narrative describes components of Rocky Mountain mule deer (*Odocoileus hemionus hemionus*) life history, ecology, and behavior that are relevant to an analysis of habitat connectivity in the Columbia Plateau Ecoregion. This analysis began 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 m 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 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 tracts of continuous habitat 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 mule deer.

Justification for Selection

Rocky Mountain mule deer are an icon of the American West and have long been an important historic feature of eastern Washington's landscape. For at least 2000 years prior to settlement by Euro-Americans, mule deer were an important part of Native American economy, providing an important source of food and clothing (Josephy 1965; Chalfant & Ray 1974). Today mule deer remain an important component of biodiversity upon the landscape. In addition to being a key large herbivore in a functioning ecosystem, mule deer provide key recreational opportunities for hunters and wildlife watchers and tremendous economic benefits to local communities and the state of Washington.

In recent decades, wildlife managers in western states have become concerned about declining trends in mule deer populations (Unsworth et al. 1999; Gill et al. 2001; Heffelfinger & Messmer 2003). The Columbia Plateau, which is home to 12,000–16,000 resident mule deer (significantly more if wintering migrants are included; WDFW unpublished data), represents a microcosm of the habitat and connectivity alterations mule deer are facing across eastern Washington and the western United States. Mule deer range within the Columbia Plateau has been altered by landscape changes from conversion to agricultural croplands, grazing by domestic livestock, wildfire, highway and road construction, irrigation expansion, wind power development, invasion of noxious weeds, and urban/suburban development.

Mule deer within the Columbia Plateau are closely associated with most native habitats including shrubsteppe, shrub, grassland, and woodland (forested) cover types. Mule deer also can be found within the dune habitat type found in the west-central portion of Columbia Plateau. Recent, relatively long-term field studies of mule deer in the Columbia Plateau have documented deer distribution and habitat use (WDFW unpublished data). While final analyses of these studies are still underway, the preliminary results aided in the selection and ranking of parameters used in the development of models to identify habitat concentration areas (HCAs) and movement corridors for this connectivity analysis. Since mule deer are widely distributed across this landscape, habitat values for habitat connectivity maps were set at the high value of 0.89 to ensure production of useful cost-weighted distance and linkage maps.

Mule deer are a useful species for this modeling and connectivity analysis because of their widespread distribution. But perhaps, more importantly, their strong association with remnant shrubsteppe and other native habitats makes them a good choice. A large portion of these habitats upon which mule deer depend have changed over time. Much of the Columbia Plateau was historically composed of shrubsteppe vegetation communities (Daubenmire 1970). Agricultural development during the late 1800s, and expanded irrigation beginning in the 1950s, changed much of the landscape (National Research Council 1995). Conversion of native habitats continues today. As habitat for mule deer becomes more fragmented, safe-guarding connectivity between mule deer sub-herds becomes increasingly more important so that corridors for seasonal migration, dispersal, and gene flow remain uninterrupted.

Mule deer are designated as a state game species in Washington and are listed as a Priority Species by the Washington Department of Fish and Wildlife (WDFW) Priority Habitats and Species Program (WDFW 2008). Mule deer have no formal federal listing.

Distribution

Rocky Mountain mule deer are the most widely distributed subspecies of mule deer (Mackie, et al. 1982). Their range in North America extends from the southern Yukon Territory of Canada, south into northern Arizona and New Mexico, and from the 100th Meridian west to the crest of the Cascade and Sierra mountain ranges (Chapman & Feldhamer 1982).

Mule deer are present in every county in eastern Washington with the highest densities found along the east slope of the Cascade Range, the Snake River breaks, along portions of the Columbia River, and the northern Kettle Mountains. Within some portions of their range in eastern Washington, mule deer migrate some distance (up to 80 km straight-line distance) between summer and winter use areas (Zeigler 1978; Myers et al. 1989), while other populations remain year-round residents within their herd boundary. Abundance has likely varied across Washington's mule deer ranges over time with current numbers stable to declining depending upon area, but density estimates across the entire Columbia Plateau are not available. Results of recent aerial surveys of mule deer within the southern portion of the Columbia Plateau in Washington, adjusted for sightability, estimated the population to total 10,000 to 12,000 mule deer (WDFW unpublished data).

Mule deer populations can be limited by a variety of both direct and indirect factors. Starvation, predation, hunting, deer-vehicle collisions, poaching, and disease can all affect mule deer numbers. Habitat loss resulting from alteration probably has the greatest effect. But habitat conditions can also be affected annually or seasonally by drought, heavy snowfall or other unusual conditions influencing mule deer survival and productivity.

Habitat Associations

General

Mule deer occupy a variety of habitat types across eastern Washington from alpine/subalpine basins above timberline to shrubsteppe along the Columbia River, and all in between, depending upon the season (Zeigler 1978; Myers et al. 1989; WDFW file data). Within the Columbia Plateau, mule deer are most closely associated with remaining native habitats including shrubsteppe, shrub, grassland, meadow, forest, and woodland classifications (WDFW unpublished data).

Breeding

Mule deer breed during late November and early December within the Columbia Plateau. No specific habitats can be described as breeding habitat except perhaps at a micro-site level. During this time of year, mule deer can generally be found using grassland or other areas including winter wheat (*Triticum* sp.), that have experienced a fall green-up from recent rains.

Winter

Portions of the mule deer population within the Columbia Plateau migrate between spring-summer-fall and winter use areas (WDFW unpublished data). Mule deer occupying some portions of southwestern Spokane, western Whitman, and eastern Adams counties south of I-90 from early spring to late fall migrate south and southwest towards the Snake River breaks, where they spend the winter on the grassland slopes. Some mule deer from Lincoln County and western Spokane County move west-southwest to spend the winter season in Conservation Reserve Program (CRP) and agricultural lands north of the town of Wilson Creek, as do some deer from northern Douglas and Grant counties. Some Lincoln County mule deer move north to the agricultural lands and timber covered breaks along the Columbia River.

Non-migratory mule deer use the same ranges all year long with shifts in food preferences. During the winter season, these deer will use winter wheat, if available, as a primary food source; secondary choices include annual grasses, shrubs, and Douglas-fir (*Psueudotsuga menziesii*; WDFW unpublished data). Micro-sites that receive higher levels of solar radiation and protection from wind are used as resting cover during the winter; shady areas are highly desirable for thermal regulation during the summer.

Fawning and Fawn Rearing

Mule deer fawning and fawn rearing habitats provide dams and their offspring with adequate amounts of lush, nutritious forage, water, and security cover. Within the Columbia Plateau, these habitats are most available at or near riparian areas or irrigated crops like hay or alfalfa (*Medicago sativa*). These habitats are limited in scope during the late spring and summer, yet become increasingly important to lactating does as vegetation begins to dry later in the growing season. Adequate fawning and fawn-rearing habitats may well be the most important factors for the well-being of mule deer and sustaining of their populations within the Columbia Plateau as nutritional requirements of a lactating female mule deer raising a fawn are from four to seven times that of a non-lactating doe (Tollefson et al. 2010). Yet these habitats are among the most limited, particularly during drought years. Low nutritional condition of pregnant and lactating does can result in late parturition, low fawn weight at birth, and poor fawn survival and recruitment potentially leading to reduced population levels.

Sensitivity to Roads and Traffic

The direct costs of deer killed on, or habitat loss associated with, highways bisecting mule deer ranges are obvious. But other effects can be more insidious (Myers et al. 2008). For example, highway development may block or reduce migration corridor widths, causing bottlenecks through which mule deer become concentrated. When such bottlenecks occur near roads, migrating animals may suffer increased traffic-related stress and collision-related mortality. Movement patterns within seasonal home ranges of resident (non-migratory) mule deer can be similarly affected. Access to fawning areas, feeding areas, bedding sites, or escape cover can be blocked or diverted. These areas are important components of daily and seasonal activity patterns, and survival can be affected by fragmentation, lowering the overall habitat quality. Even when movement corridors are not blocked by highway construction, but only bisected, there are likely increased costs to animals that have to cross a highway to access food or cover. Those costs may come in the form of added stress or energy demands that, in turn, can have cumulative deleterious effects. Traffic levels may also negatively affect mule deer. Modeling of deer-vehicle collision rates and traffic levels showed increasing levels of average annual daily traffic were associated with higher numbers of collisions in most eastern Washington models (Myers et al. 2008).

Sensitivity to Development

Urban/suburban and other forms of development directly remove habitat used by mule deer. While mule deer may use the habitat adjacent to and around developments, such habitats cannot be considered completely suitable.

Sensitivity to Energy Development

Alternative energy solutions are being pursued across the western United States as concerns for diminishing fossil fuel resources have grown in recent decades. Electricity generated by wind power currently is one of the fastest growing alternative energy sources in the region with numerous wind power sites already in operation and new development sites being planned.

Although wind power is generally considered to be a "green energy" source, there may be associated costs to mule deer and the habitat upon which they depend. Direct impacts to mule deer may occur in the form of habitat loss and increased mortality as a result of turbine construction and operation. Congruent with each wind power site are extensive new road construction, transmission line development, and increased levels of human disturbance; these factors can have both direct and indirect effects to mule deer populations which may be immediate as well as long term.

WIND ENERGY DEVELOPMENT

While few studies have focused on impacts to mule deer resulting from wind energy development (Hebblewhite 2011), long-term studies of energy development impacts to mule deer have been conducted in Wyoming (Sawyer 2005, 2006). Energy development in Wyoming has a similar footprint to wind energy development, and it is on that basis that some impacts are assumed to occur.

TRANSMISSION LINES

Habitat use by mule deer is most likely to be disrupted during construction of power transmission lines. Outside of construction, transmission lines are not thought to provide appreciable impacts to habitat quality or movement.

Sensitivity to Climate Change

Mule deer sensitivity to climate change would probably be manifested in changes to habitat quality and availability. Any climate changes that affect changes in seasonal or annual rainfall, snowfall, or temperature levels could ultimately result in increases or decreases in mule deer body condition, productivity, and survival, depending upon the direction of change.

Dispersal

Five years of monitoring movements of 139 radio-marked adult female and subadult mule deer across portions of the Columbia Plateau provided estimates of annual home-range size and mean migration and dispersal distances (straight-line distance; 2002–2006 WDFW file data). Home-range sizes ranged from 12.7 to 87.7 km^2 in size with a mean of 46.6 km^2; the higher home-range sizes reflect migratory deer. The mean migration distance between seasonal ranges was 42.0 km. Yearling male mule deer were observed to disperse up to 100 km with a mean straight-line distance of 70 km.

Conceptual Basis for Columbia Plateau Model Development

Overview

A five year field study involving the monitoring of movements and habitat use by radio-marked mule deer in portions of the Columbia Plateau, although as yet not published, provided estimates of resource selection functions and utilization functions across a segment of the landscape. Preliminary results from this field study provided *a priori* knowledge that formed the basis for the parameters and values used in the habitat and resistance modeling exercises. In addition, results of aerial surveys conducted by WDFW each fall to count and classify mule deer have expanded the level of knowledge of mule deer distribution and abundance across the Columbia Plateau.

Movement Distance

Observed movement distances of radio-marked mule deer within the Columbia Plateau were relatively modest. Home range estimates ranged from 12.7 to 87.7 km^2 with a mean of 46.6 km^2 (See Dispersal). Home ranges had a mean radius of 3.5 km and a range of 1.6 km to 5.1 km for non-migratory mule deer; inclusion of migratory deer would have increased this value to 4.0 km, thus only values for seasonal home ranges were used thereby omitting migration corridors from home range calculations. Maximum observed dispersal by yearling male mule deer was 100 km and was the dispersal distance used in modeling dispersal through suitable habitat, thus the linkage cut-off distance was set at 100 km with a maximum linkage width of 20 km.

Habitat Concentration Areas

Habitat concentration areas (HCAs) for mule deer were modeled using a threshold habitat value of 0.89 and a home range radius of 3500 m. The habitat value threshold was chosen to select the largest blocks of predicted optimal habitat while still allowing room on the landscape to model linkages. Two additional HCAs (HCA ID #70 and #71; see Cost-weighted Distance Modeling section for HCA identification) were added manually because these were areas of high mule deer densities based upon aerial survey results (WDFW unpublished data).

Resistance and Habitat Values for Landscape Features

Data layers (Table A.8.1) used to model resistance and habitat for mule deer:

1) Land cover/Land use
2) Elevation
3) Slope
4) Ruggedness Measure
5) Insolation
6) Housing Density
7) Roads
8) Railroads Active
9) Railroads Inactive
10) Transmission Lines
11) Wind Turbine
12) Irrigation Infrastructure

Because mule deer are most closely associated with remaining native habitats including shrubsteppe, shrub, grassland, meadow, forest, and woodland classifications (WDFW unpublished data), these habitats were given high habitat and low resistance values. Increasing levels of average annual daily traffic are associated with higher numbers of mule deer collisions in most eastern Washington models (Myers et al. 2008), so resistance values were ranked high for roadway centerlines and low or zero for roadway buffer; while habitat values of roadway centerlines were scored as zero, habitat values increased with distance from the centerline. Even though the potential impacts from active railroads are unknown, we assumed that railroads, both active and inactive, have little effect on habitat quality and form only a weak barrier to dispersal. Although mule deer may use the habitat adjacent to and around developments, such habitats cannot be considered completely suitable thus this category was assigned high resistance and low habitat values. Wind energy development was assumed to potentially impact mule deer habitats in a deleterious way, so habitat quality and resistance values were scored relatively high. Transmission lines, however, were not thought to provide appreciable impacts to habitat quality or movement therefore habitat and resistance values were set relatively low.

(continued on page A.8-10)

Table A.8.1. Landscape features and resistance values used to model habitat connectivity for mule deer.

Spatial data layers and included factors	*Resistance value*	*Habitat value*
Landcover/Landuse		
Grassland_Basin	0	1.00
Grassland_Mountain	0	1.00
Shrubsteppe	0	1.00
Dunes	0	0.80
Shrubland_Basin	0	1.00
Shrubland_Mountain	0	1.00
Scabland	0	1.00
Introduced upland vegetation_Annual grassland	0	1.00
Cliffs_Rocks_Barren	5	0.00
Meadow	0	1.00
Herbaceous wetland	1	0.60
Riparian	0	1.00
Introduced riparian and wetland vegetation	1	0.60
Water	20	0.00
Aspen	0	1.00
Woodland	0	1.00
Forest	0	1.00
Disturbed	50	0.20
Cultivated cropland from RegapNLCD	10	0.40
Pasture_Hay from CDL	1	0.80
Non-irrigated cropland from CDL	10	0.40
Irrigated cropland from CDL	10	0.40
Highly structured agriculture from CDL	20	0.20
Irr Not Irr Cult Ag buffer 0 - 250m from native habitat	1	0.80
Irr Not Irr Cult Ag buffer 250 - 500m from native habitat	1	0.80
Pasture Hay Ag buffer 0 - 250m from native habitat	1	0.80
Pasture Hay Ag buffer 250 - 500m from native habitat	1	0.80
Elevation (meters)		
0 - 250m	1	0.80
250 - 500m	0	1.00
500- 750m	0	1.00
750 - 1000m	0	1.00
1000- 1250m	0	1.00
1250 - 1500m	0	1.00
1500 - 2000m	0	1.00
2000 - 2500m	1	0.80
2500 - 3300m	1	0.80
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	1	0.80
Ruggedness		
Very gentle terrain (or surface water)	1	0.80
Gentle terrain	0	1.00
Moderate terrain	0	1.00
Rough terrain	3	0.80
Very rough terrain or escarpment	3	0.80
Potential wet zone	0	1.00
Insolation		
Very low insolation	1	0.80
Low insolation	0	1.00
Moderate insolation	0	1.00
High insolation	0	1.00

Spatial data layers and included factors	*Resistance value*	*Habitat value*
Very high insololation	1	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	1	0.80
Greater than 20 and less than or equal 40 ac per dwelling unit	2	0.60
Greater than 10 and less than or equal 20 ac per dwelling unit	30	0.40
Less than or equal 10 ac per dwelling unit	50	0.20
Roads		
Freeway Centerline	200	0.00
Freeway Inner buffer 0 - 500m	2	0.80
Freeway Outer buffer 500 - 1000m	0	0.80
Major Highway Centerline	120	0.00
Major Highway Inner buffer 0 - 500m	1	0.80
Major Highway Outer buffer 500 - 1000m	0	0.80
Secondary Highway Centerline	60	0.00
Secondary Highway Inner buffer 0 - 500m	1	0.80
Secondary Highway Outer buffer 500 - 1000m	0	0.80
Local Roads Centerline	20	0.00
Local Roads Inner buffer 0 - 500m	1	0.80
Local Roads Outer buffer 500 - 1000m	0	1.00
Railroads Active		
Railroads Centerline	10	0.00
Railroads Inner buffer 0 - 500m	1	0.80
Railroads Outer buffer 500 - 1000m	0	1.00
Railroads Inactive		
Railroads Inactive Centerline	3	0.00
Railroads Inactive Inner buffer 0 - 500m	1	0.80
Railroads Inactive Outer buffer 500 - 1000m	0	1.00
Transmission Lines		
LessThan 230KV One Line Centerline	1	0.80
LessThan 230KV One Line Inner buffer 0– 500m	1	0.80
LessThan 230KV One Line Outer buffer 500 – 1000m	0	1.00
LessThan 230KV Two or More Lines Centerline	1	0.80
LessThan 230KV Two or More Lines Inner buffer 0 – 500m	1	0.80
LessThan 230KV Two or More Lines Outer buffer 500 – 1000m	0	1.00
Greater Than or Equal 230KV One Line Centerline	1	0.80
Greater Than or Equal 230KV One Line Inner buffer 0 – 500m	1	0.80
Greater Than or Equal 230KV One Line Outer buffer 500 – 1000m	0	1.00
Greater Than or Equal 230KV Two Lines Centerline	1	0.80
Greater Than or Equal 230KV Two Lines Inner buffer 0 – 500m	1	0.80
Greater Than or Equal 230KV Two Lines Outer buffer 500 –	0	1.00
Greater Than or Equal 230KV Two Lines no transmission line	0	1.00
Wind Turbine		
Wind turbine point buffer 45m radius	1000	0.20
Buffer zone beyond point buffer 0 - 500m	1	0.60
Buffer zone beyond point buffer 500 - 1000m	0	1.00
Irrigation Infrastructure		
Irrigation canals	1000	0.20

Modeling Results

Resistance Modeling

Results of modeling resistance to mule deer movements across the Columbia Plateau are illustrated in the map below (Fig. A.8.1). This map shows the relative difficulty of mule deer movement across the Columbia Plateau's varied landscape and provides the foundation for production of HCAs, cost-weighted distance (CWD), and linkage maps. To illustrate the varying effects of changing resistance values, a cell resistance value of 1 is the energetic cost to move the distance equaling the actual cell diameter of 30 m; if the cell has a resistance value of 5, the energetic costs are 5 times as much. Resistance values for mule deer are all relative to the cost of moving across a cell of ideal habitat.

As seen in Fig. A.8.1, resistance to mule deer movement is defined by a landscape fragmented by agriculture, irrigation, urban and suburban development, roads, power lines, and wind power development. Areas of high resistance are presented by large tracts of irrigated and dryland agriculture, irrigation canals, urban/suburban development and relatively wide reservoirs. Areas of low resistance are composed primarily of remaining tracks of shrubsteppe and other native vegetation types through which mule deer can move freely. Networks of low resistance can be seen which follow the patterns of channeled scablands and other remaining natural habitats such as Crab Creek, Wilson Creek, coulee systems such as Moses Coulee and Grand Coulee/Banks Lake, and the breaks of the Snake and Columbia rivers.

Given the relatively broad bands of low resistance to mule deer movement, connectivity between mule deer populations should be expected to remain stable in the near future. However, development and expansion of the East Irrigation Project over the next 20 to 30 years would create increased resistance to deer movement across former shrubsteppe habitats between the area east of Ephrata and west of Wilson Creek and northeast of Moses Lake to Wilson Creek. Similarly, increased urban/suburban and wind power development and future highway expansion would raise the level of resistance to mule deer movements and decrease connectivity between populations.

Habitat Modeling and Habitat Concentration Areas

The map illustrated in Fig. A.8.2 delineates suitable mule deer habitat. Concurrently, the juxtaposition of suitable habitat is also a clear representation of the distribution of remnant shrubsteppe and other native habitats within the Columbia Plateau. Low quality habitat includes areas of intensive irrigated agriculture such as that in south-central Grant County and the Yakima Valley in east-central Yakima and west-central Benton counties and large tracts of dryland monoculture in parts of Douglas, Lincoln, Adams, Franklin, Whitman, and Walla Walla counties.

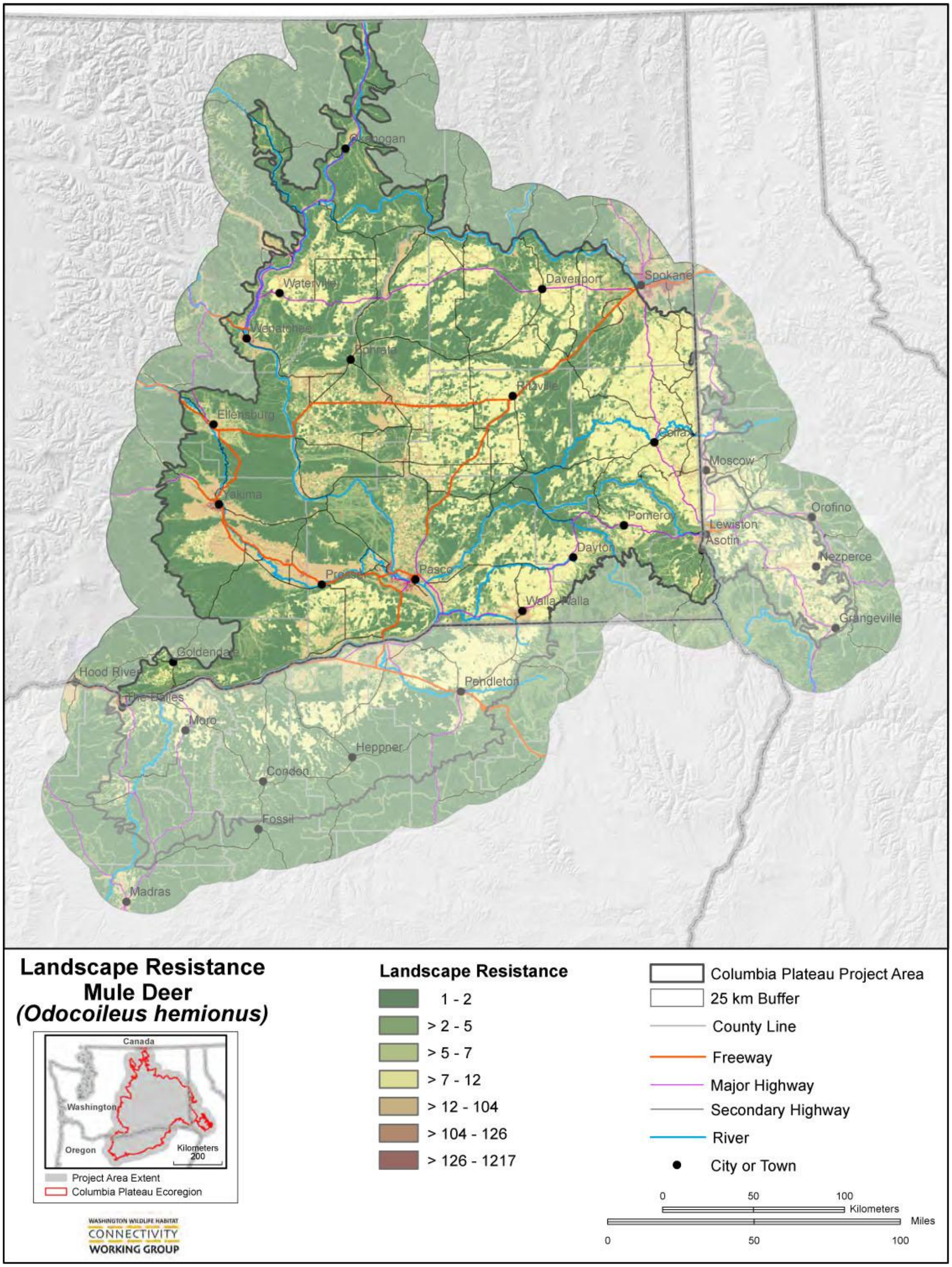

Figure A.8.1. Resistance map for mule deer in the Columbia Plateau Ecoregion.

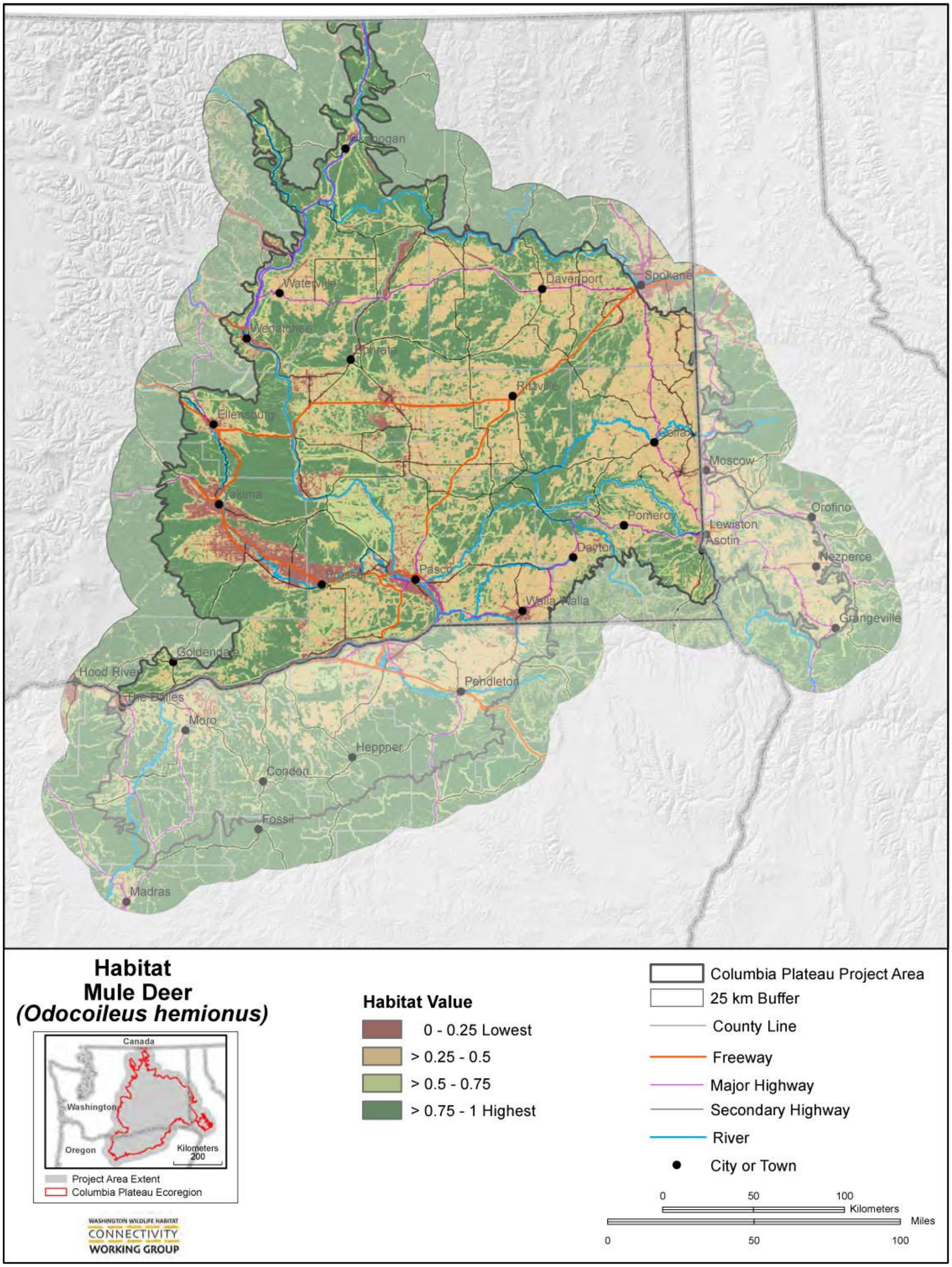

Figure A.8.2. Habitat for mule deer in the Columbia Plateau Ecoregion.

There are 71 mule deer HCAs which were generated using relatively high thresholds for habitat value (0.89) and home range radius (3500 m; Fig. A.8.3). These values clearly exclude habitat that is suitable and presently occupied by mule deer (Johnson & Cassidy 1997). However, maintaining high thresholds provided greater opportunity to model linkages which, in turn, allowed for exploration of connectivity between mule deer populations across the landscape. Boundaries of some HCAs delineated known areas of high habitat suitability and mule deer concentration areas (WDFW unpublished data), suggesting strong predictive values by the model.

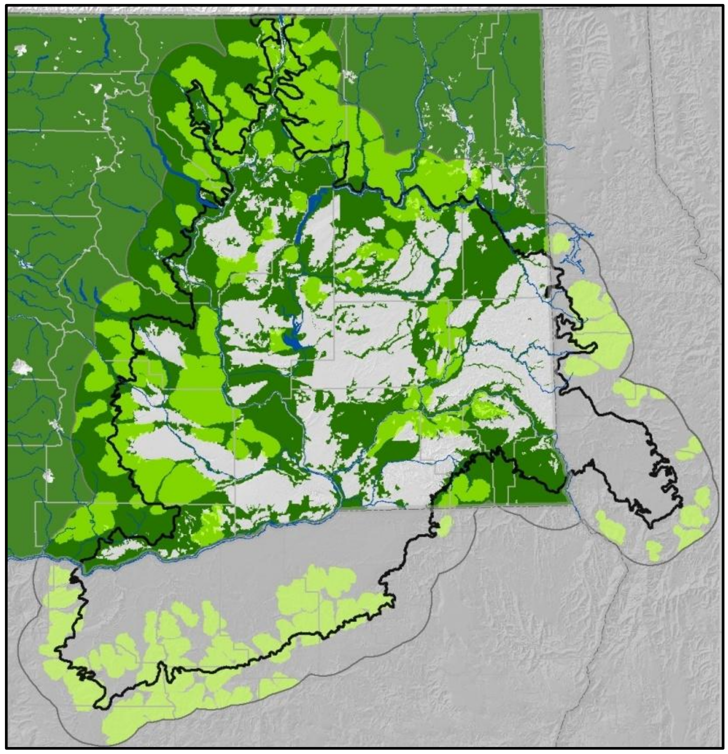

Figure A.8.3. Mule deer HCAs (light green) and GAP distribution (dark green) in the Columbia Plateau Ecoregion.

Cost-Weighted Distance Modeling

Areas of potentially adequate or currently occupied mule deer habitat not included in HCAs are represented by the linkages developed by cost-weighted distance (CWD) modeling (Fig. A.8.4). Across much of the Columbia Plateau, the rate of accumulation of CWD is relatively low indicating that mule deer movement between HCAs is relatively short in distance and unimpaired. The fact that mule deer occupy areas of suitable habitat outside of HCAs (Fig. A.8.3) could potentially influence estimates of rates of accumulation of CWD, keeping them relatively low because of the distance between HCAs, and secondarily, relative resistance values.

However, there are large areas within the Columbia Plateau where the rate of accumulation of CWD is high suggesting that mule deer movement across these areas to adjacent HCAs is of long distance across a potentially highly resistant landscape. The highest CWD accumulation rates are seen stretching across a corridor also representing the largest potential barrier within the central Columbia Plateau from Pendleton, Oregon and the Columbia River north to Ritzville, Washington. Another area where CWD accumulates rapidly is located to the east of the polygon described above, in the eastern portion of the Columbia Plateau near the Washington-Idaho border, running from Lewiston, Idaho north to Spokane, Washington. These areas are characterized by intensive agricultural development and support little mule deer habitat. Habitat concentration areas (HCAs) 30, 34, 38, and 71 lay between these 2 areas of high CWD and are the most isolated HCAs (See Fig. A.8.5 for HCA identification); connection to adjacent populations is available only via corridors to the north. Given these results of CWD modeling, it is important to monitor connectivity between these HCAs and adjacent populations to ensure future connectivity and genetic viability. There are several other bands showing high CWD rate of accumulation including the lower Yakima Valley and south of the Spokane River, but these areas are of minor concern because CWD between affected HCAs and other adjacent HCAs are relatively low.

Linkage Modeling

The 71 mule deer HCAs identified by the models are linked, so no HCA is completely isolated (Fig. A.8.6). Most areas contained within the links are either identified as potentially suitable mule deer habitat or presently occupied by mule deer. However, even these links are potentially vulnerable to disruption depending upon the risk of increased residential and agricultural development, road construction, and other factors. Perhaps the most vulnerable links to disruption are those in southern Walla Walla and Benton counties in Washington connecting to HCAs in Umatilla County, Oregon; the linkages connecting HCA 30 in northeastern Adams and northwestern Whitman counties to HCA 69 in Spokane County, Washington and HCA 21 in Kootenai County, Idaho; and the link between HCA 69 in Spokane County, Washington and HCA 21 in Kootenai County, Idaho. All of these linkages cross large tracts of agricultural lands or areas altered by intense urban/suburban development.

Comparative Insights between the Statewide and Ecoregional Connectivity Analyses

In reviewing results between statewide and regional connectivity analyses for mule deer, the influence of scale becomes most notable. Statewide modeling to predict mule deer HCAs produced 14 compared to 71 individual HCAs identified when modeling was restricted to the Columbia Plateau Ecoregion. Resistance to movement between HCAs, as predicted by statewide models, showed low resistance values across much of the Columbia Plateau with higher values associated only with areas of urban/suburban development. The statewide resistance model did not predict the increased level of resistance associated with irrigated and dryland agricultural lands predicted by the ecoregional model. Comparing results of linkage modeling between statewide and ecoregional level models were similar to HCA comparisons, as would be expected. The number and length of the links are a function of the number and location of the HCAs. Consequently, the number of links was much lower using the statewide model when compared to the ecoregional models. Clearly, modeling at the finer ecoregional level using higher habitat values produces results that appear to not only predict the highest quality mule deer habitat, but also identify the important linkages between these habitats and those links that could be at risk to disruption. From an ecological or conservation planning perspective, the ability to identify or predict potential influences to mule deer use areas and movement corridors at a local, fine scale provides the level of knowledge that could be used by government planners and deer managers to protect those areas. Such knowledge is not available from the statewide level models.

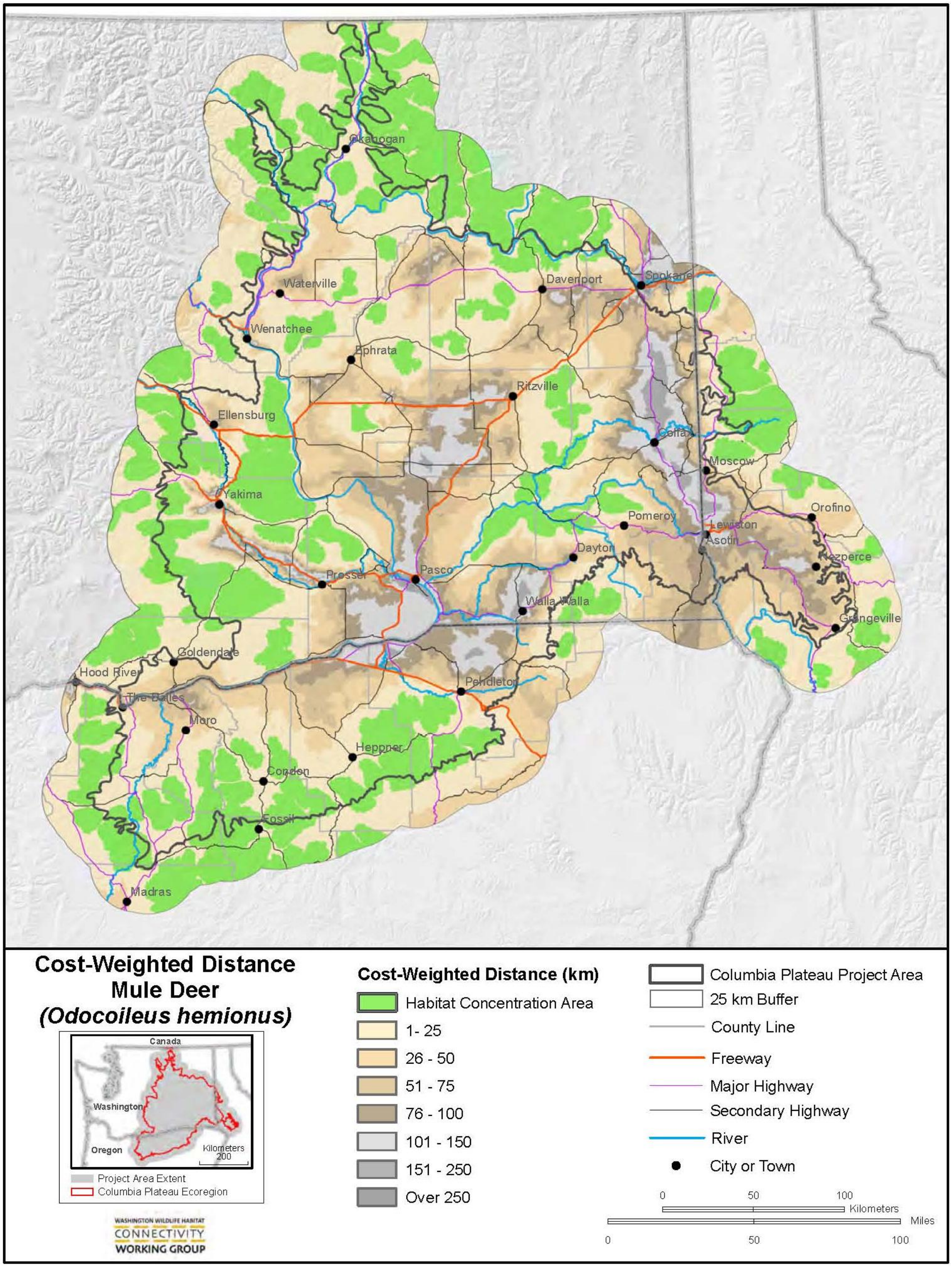

Figure A.8.4. Cost-weighted distance map for mule deer in the Columbia Plateau Ecoregion.

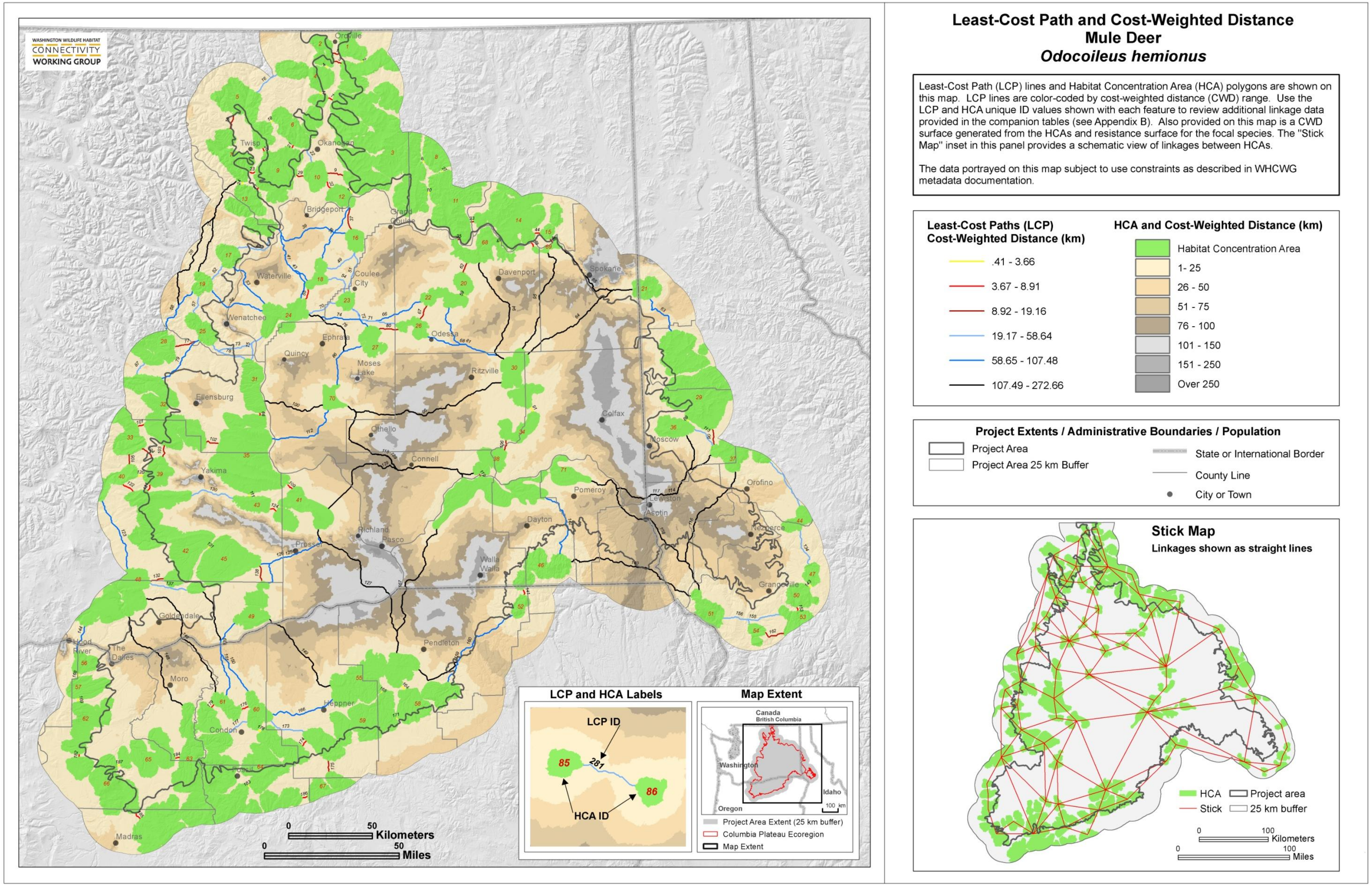

Figure A.8.5. HCAs (green polygons labeled with red numerals) and least-cost pathways (lines labeled with black numerals) between HCAs for mule deer. Linkage modeling statistics provided in Appendix B.

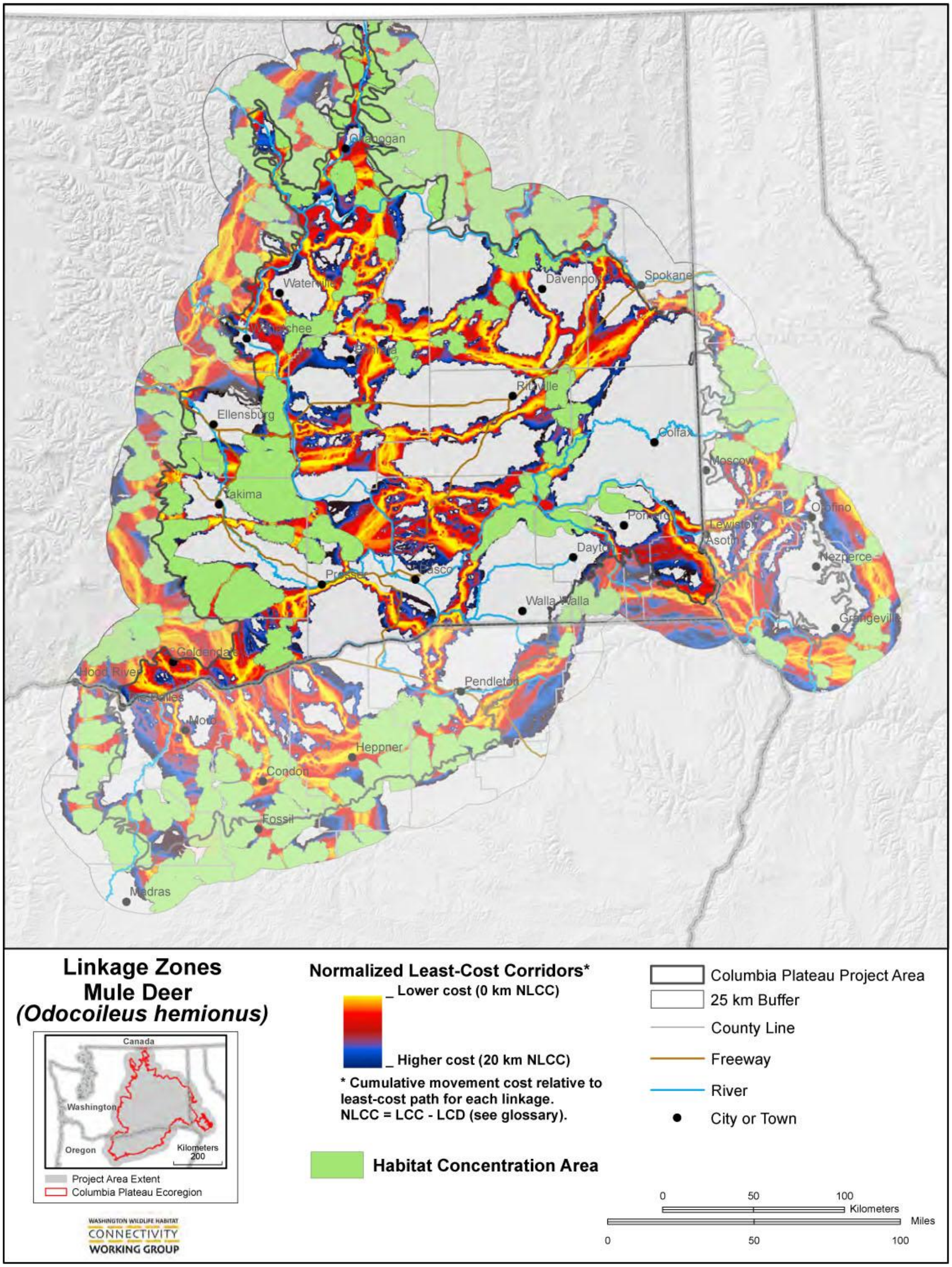

Figure A.8.6. Linkage map for mule deer in the Columbia Plateau Ecoregion.

Key Patterns and Insights

- There are 71 mule deer HCAs which were generated using relatively high threshold values for habitat (0.89).
- Suitable habitat identified as mule deer HCAs represent the distribution of remnant shrubsteppe and other native habitats within the Columbia Plateau.
- Areas predicted to have low resistance are composed primarily of remaining tracks of shrubsteppe and other native vegetation types through which mule deer can move freely.
- Areas predicted to have low quality habitat include areas of intensive irrigated agriculture, large tracts of dryland monoculture, and urban/suburban development.
- Two large polygons with high CWD values, one located in the central Columbia Plateau and one in the eastern portion of the Columbia Plateau with four HCAs between them, have the potential to limit or block mule deer movements. Future connectivity should be closely monitored to ensure protection of links between populations and genetic viability.
- Modeling at the finer ecoregional level produces results that predict the highest quality mule deer habitat and identify the important linkages between these habitats as well as those links that could be at risk to disruption.
- The ability to predict high quality mule deer habitat and movement corridors at a local, fine scale provides the level of knowledge that would allow government planners and deer managers to protect those areas.

Considerations and Needs for Future Modeling

Mule deer are widely distributed across the Columbia Plateau outside of intensively farmed areas. Field studies of mule deer within the project area have been limited to only portions of the region and have generally focused on adult females. Extending field studies to other portions of the region to measure resource selection, and increasing sample sizes to include juveniles to assess distribution and dispersal, would increase our understanding of habitat use and dispersal capabilities across a broader portion of the range. Such new knowledge would enhance model validation capabilities.

Opportunities for Model Validation

Two opportunities for model validation are available using existing data sets. Mapping mule deer distributions using results of aerial surveys over the last 5 years and comparing density contours with HCA locale would provide one level of validation. Initial comparisons between preliminary results of habitat use and resource selection models based on telemetry field studies and this exercise are favorable. These comparisons should be continued once resource selection models are finalized and could potentially provide a higher level of validation.

Genetic analysis of samples collected from mule deer across the Columbia Plateau is being conducted and will soon be completed. This new information will provide measures of genetic relatedness among mule deer populations. Modeling genetic relatedness as a function of connectivity could compliment validation of connectivity model results.

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