Chapter 9. Network Centrality, Pinch-Points, and Barriers and Restoration Opportunities for Mule Deer (*Odocoileus hemionus*)

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This chapter is an addendum to the *Washington Connected Landscapes Project: Analysis of the Columbia Plateau Ecoregion* (2012). It includes supplemental connectivity maps for mule deer (*Odocoileus hemionus*) that can be used to help prioritize and implement conservation actions. We have also included the linkage network (Fig. 9.1) and cost-weighted distance surface (Fig. 9.2) previously modeled for mule deer (See Appendix A.8, WHCWG 2012, available from http://waconnected.org).

Mule deer, photo by Woodrow Myers

Addendum Connectivity Maps

The supplemental connectivity products developed for mule deer include maps of (1) linkage network centrality (Fig. 9.3), (2) linkage pinch-points (Fig. 9.4), and (3) barriers and restoration opportunities (Fig. 9.5). There are numerous potential applications of these maps for informing connectivity conservation. We highlight examples on the landscape where conservation efforts for connectivity may be needed (Figs. 9.6–9.13).

Conservation of Connectivity for Mule Deer

- Models suggest mule deer habitat concentration areas (HCAs) are grouped in a circular pattern around the Columbia Plateau and the highly agriculturally developed Columbia Basin Irrigation Project area.
- Model projected HCAs for mule deer delineate remaining tracts of shrubsteppe communities and channeled scablands.
- While mule deer HCAs are widely distributed around the Columbia Plateau, HCAs 3 and 24, corridors between HCAs 26 and 30, and corridors between HCAs 21 and 69 are pivotal to maintaining connectivity and gene flow between mule deer herds within and adjacent to the Columbia Plateau.
- Models indicate some state highways and wide water courses present the strongest barriers to mule deer movement.
- Management actions intended to retain or improve mule deer connectivity should focus on maintaining or enhancing shrubsteppe and channeled scabland habitats and corridors, and providing safe crossing of state highways.

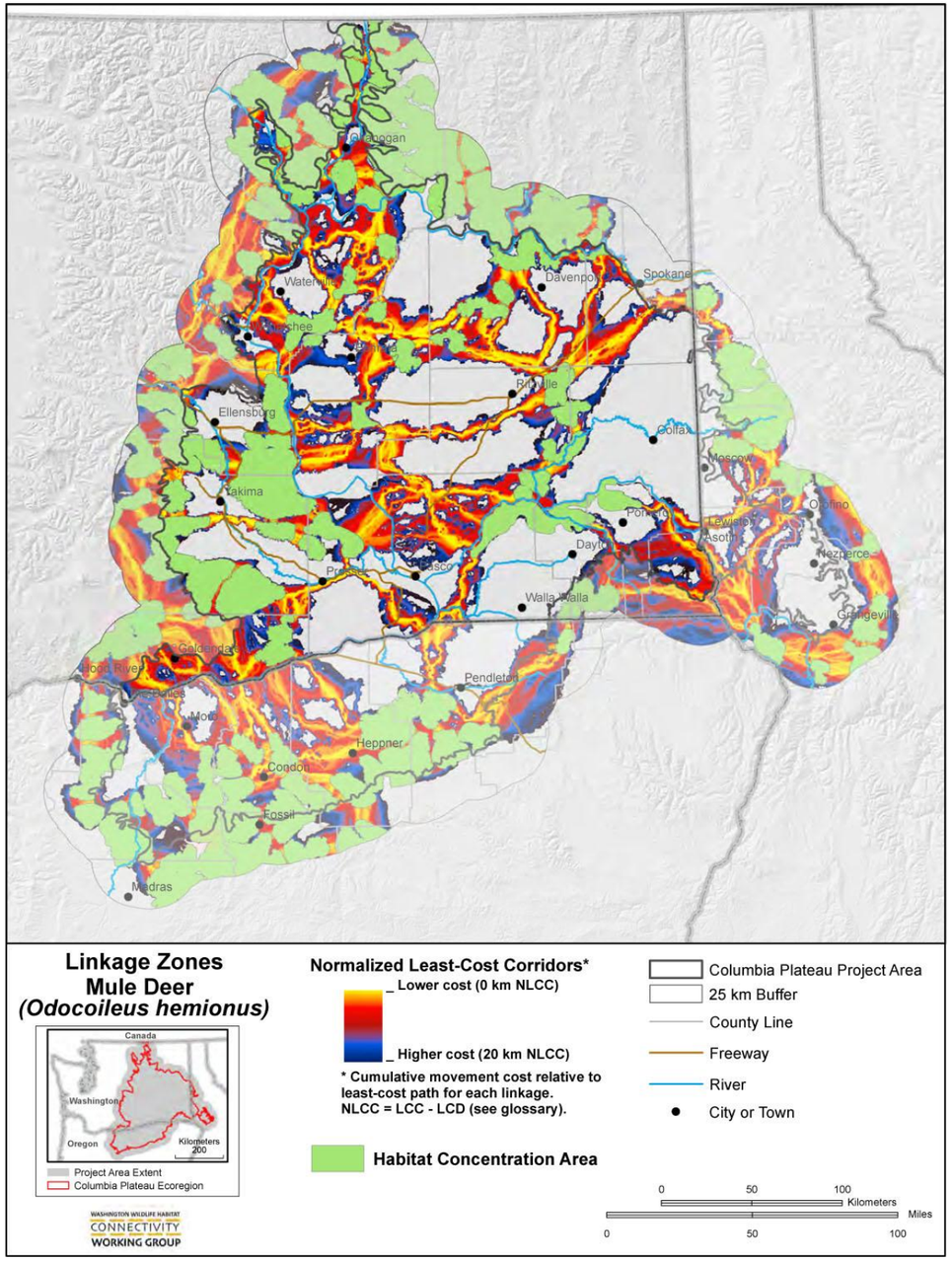

Figure 9.1. Linkage network modeled for mule deer in the Columbia Plateau Ecoregion (Appendix A.8, WHCWG 2012). Green polygons represent habitat concentration areas (HCAs) for mule deer. Linkages between HCAs are shown in bright colors; the least-cost pathways are highlighted yellow.

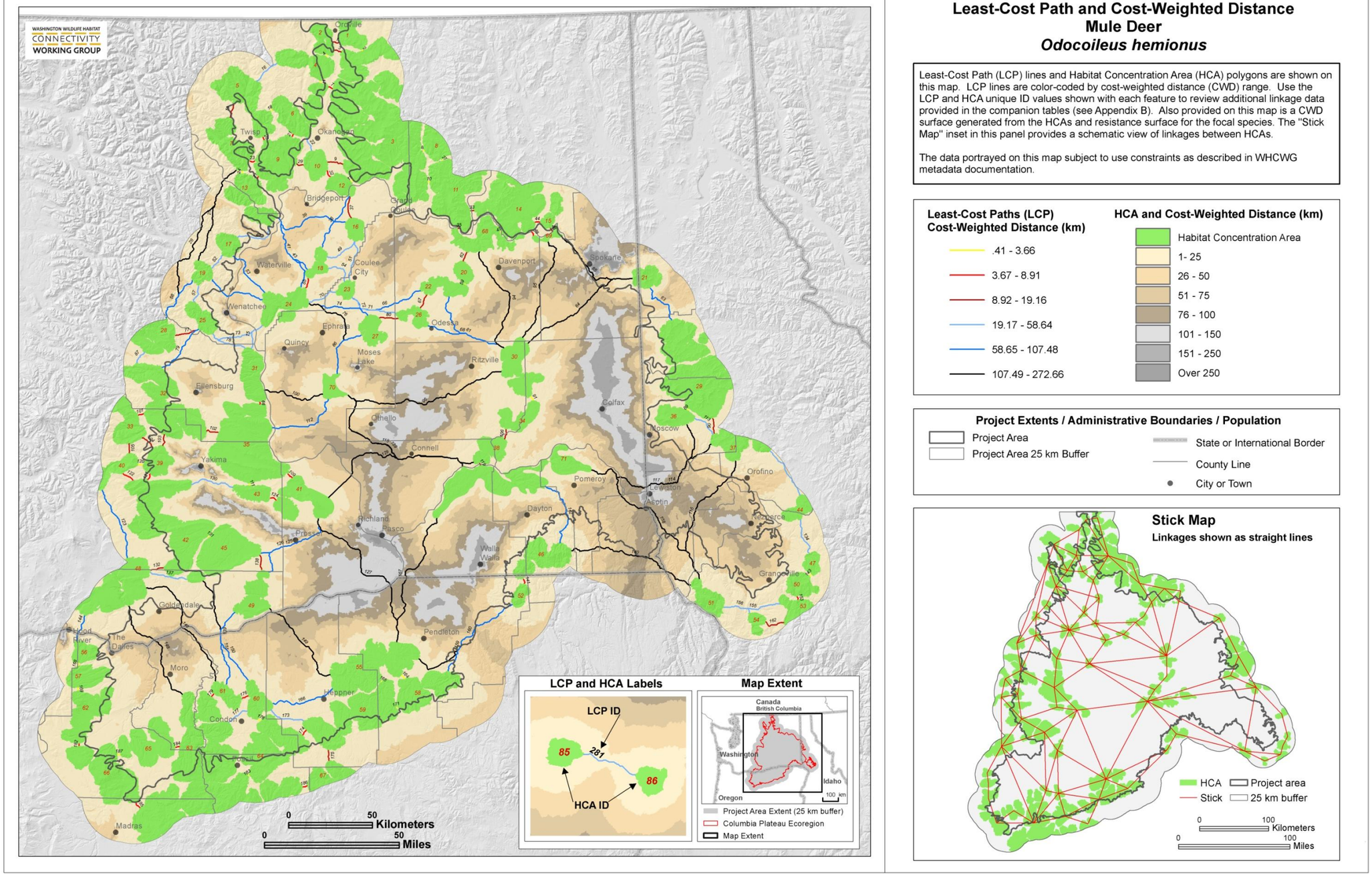

Figure 9.2. The cost-weighted distance map with numbered habitat concentration areas (HCAs) and least-cost paths for mule deer in the Columbia Plateau Ecoregion (Appendix A.8, WHCWG 2012).

Figure 9.3. Linkage Network Centrality for Mule Deer (*Odocoileus hemionus*).

WHAT IS CENTRALITY?

Centrality is a measure of how important a habitat area or linkage is for keeping the overall connectivity network connected. For our analyses, we calculated current flow centrality using the Linkage Mapper Toolbox (see more at http://www.circuitscape.org /linkagemapper).

WHY IS CENTRALITY IMPORTANT?

The connectivity network is comprised of habitat concentration areas (HCAs) and linkages for movement of wildlife between them. Linkages or HCAs with high centrality are expected to be the "gatekeepers" for connectivity. For example, if a linkage with high centrality is severed, a wildlife species may risk having its population separated into sub-populations.

HOW IS CENTRALITY DEPICTED ON THE MAP?

- Centrality results are depicted based on four quartiles (four equal parts). However, the top quartile includes areas shown in yellow (the top 10% of this quartile), and red (the remaining 90%).
- Linkages and HCAs shown in orange also have relatively high network centrality, while those colored blue and green tend to be on the periphery of the network.

TYPES OF QUESTIONS AND DECISIONS THIS MAP HELPS INFORM

- Where are important areas on the landscape for maintaining connectedness?
- Where should further disturbance to connectivity be avoided?
- Which HCAs might be important for species recovery efforts (e.g., sites for translocations and augmentations of populations)?

Notes: This map depicts modeled HCAs and linkages (see more at http://waconnected.org). While we've used the best available data layers, field review is necessary to ensure the HCAs and linkages are viable. We included areas in Oregon and Idaho to help understand transboundary connectivity; however, our products may be less accurate in these adjoining areas.

Habitat Concentration Area (HCA) Centrality*

- Highest
- Very High
- High
- Medium
- Low
- Not Connected

*Habitat Concentration Area (HCA) polygon labels on the map indicate HCA ID number.

Least-Cost Path (LCP) Centrality

- Highest
- Very High
- High
- Medium
- Low

Boundaries and Population Centers

- Columbia Plateau Project Area
- Columbia Plateau Project Area 25 km Buffer
- State or Provincial Border
- Freeway
- Major Highway
- City or Town
- Important Site

The data portrayed on this map are subject to use constraints as described in WHCWG metadata documentation.

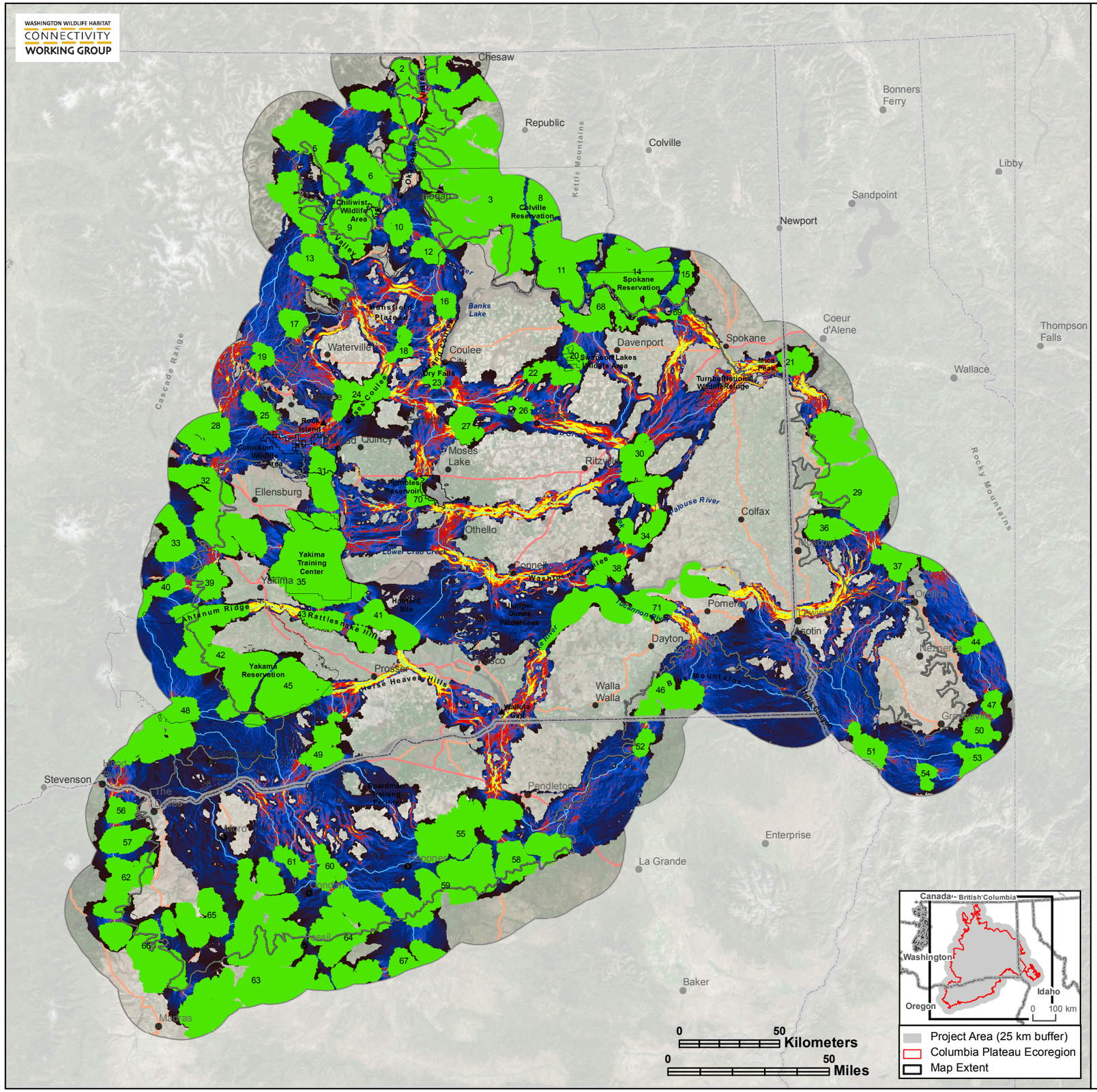

Figure 9.4. Linkage Pinch-Points for Mule Deer (*Odocoileus hemionus*).

WHAT ARE PINCH-POINTS?

Pinch-points are "bottlenecks" where wildlife movement is funneled within linkages. Pinch-point modeling methods are based on electrical circuit theory. Locations where current is very strong are constrictions within linkages and represent areas most vulnerable to being severed (see more at http://www.circuitscape.org /linkagemapper). Pinch-points can be the result of both natural and human-made landscape features.

WHY ARE PINCH-POINTS IMPORTANT?

Pinch-points are a conservation priority as they are locations where loss of a small area could disproportionately compromise connectivity due to a lack of alternative movement routes. Loss of these areas may sever migration routes, or impact other critical movement needs.

HOW ARE PINCH-POINTS DEPICTED ON THE MAP?

- Habitat concentration areas (HCAs) are indicated in green, while the linkages are depicted in a yellow to blue color ramp.
- Reds and yellows indicate moderate to highly constrained areas for movement within linkages.
- Blue areas are not necessarily "better" areas of the linkages but rather places where resistance is similar across broad swaths of the landscape.

TYPES OF QUESTIONS AND DECISIONS THIS MAP HELPS INFORM

- Where along linkages is potential movement highly or moderately constrained?
- Are there areas where alternative movement routes may not be available?

To determine the relative importance of pinch-points in different linkages, users should consider the pinch-point map in conjunction with other measures, such as centrality.

Notes: This map depicts modeled HCAs and linkages (see more at http://waconnected.org). While we've used the best available data layers, field review is necessary to ensure the HCAs and linkages are viable. We included areas in Oregon and Idaho to help understand transboundary connectivity; however, our products may be less accurate in these adjoining areas.

Linkage Pinch-Points

Current Flow

Highly Constrained

Unconstrained

Habitat Concentration Area (HCA)*

Least-Cost Path (LCP)

*Habitat Concentration Area (HCA) polygon labels on the map indicate HCA ID number.

Boundaries and Population Centers

Columbia Plateau Project Area

Columbia Plateau Project Area 25 km Buffer

State or Provincial Border

Freeway

Major Highway

City or Town

Important Site

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Figure 9.5. Barriers and Restoration Opportunities for Mule Deer (*Odocoileus hemionus*).

WHAT ARE BARRIERS?

Barriers are areas where landscape features impede wildlife movement between habitat concentration areas (HCAs). Least-cost modeling methods (see more at http://www.circuitscape.org/linkagemapper) identify and rank barriers by their impact and quantify the extent to which restoration may improve connectivity. Barriers may be partial or complete, and they may be natural (e.g., rivers, cliffs) or human-made (e.g., urban areas, highways, some types of agriculture). Not all barriers are restorable.

HOW ARE BARRIERS AND RESTORATION OPPORTUNITIES DEPICTED?

- The Barrier Impact/Restoration Improvement Score reflects the percent reduction in corridor resistance per hectare restored. The scores are shown as three equal proportions, indicated in the colors of yellow, red, and blue.
- Barriers highlighted yellow or red are places that, if restored or enhanced, may yield the greatest improvement in potential movement between HCAs.
- Areas highlighted blue may yield moderate improvement in potential movement if restored.
- Barriers identified outside linkage pathways have the potential to produce new, alternative corridors for movement between HCAs if restored.

TYPES OF QUESTIONS AND DECISIONS THIS MAP HELPS INFORM

- Where in a linkage will restoration efforts have the greatest effect on connectivity?
- Where can alternate linkage pathways be created through restoration of key areas or removal of key barriers?

Since **all types** of barriers to movement are identified on this map users must further evaluate the feasibility of each restoration opportunity.

Notes: This map depicts modeled HCAs and linkages (see more at http://waconnected.org). While we've used the best available data layers, field review is necessary to ensure the HCAs and linkages are viable. We included areas in Oregon and Idaho to help understand transboundary connectivity; however, our products may be less accurate in these adjoining areas.

Barrier Impact / Restoration Improvement Score

- Highest
- High
- Moderate

HCAs and LCPs

- Habitat Concentration Area (HCA)*
- Least-Cost Path (LCP)

*Habitat Concentration Area (HCA) polygon labels on the map indicate HCA ID number.

Boundaries and Population Centers

- Columbia Plateau Project Area
- Columbia Plateau Project Area 25 km Buffer
- State or Provincial Border
- Freeway
- Major Highway
- City or Town
- Important Site

Project Area (25 km buffer)
Columbia Plateau Ecoregion
Map Extent

Example Areas of Interest for Connectivity

Linkage Network Centrality

- Two HCAs (3 and 24, Fig. 9.6) were identified through modeling as having Highest centrality to mule deer connectivity in the Columbia Plateau.
- The Highest centrality rank of HCA 3 is probably influenced by its key location in completing the "circle of connectivity" around the Columbia Plateau as well as providing connectivity to mule deer populations living in ecoregions to the north and northeast adjacent to the Columbia Plateau (Fig. 9.6).
- HCA 24 ranks Highest for centrality and provides connectivity for mule deer across Douglas County to HCAs to the north, south, and west (Fig. 9.6).

Linkage Pinch-Points

- A significant linkage pinch-point along Crab Creek between HCAs 26 and 30 was identified; Crab Creek provides important habitat for mule deer and other species (Fig. 9.7).
- An important linkage pinch-point was identified between HCAs 21 and 69 that follows the lower Hangman Creek drainage (Fig. 9.8).
- Linkage pinch-points in the vicinity of Dayton and Pomeroy funnel movement of mule deer from the Blue Mountains and parts of Idaho to the central portion of the Columbia Plateau (Fig. 9.9).

Barriers and Restoration Opportunities

- Many of the model identified barriers to mule deer connectivity are created by the presence of state highways or relatively wide bodies of water (Figs. 9.10, 9.11, 9.13).
- The model identified a number of areas containing barriers that if possible to restore may improve connectivity for mule deer (Fig. 9.12).
- Mule deer friendly crossing structures are scheduled to be constructed that would reduce barrier affects between HCAs 3 and 6 (Fig. 9.13).

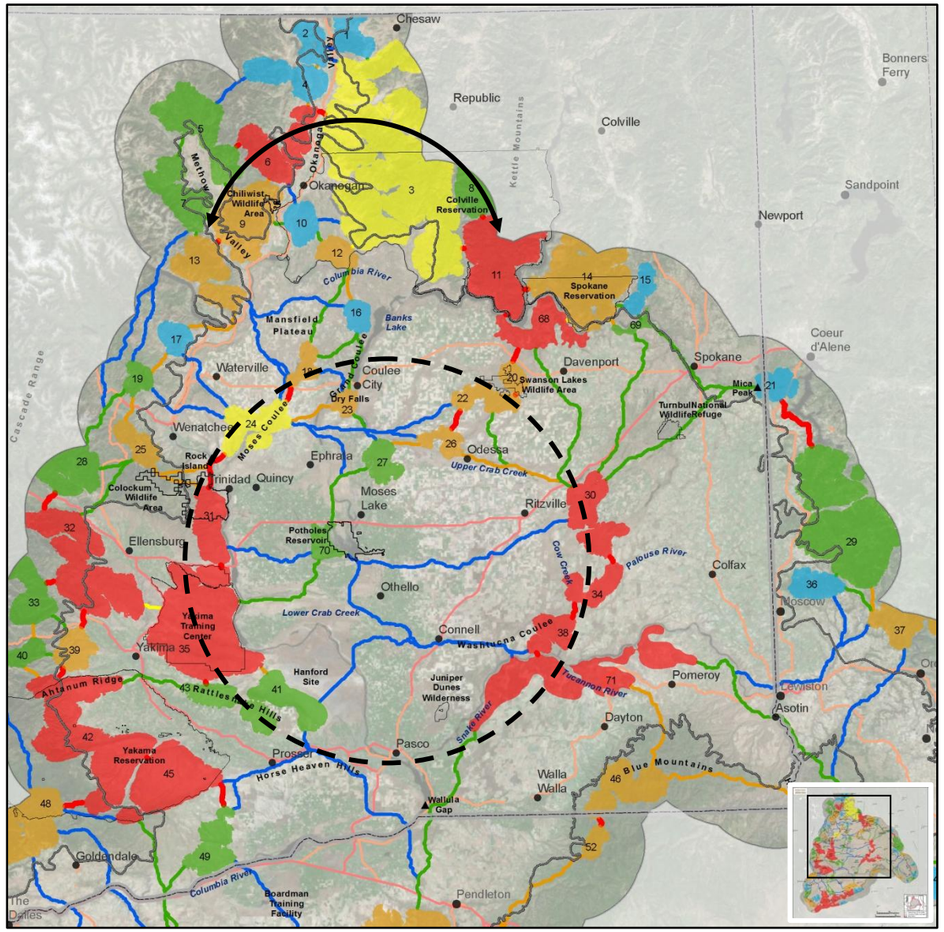

Figure 9.6. Pattern of centrality for mule deer in the Columbia Plateau.

- The centrality analysis suggest two patterns of movement for mule deer; (1) movement "around" the Columbia Plateau (solid arc), and (2) movement within the Columbia Plateau (dashed circle).
- HCAs 3 and 24 are ranked Highest with respect to centrality for mule deer linkage network connectivity in the Columbia Plateau. HCA 3 is a key location in completing the "circle of connectivity" around the Columbia Plateau as well as providing connectivity to mule deer populations living in ecoregions to the north and northeast adjacent to the Columbia Plateau. HCA 24 provides connectivity for mule deer across Douglas County to HCAs to the north, south, and west.

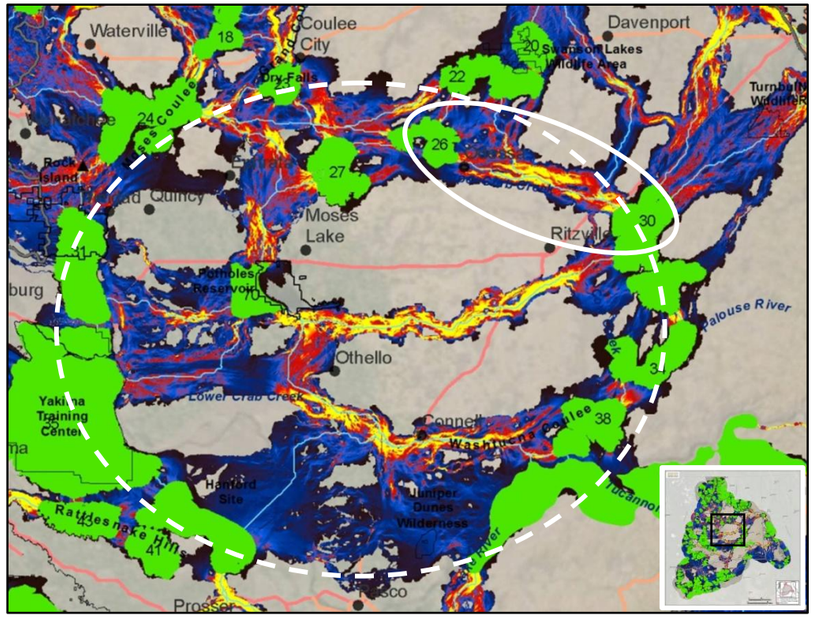

Figure 9.7. Pinch-points in the key linkage between HCAs 26 and 30 (solid oval). Dashed oval represents "circle of connectivity" within the Columbia Plateau.

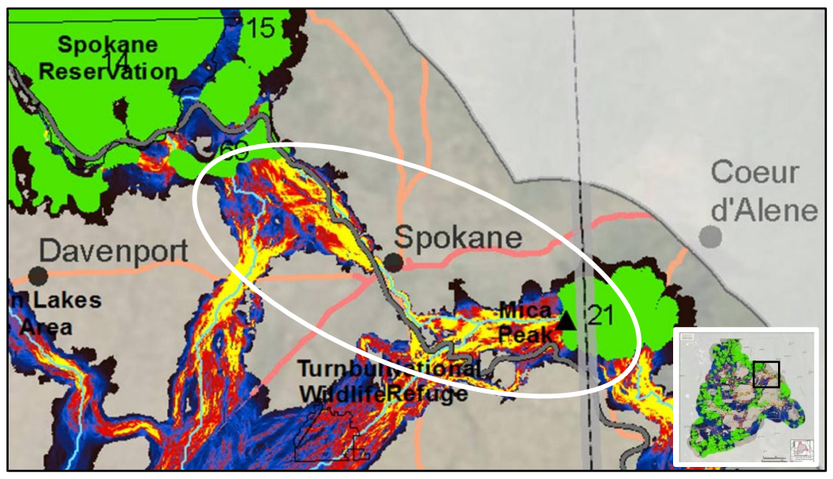

Figure 9.8. Highly constrained linkage between HCAs 21 and 69 (oval) that follows the lower Hangman Creek drainage.

- This linkage is important for maintaining connectivity of HCAs in the periphery of the Columbia Plateau Ecoregion.

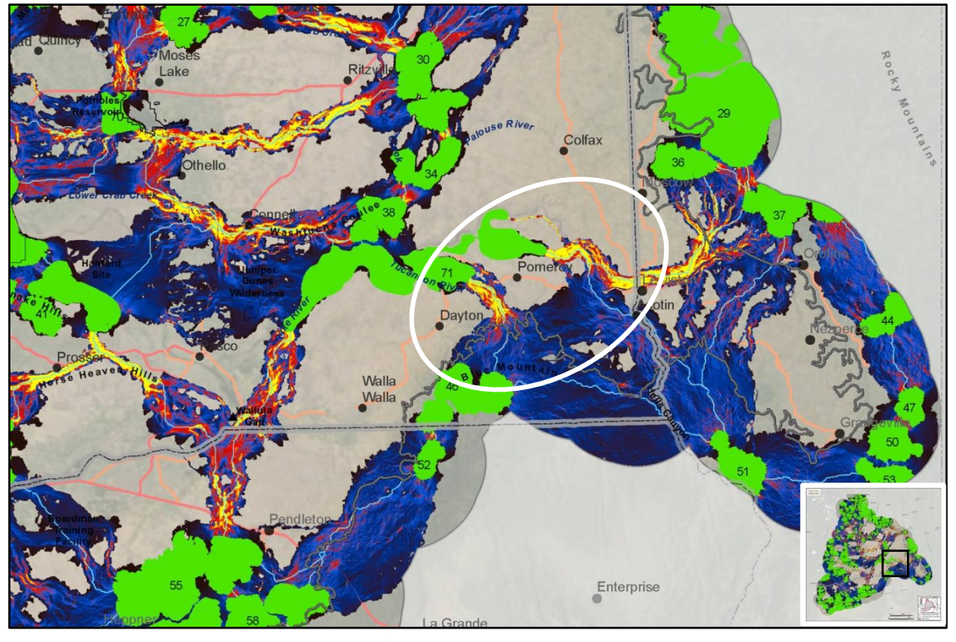

Figure 9.9. Pinch-points in linkages in vicinity of Dayton and Pomeroy (oval).

- These linkages are important for movement of mule deer from the Blue Mountains and parts of Idaho to the central portion of the Columbia Plateau.

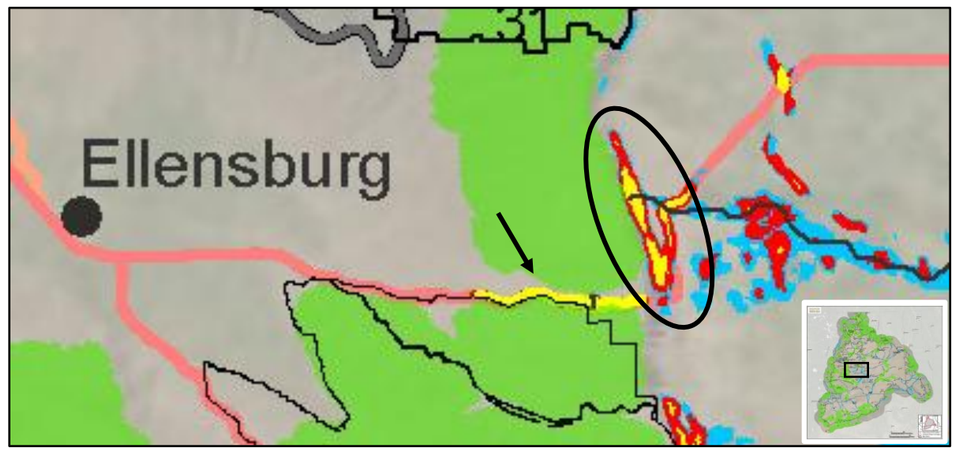

Figure 9.10. Area near Ellensburg where I-90 (arrow) is identified as a barrier for mule deer. Barrier identified by oval is created in part by the Columbia River, I-90, and steep terrain.

Figure 9.11. Barrier to north–south movement for mule deer in the "connected backbone."

- Barrier to movement (oval) created by the Columbia River, steep terrain, State Highway 28, and infrastructure associated with Rock Island Dam.

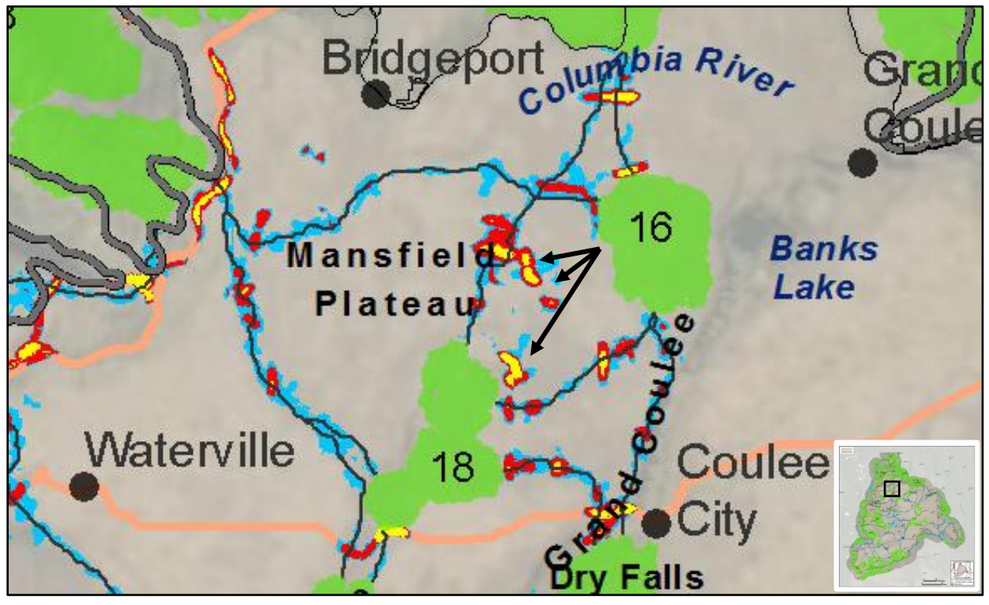

Figure 9.12. Barriers (arrows) where if possible to restore may create alternate linkage pathways between HCAs on the Mansfield Plateau.

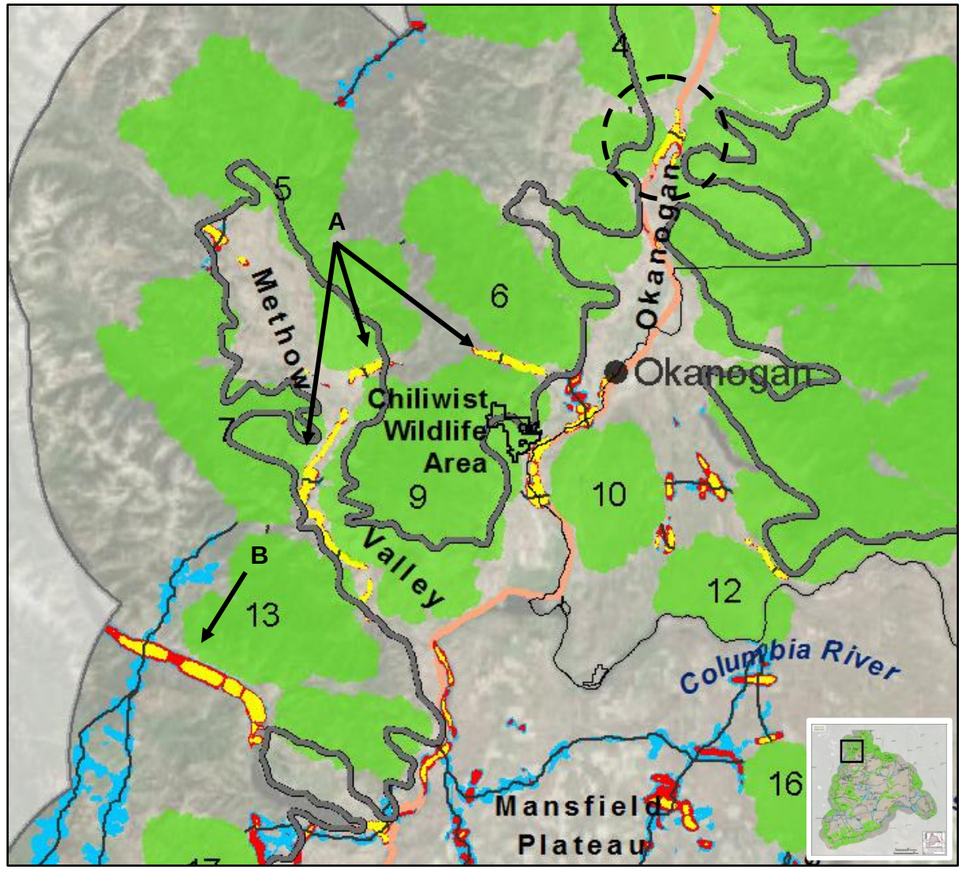

Figure 9.13. Barriers to movement of mule deer created by highways (arrows labeled "A") and water bodies (arrow labeled "B"). Dashed circle indicates approximate location of planned WSDOT wildlife crossing structure.

Acknowledgements

Special thanks to the following persons who provided model review and input: Kelly McAllister (WSDOT), Brad McRae (TNC), and Leslie Robb (Independent Researcher).