Chapter 7. Network Centrality, Pinch-Points, and Barriers and Restoration Opportunities for Washington Ground Squirrel (*Urocitellus washingtoni*)

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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 Washington ground squirrel (*Urocitellus washingtoni*) that can be used to help prioritize and implement conservation actions. We have also included the linkage network (Fig. 7.1) and cost-weighted distance surface (Fig. 7.2) previously modeled for Washington ground squirrel (See Appendix A.6, WHCWG 2012, available from http://waconnected.org).

Washington ground squirrel, photo by Rich Finger

Addendum Connectivity Maps

The supplemental connectivity products developed for Washington ground squirrel include maps of (1) linkage network centrality (Fig. 7.3), (2) linkage pinch-points (Fig. 7.4), and (3) barriers and restoration opportunities (Fig. 7.5). 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. 7.6–7.15).

Conservation of Connectivity for Washington Ground Squirrel

- Connectivity between Washington and Oregon is tenuous and passes through a single habitat concentration area (HCA).
- The largest HCAs with greatest centrality in Washington are located in the central Columbia Plateau in a broad circular pattern. Many HCAs with High–Highest centrality have tenuous linkages.
- Many linkages are highly constrained and have multiple barriers. Barriers include natural features such as rivers, and human-created-features such as irrigated agriculture, towns, and highways.
- Effective linkages will need to sustain Washington ground squirrels as corridor dwellers. Thus consideration of habitat patch size is necessary.
- Field surveys in the connectivity network and other areas with suitable habitat are needed to verify the connectivity models. We recommend the models be validated by genetic assessment to support restoration decision making.

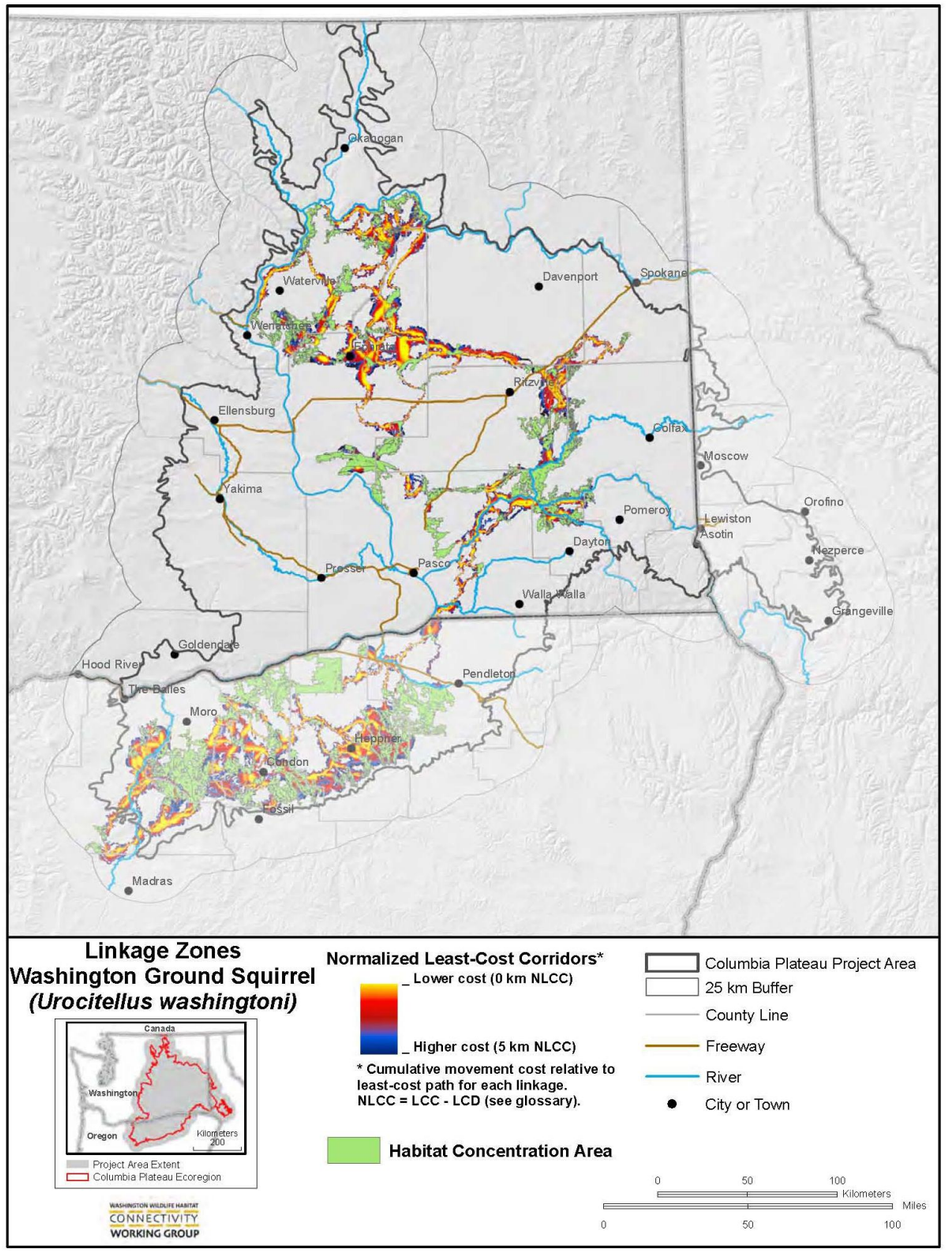

Figure 7.1. Linkage network modeled for Washington ground squirrel in the Columbia Plateau Ecoregion (Appendix A.6, WHCWG 2012). Green polygons represent habitat concentration areas (HCAs) for Washington ground squirrel. Linkages between HCAs are shown in bright colors; the least-cost pathways are highlighted yellow.

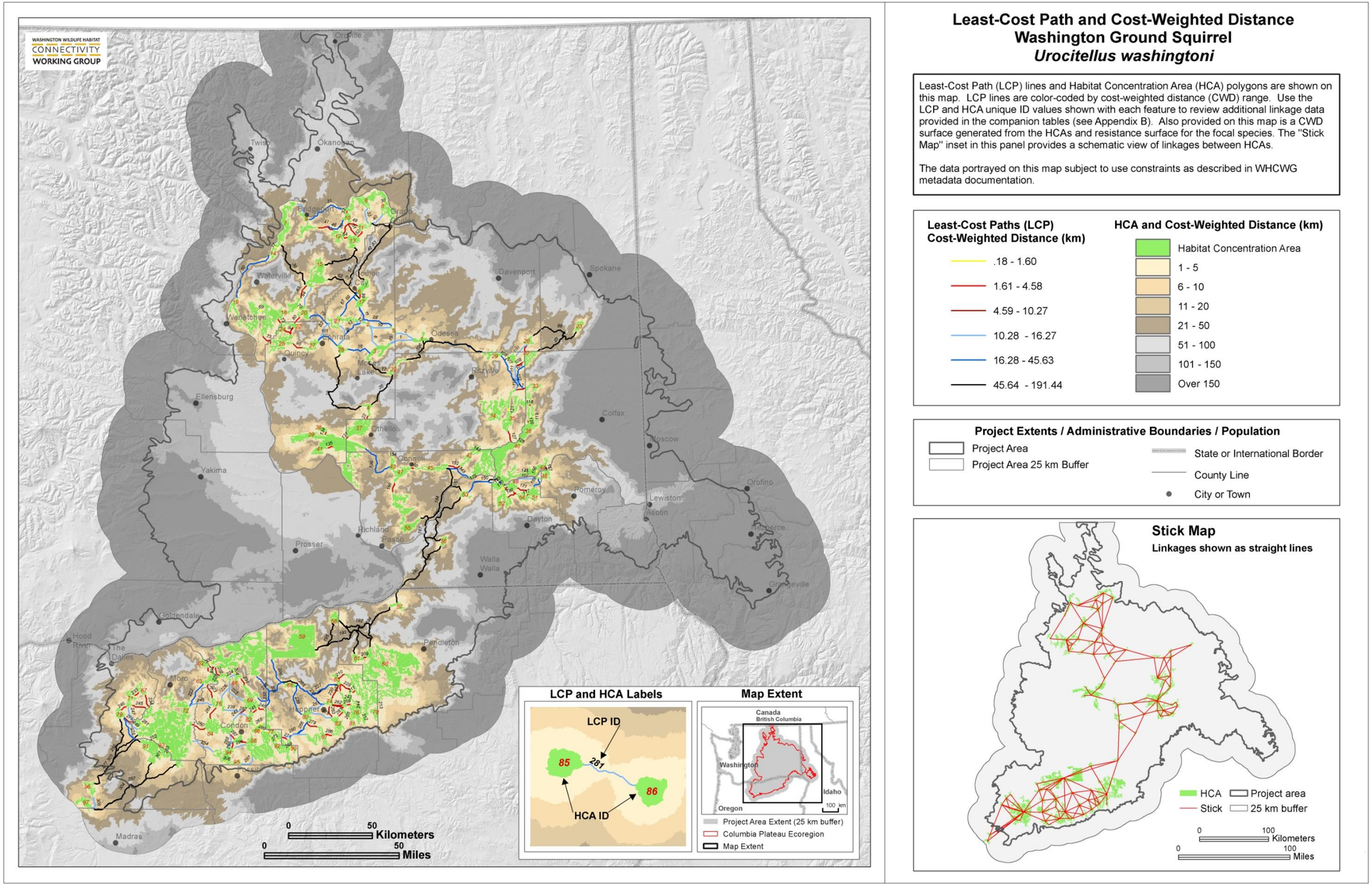

Figure 7.2. The cost-weighted distance map with numbered habitat concentration areas (HCAs) and least-cost paths for Washington ground squirrel in the Columbia Plateau Ecoregion (Appendix A.6, WHCWG 2012).

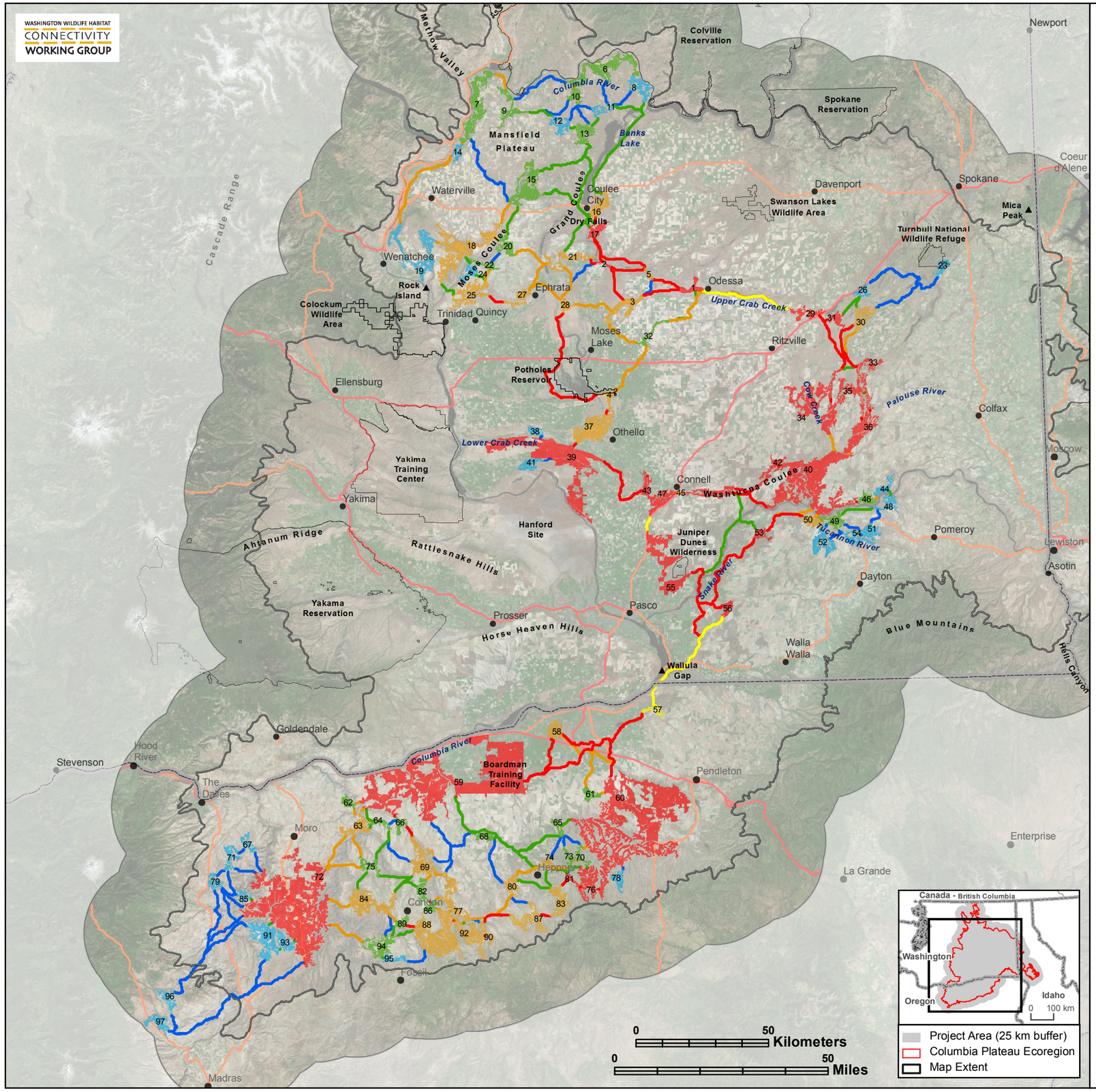

Figure 7.3. Linkage Network Centrality for Washington Ground Squirrel (*Urocitellus washingtoni*).

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

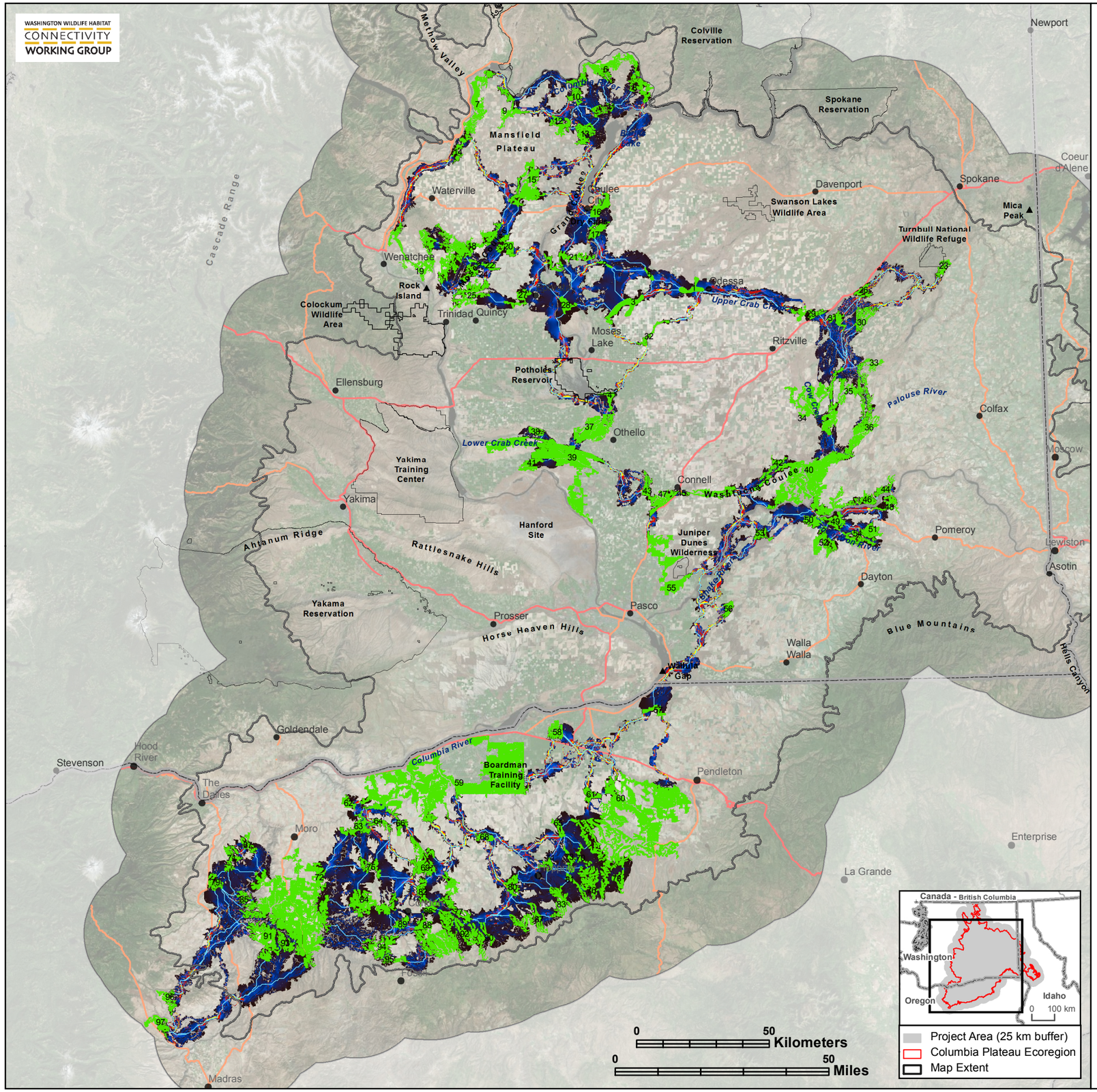

Figure 7.4. Linkage Pinch-Points for Washington Ground Squirrel (*Urocitellus washingtoni*).

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

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

Figure 7.5. Barriers and Restoration Opportunities for Washington Ground Squirrel (*Urocitellus washingtoni*).

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

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

Example Areas of Interest for Connectivity

Linkage Network Centrality

- The largest HCAs with greatest centrality in Washington are located in the central Columbia Plateau in a broad circular pattern (Figs. 7.6, 7.7).
- HCA 57 acts as a stepping-stone for connectivity between Washington and Oregon (Fig. 7.6). However, there is little data on this area, and it merits more study.
- The linkage along Upper Crab Creek is important for east–west connectivity; however not much is known about Washington ground squirrel populations along or to the west of this linkage (Fig. 7.6).
- Medium to Low centrality HCAs are clustered in the northern section of the Mansfield Plateau. Very High centrality linkages connect this area to the central portion of the Columbia Plateau (Fig. 7.8).

Linkage Pinch-Points

- Linkages between Washington and Oregon are long, narrow, and have many pinch-points (Fig. 7.9).
- Many linkages in the Washington ground squirrel connectivity network are narrow and highly constrained (Figs. 7.9–7.12), while other linkages, such as those north of Moses Lake, exhibit unconstrained linkages (Fig. 7.12).

Barriers and Restoration Opportunities

- Many linkages for Washington ground squirrel have barriers created by natural features such as topography or water, and human created features including irrigated and dryland agriculture, towns, and highways.
- The cluster of HCAs in the vicinity of the Moses Coulee (Fig. 7.13) has numerous mapped squirrel or colony occurrences. Maintaining and improving connections among these HCAs is a conservation priority.
- Several barriers were identified on the Mansfield Plateau that if restored may create alternate linkage pathways within the Plateau (Fig. 7.14).
- Intensive surveys in HCAs and other areas with suitable habitat may find populations previously overlooked. Techniques such as translocation have been used to improve connectivity (Fig. 7.15) but are not a long-term solution for maintaining population viability.
- We recommend the models be validated by genetic assessment to support restoration decisions.

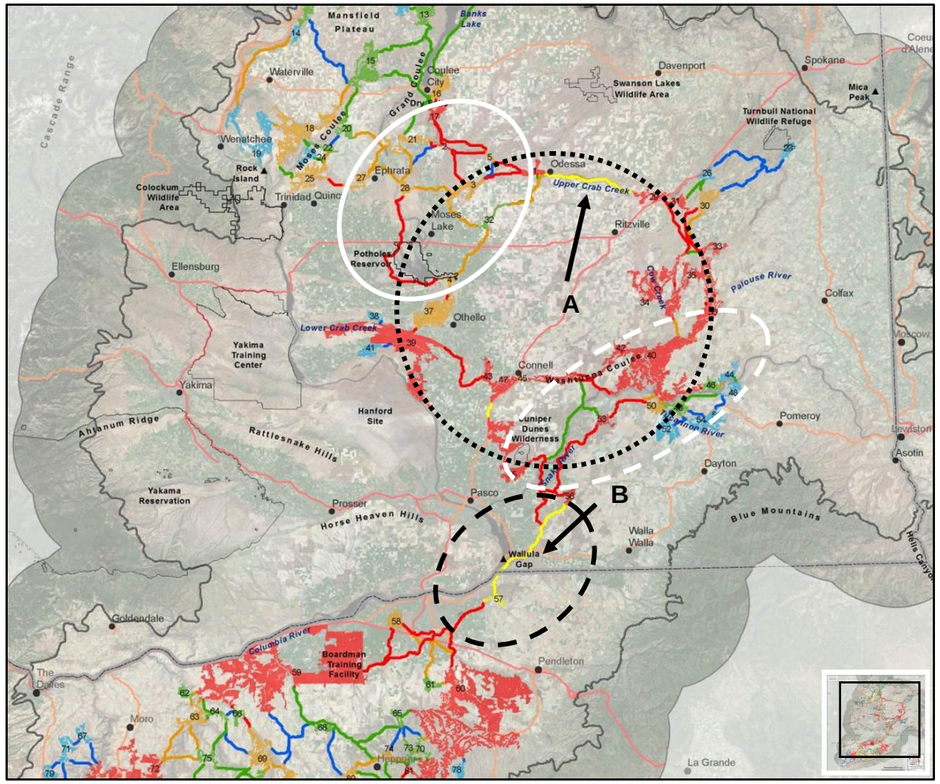

Figure 7.6. Key features of the centrality map for Washington ground squirrel.

- Within Washington, centrality is greatest for HCAs and linkages that follow, in a circular pattern, the Washtucna Coulee, Cow Creek, Upper Crab Creek, and Lower Crab Creek (black circle with tight dashes; see also Fig. 7.7).
- Very High centrality linkages (white solid oval) connect HCAs in the central portion of the Columbia Plateau with those to the north on the Mansfield Plateau (See also Fig. 7.8).
- Potential movement for Washington ground squirrel between Washington and Oregon must pass through HCA 57 (dashed black oval) near Wallula Gap.
- HCAs with Very High centrality are located on both sides of the Snake River (white dashed oval), and modeled linkages of Low to Very High centrality provide connections across the river between these HCAs. Washington ground squirrels inhabit both sides and it would be useful to understand genetic similarity between squirrels on opposite sides of the river.
- Arrows indicate linkages that are especially important for keeping the connectivity network for Washington ground squirrel intact. Arrow “A” identifies a key linkage near Odessa for east–west movement across the Columbia Plateau. However, not much is known about Washington ground squirrel populations along or to the west of this linkage. Arrow “B” identifies a key linkage for connectivity between Washington and Oregon.

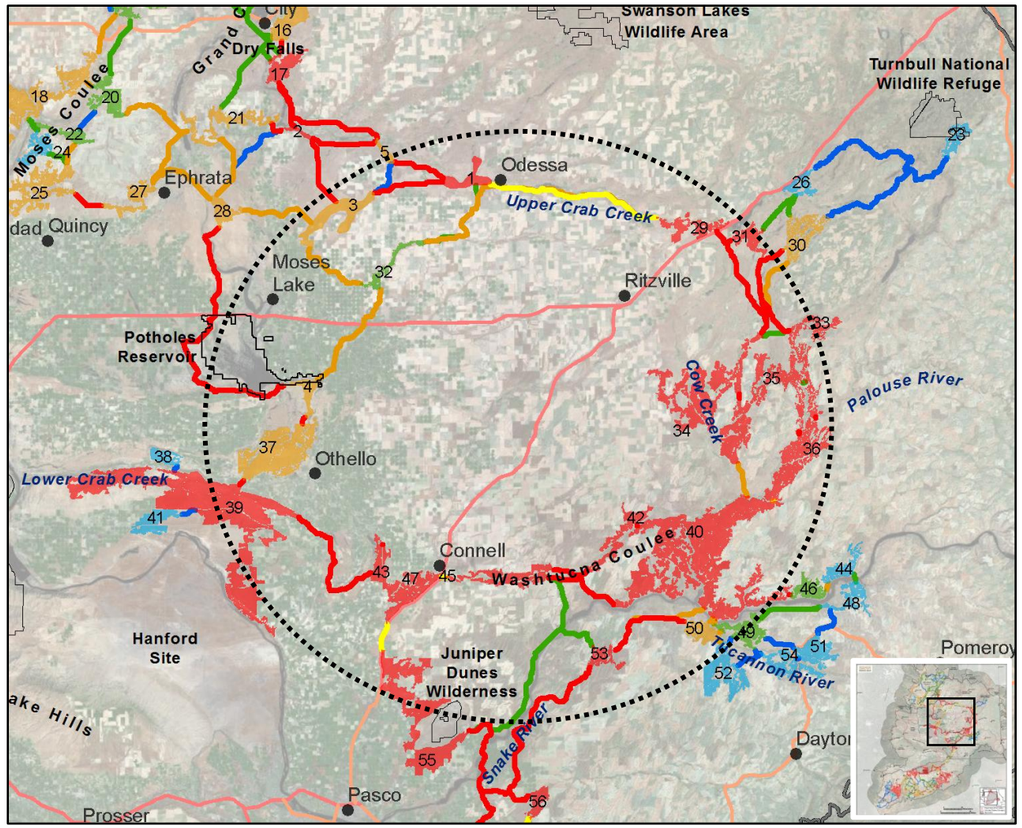

Figure 7.7. Portion of the Columbia Plateau within Washington State, where centrality for Washington ground squirrel HCAs ranks High–Very High.

- Dashed circle denotes circular pattern of HCA distribution.
- Washington ground squirrel distribution and occupancy in this area of strong centrality is poorly documented in the east and south. Thus we emphasize a need for field validation within this area.

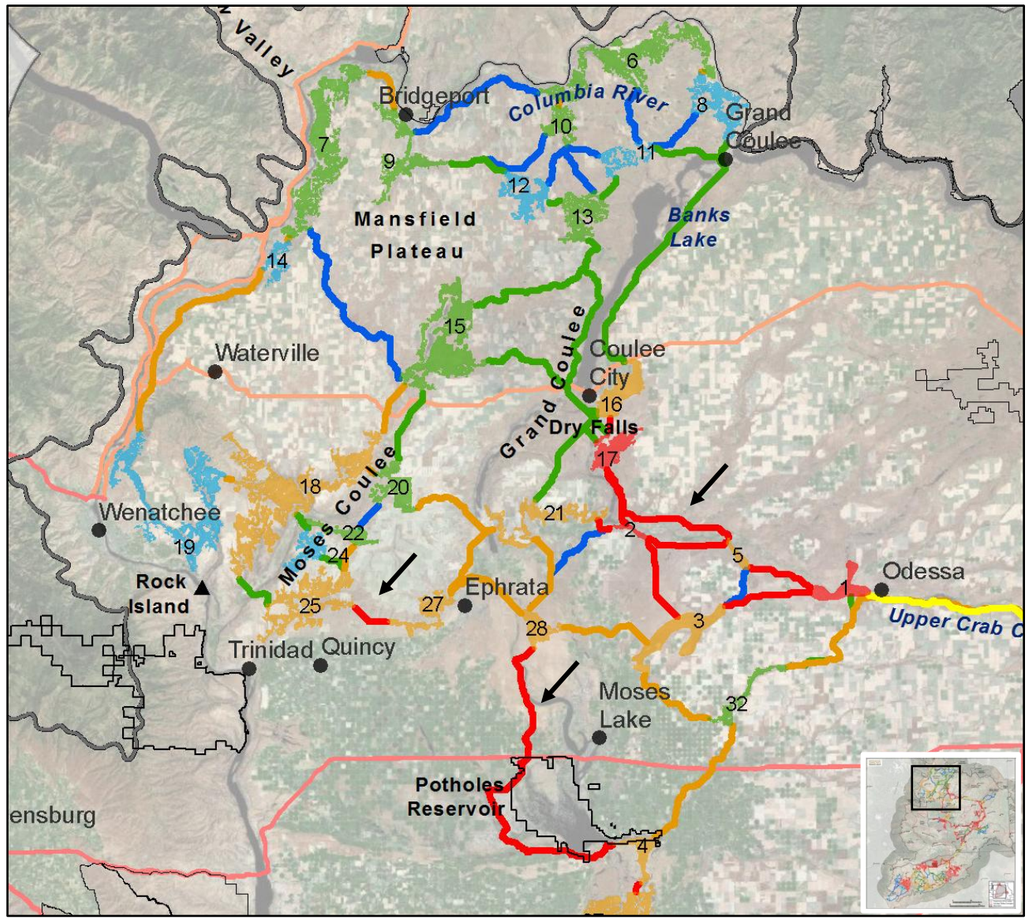

Figure 7.8. Detailed view of Washington ground squirrel centrality results for the Mansfield Plateau.

- Linkages connecting the Mansfield Plateau to the central Columbia Plateau (see Fig. 7.6) have Very High centrality (arrows labeled “A” and “B”), are fairly long, and connect small HCAs.
- The linkage between HCAs 4 and 28 passes east of Potholes Reservoir and may not be viable; length of the least-cost path is 60 km and it passes through habitat that is mostly resistant to movement.
- Work is needed to determine viability of HCAs and linkages in this area.

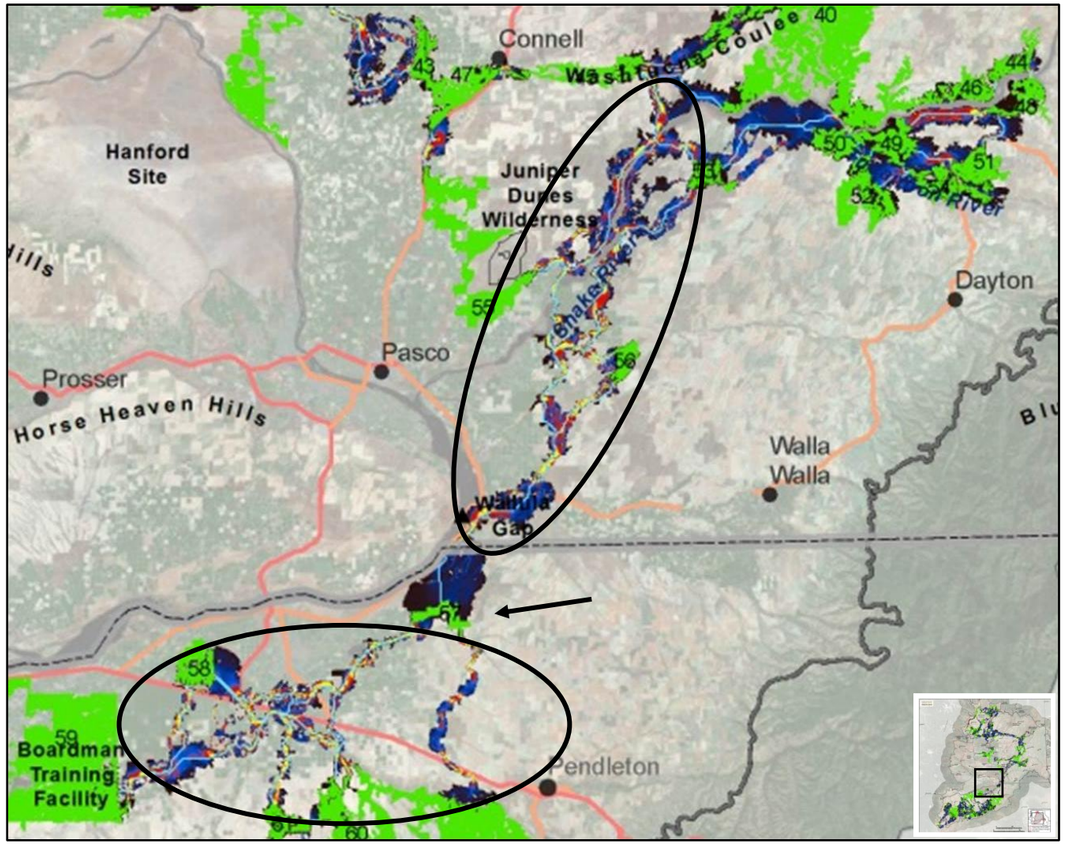

Figure 7.9. Highly constrained linkages (ovals) for Washington ground squirrel near Wallula Gap (WA) and Boardman Training Facility (OR) represent the modeled route for bi-state connectivity. The arrow points to the Highest centrality HCA (57) which is an important gatekeeper/stepping stone for connectivity.

- Linkages for movement of Washington ground squirrel between Washington and Oregon are long, narrow, and have many highly constrained pinch-points.
- Potential movement of Washington ground squirrels in this area is challenging as pinch-points are prevalent along all linkages.
- Further work is needed to evaluate if the HCAs (especially HCA 57) and linkages in this area are viable.
- Loss of habitat in any of the many pinch-points could sever connectivity between Washington and Oregon.

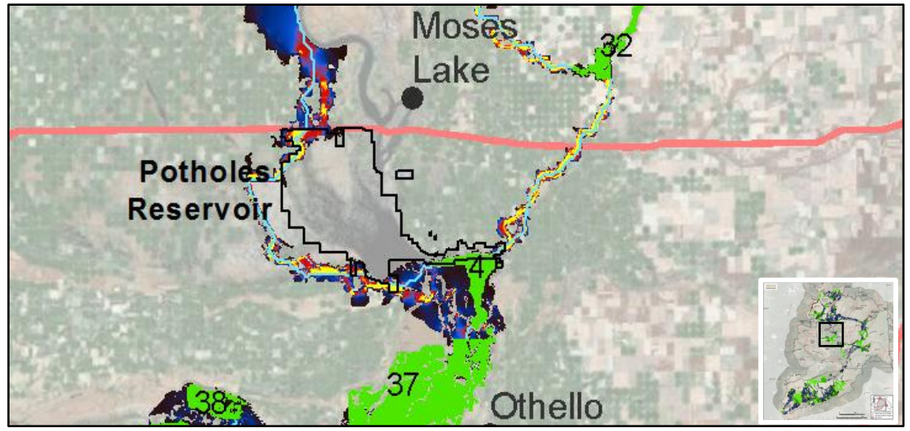

Figure 7.10. Linkages east and west of the Potholes Reservoir.

- Linkages modeled for the Washington ground squirrel east and west of the Potholes Reservoir are narrow, highly constrained, and have Very High cost-weighted distance (see Fig. 7.2).
- These linkages may not be viable. If so, the ground squirrel populations south of Potholes Reservoir may be isolated from those north of the reservoir.

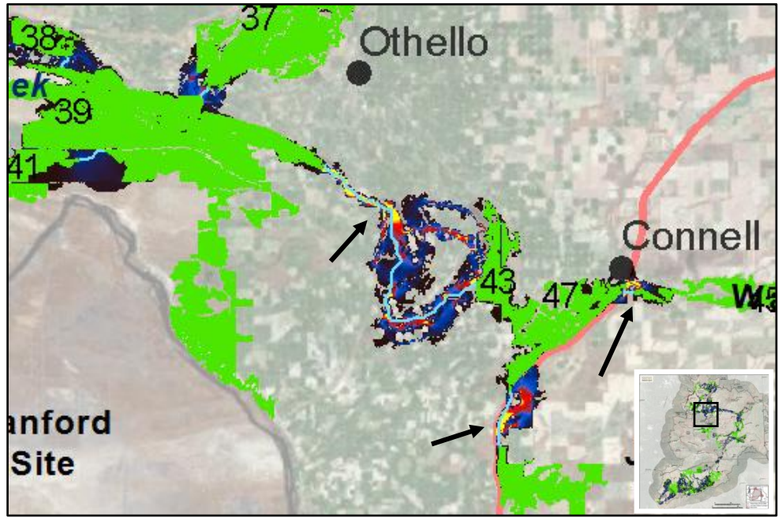

Figure 7.11. Highly constrained Washington ground squirrel linkages that also have Very High and Highest centrality ranking.

- Pinch-points (indicated by arrows) along the linkages near Connell represent potential “bottlenecks” for movement of Washington ground squirrel in the central portion of the Columbia Plateau.

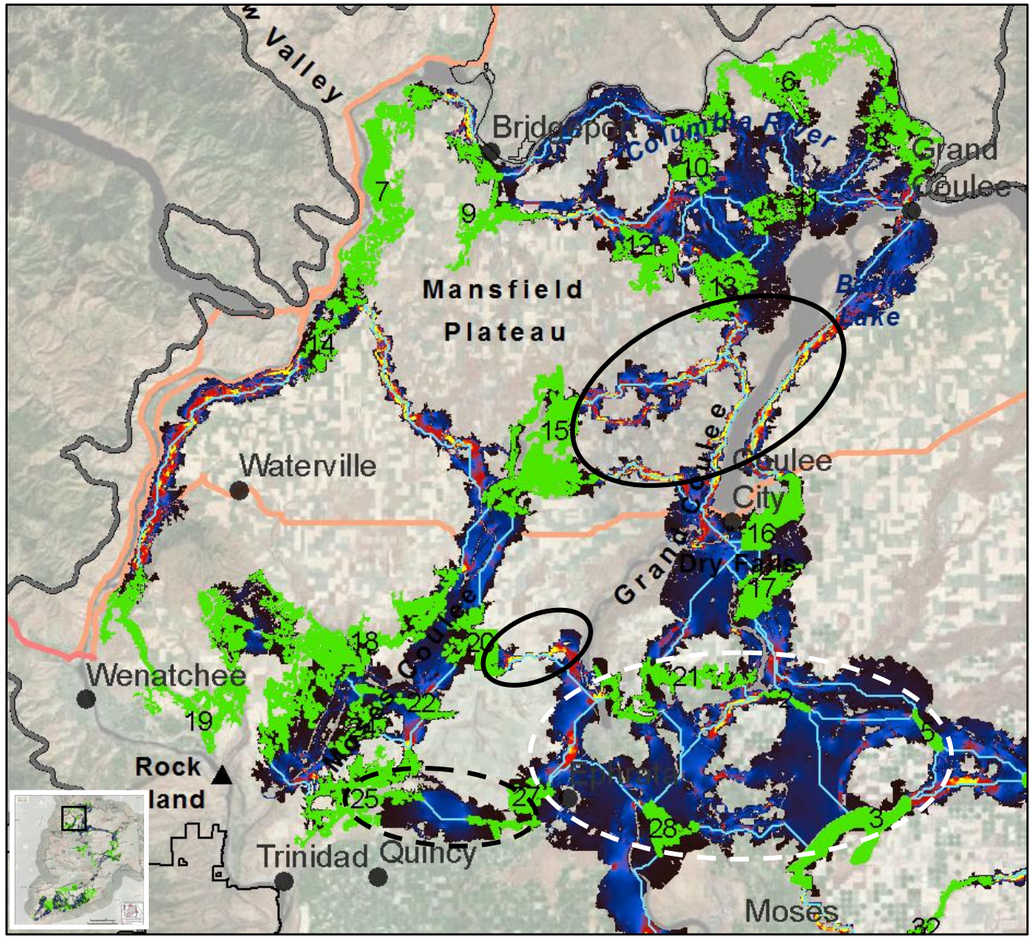

Figure 7.12. Washington ground squirrel linkage pathways (within solid and dashed ovals) connecting HCAs in the Mansfield Plateau with those in the central portion of the Columbia Plateau.

- The HCAs in the area of the Mansfield Plateau are at risk of isolation as linkages connecting this area to the central portion of the Columbia Plateau are highly constrained (solid ovals).
- Further south, the linkage pathway between HCAs 25 and 27 near the southern end of Moses Coulee (dashed black oval) is unconstrained and appears to be largely over natural habitat.
- Also indicated in the map are unconstrained linkages (e.g., large areas with blue north of Moses Lake; dashed white oval).

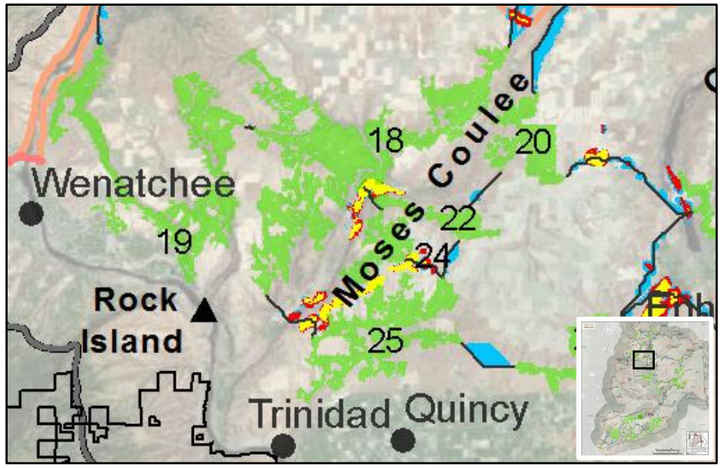

Figure 7.13. Cluster of HCAs in the vicinity of the Moses Coulee (22, 24, 25, 18, and 19) with known Washington ground squirrel populations and modeled barriers.

- Maintaining and improving connectivity among these HCAs with known ground squirrel populations is a conservation priority.
- Modeled barriers between HCAs 18 to 22, 24 to 25, and 18 to 25 include irrigated and/or dryland agricultural areas that could be considered for restoration.

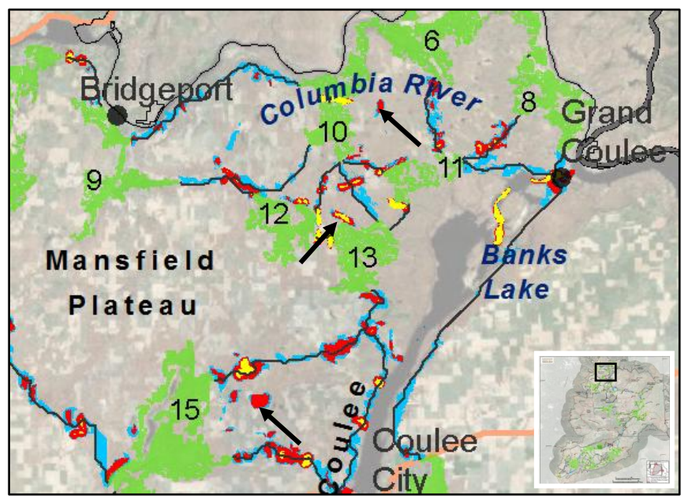

Figure 7.14. Barriers identified in the northern area of the Mansfield Plateau.

- Those identified outside least-cost pathways (arrows), if possible to restore, may create alternate linkages between HCAs (green polygons).

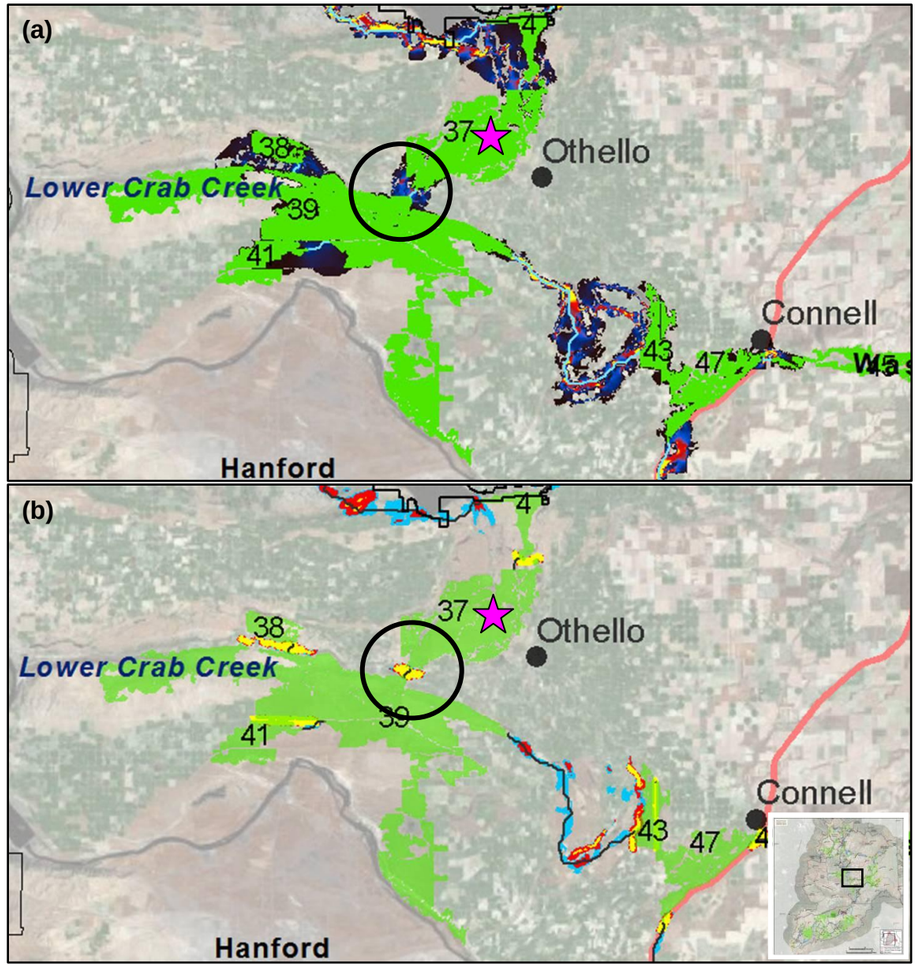

Figure 7.15. Washington ground squirrel important habitat areas near Othello, and linkage considerations.

- This example shows important Washington ground squirrel HCAs that are connected by an unconstrained linkage (panel "a", see circle) containing a potential farmstead and agricultural barrier (panel "b", see circle).
- The "Star" indicates an HCA where Washington ground squirrels have recently been translocated further highlighting the importance of this example.

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