Chapter 6. Network Centrality, Pinch-Points, and Barriers and Restoration Opportunities for Townsend's Ground Squirrel (*Urocitellus townsendii*)

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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 Townsend's ground squirrel (*Urocitellus townsendii*) that can be used to help prioritize and implement conservation actions. We have also included the linkage network (Fig. 6.1) and cost-weighted distance surface (Fig. 6.2) previously modeled for Townsend's ground squirrel (See Appendix A.5, WHCWG 2012, available from http://waconnected.org).

Townsend's ground squirrel, photo by Ryan Shaw

Addendum Connectivity Maps

The supplemental connectivity products developed for Townsend's ground squirrel include maps of (1) linkage network centrality (Fig. 6.3), (2) linkage pinch-points (Fig. 6.4), and (3) barriers and restoration opportunities (Fig. 6.5). 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. 6.6–6.10).

Conservation of Connectivity for Townsend's Ground Squirrel

- A prominent pattern of the connectivity network for this species includes westerly and easterly HCAs and associated linkages clusters located on opposite sides of the Yakima River. Linkages indicated as having high importance for keeping these distinct groups connected are located between Ahtanum Ridge and the Rattlesnake Hills (crossing Union Gap, to the north), and between HCAs 32 and 20 via the Horse Heaven Hills vicinity (to the south).
- Substantial numbers of constricted areas were identified by the pinch-point modeling. These areas can be further evaluated for local significance.
- Barriers include natural features such as rivers and canyons, as well as human-created features such as highways and agricultural areas. The latter may be further considered for potential restoration opportunities and research to better understand the strength of these barriers.
- The connectivity network includes linkages which cross the Yakima River, a potential natural barrier for the Townsend's ground squirrel. However, the Yakima River may be crossable for other species for which the ground squirrel serves as a focal species.

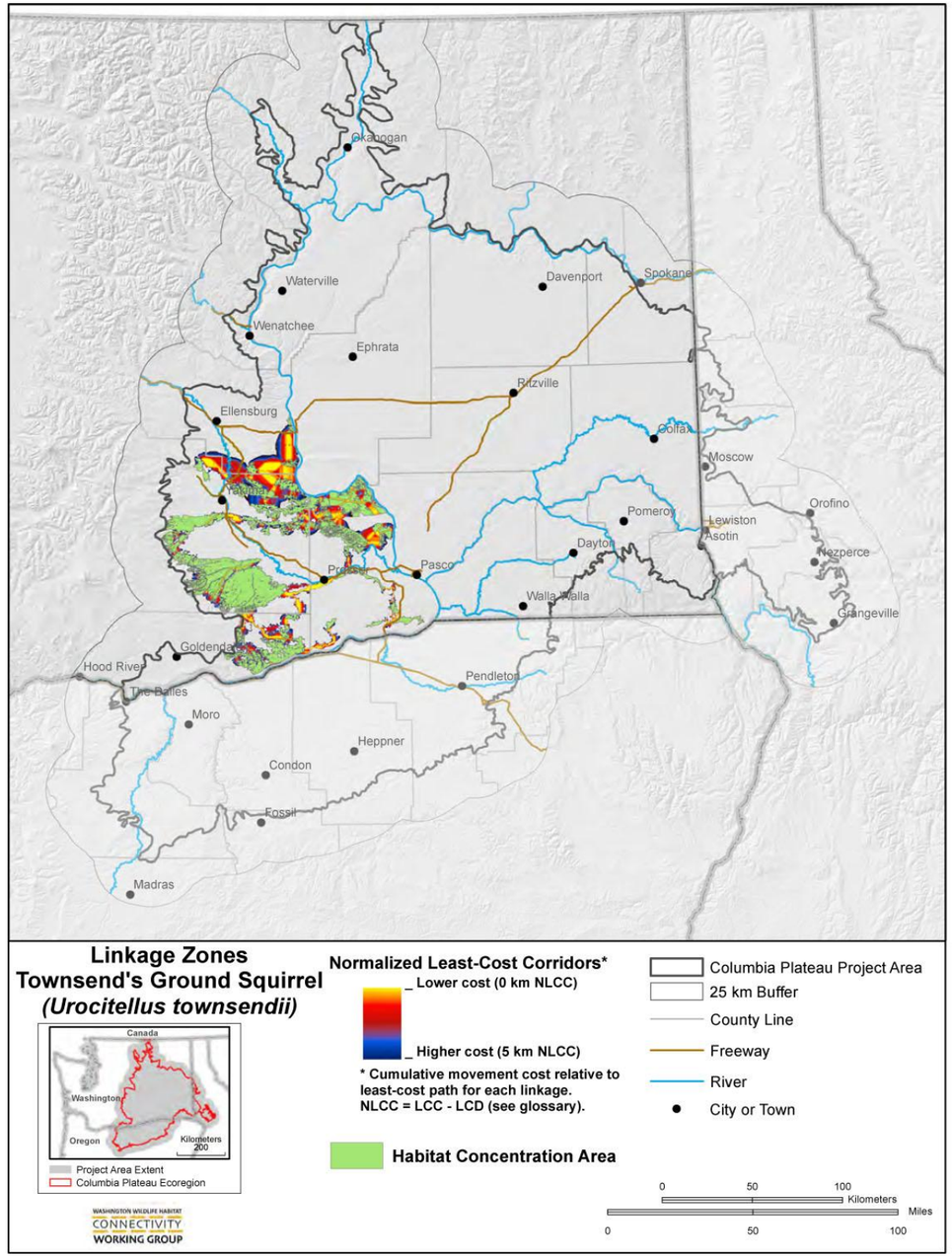

Figure 6.1. Linkage network modeled for Townsend's ground squirrel in the Columbia Plateau Ecoregion (Appendix A.5, WHCWG 2012). Green polygons represent habitat concentration areas (HCAs) for Townsend's ground squirrel. Linkages between HCAs are shown in bright colors; the least-cost pathways are highlighted yellow.

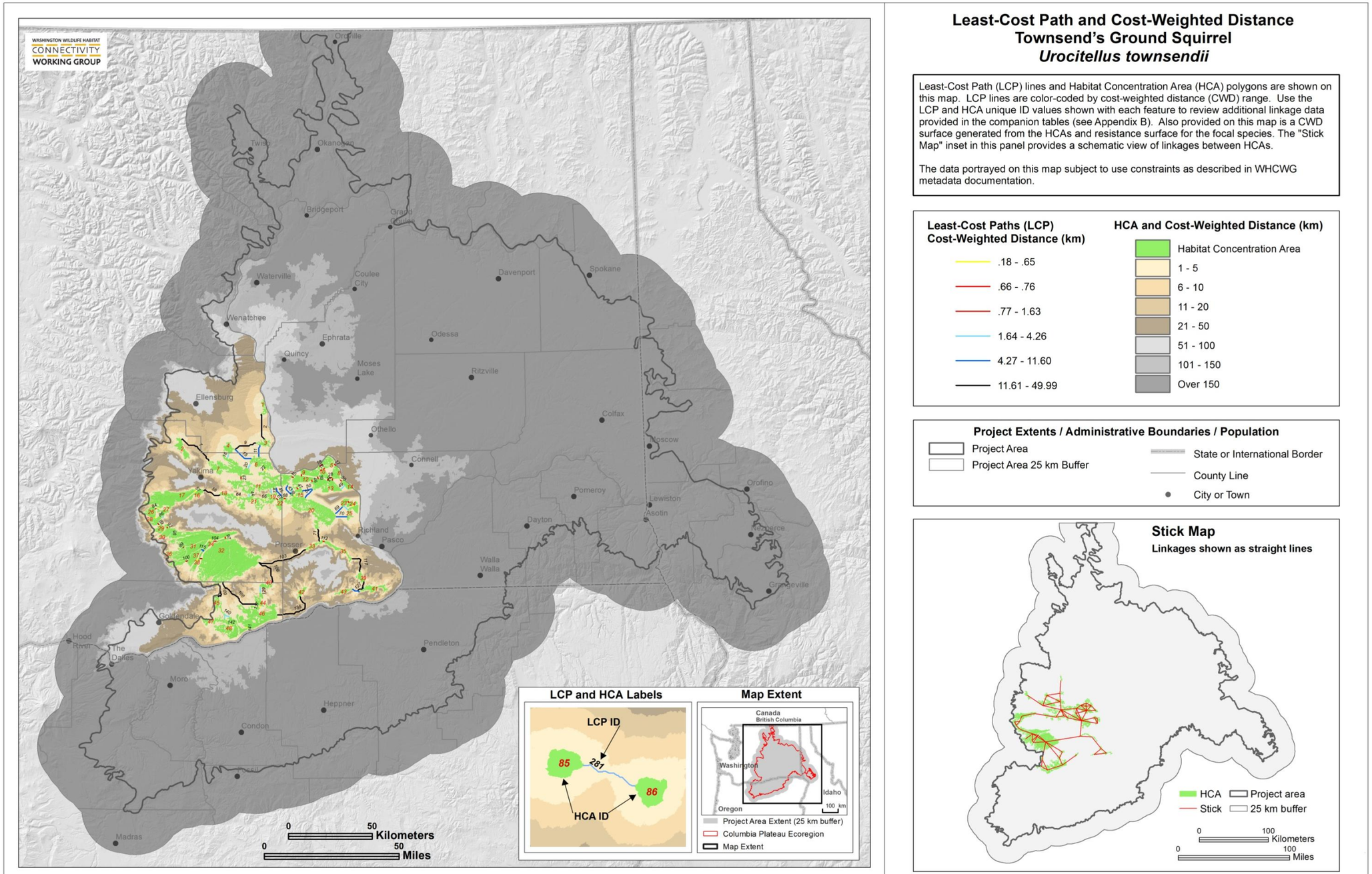

Figure 6.2. The cost-weighted distance map with numbered habitat concentration areas (HCAs) and least-cost paths for Townsend's ground squirrel in the Columbia Plateau Ecoregion (Appendix A.5, WHCWG 2012).

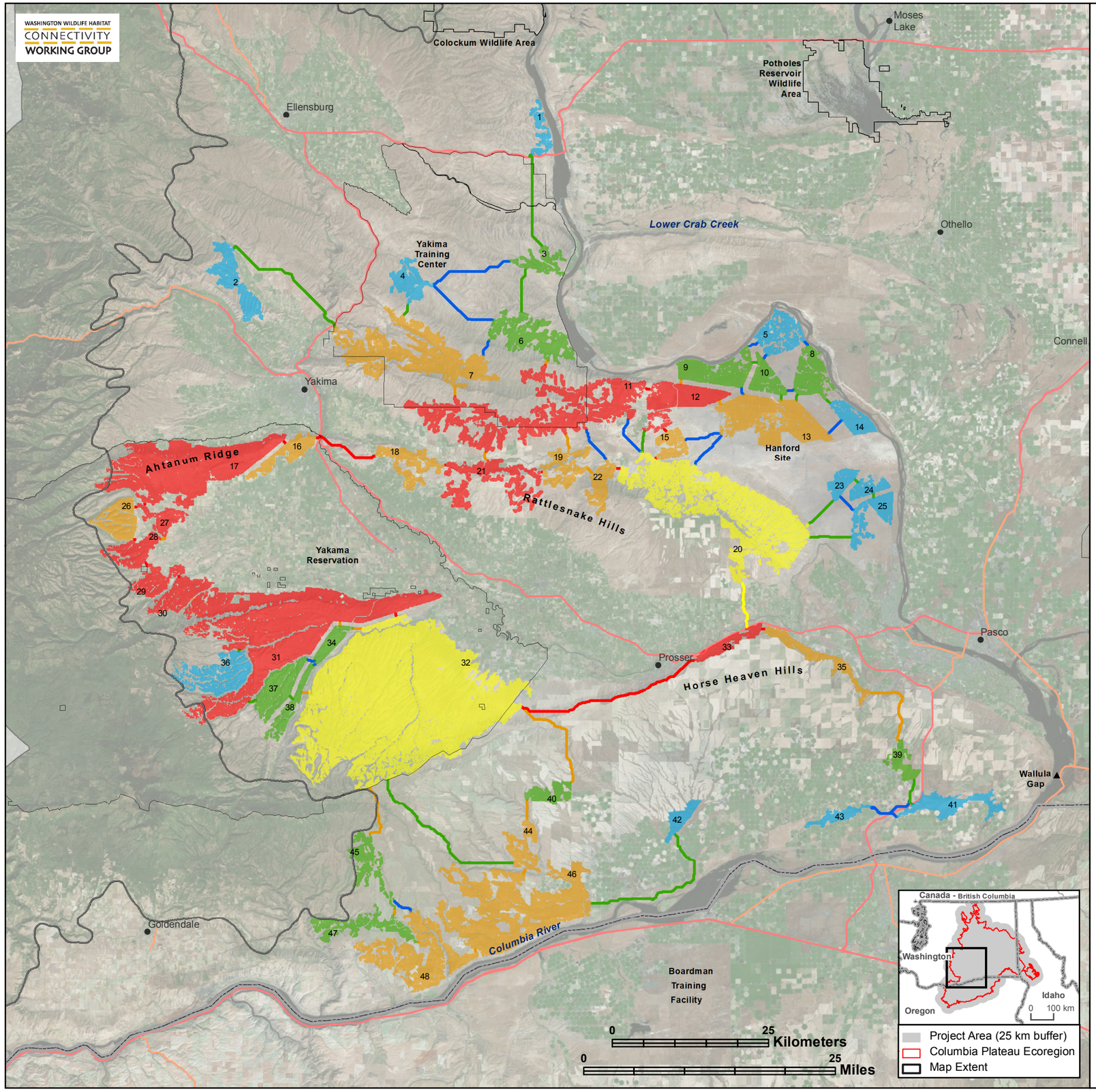

Figure 6.3. Linkage Network Centrality for Townsend's Ground Squirrel (*Urocitellus townsendii*).

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

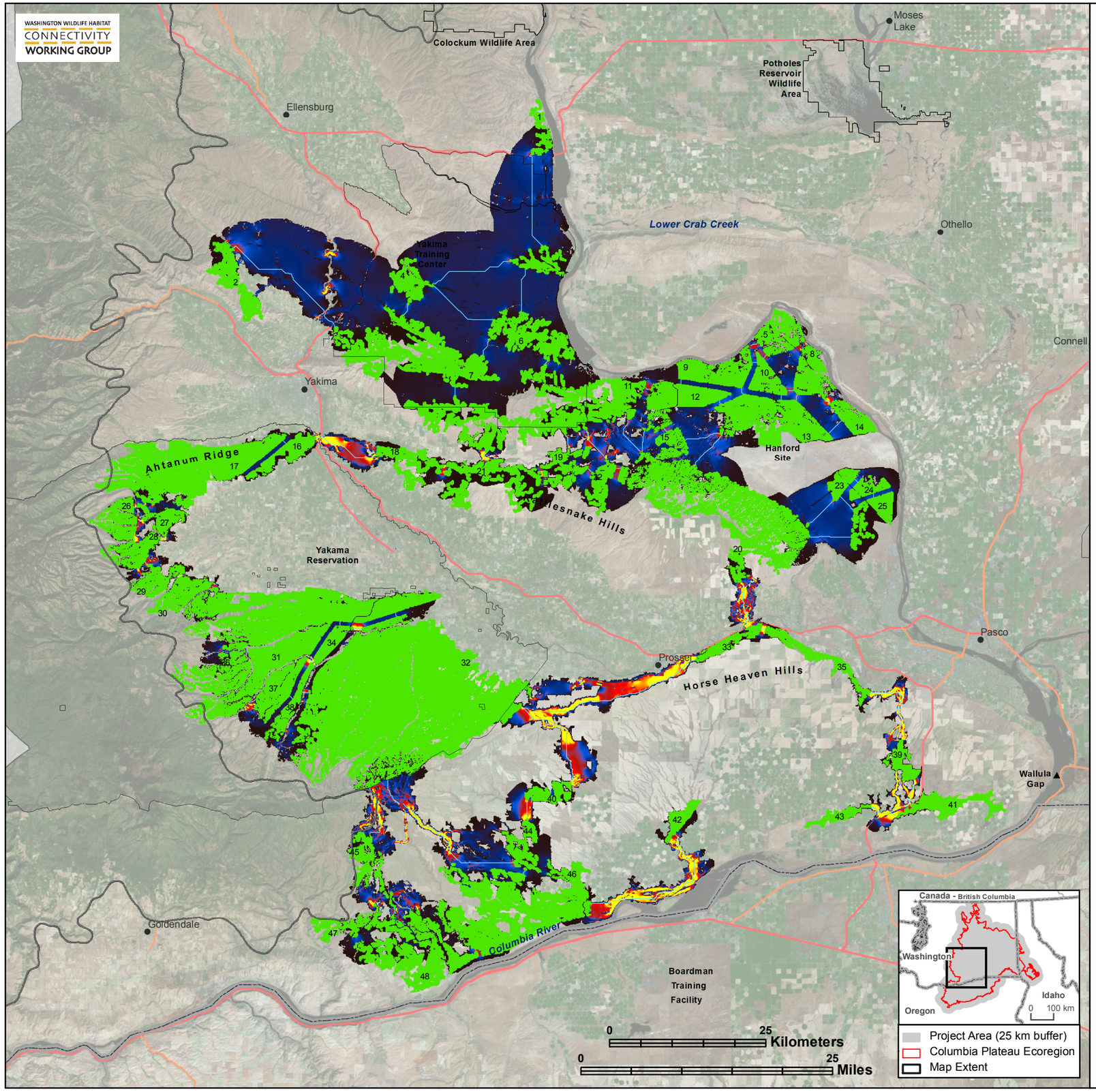

Figure 6.4. Linkage Pinch-Points for Townsend's Ground Squirrel (*Urocitellus townsendii*).

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

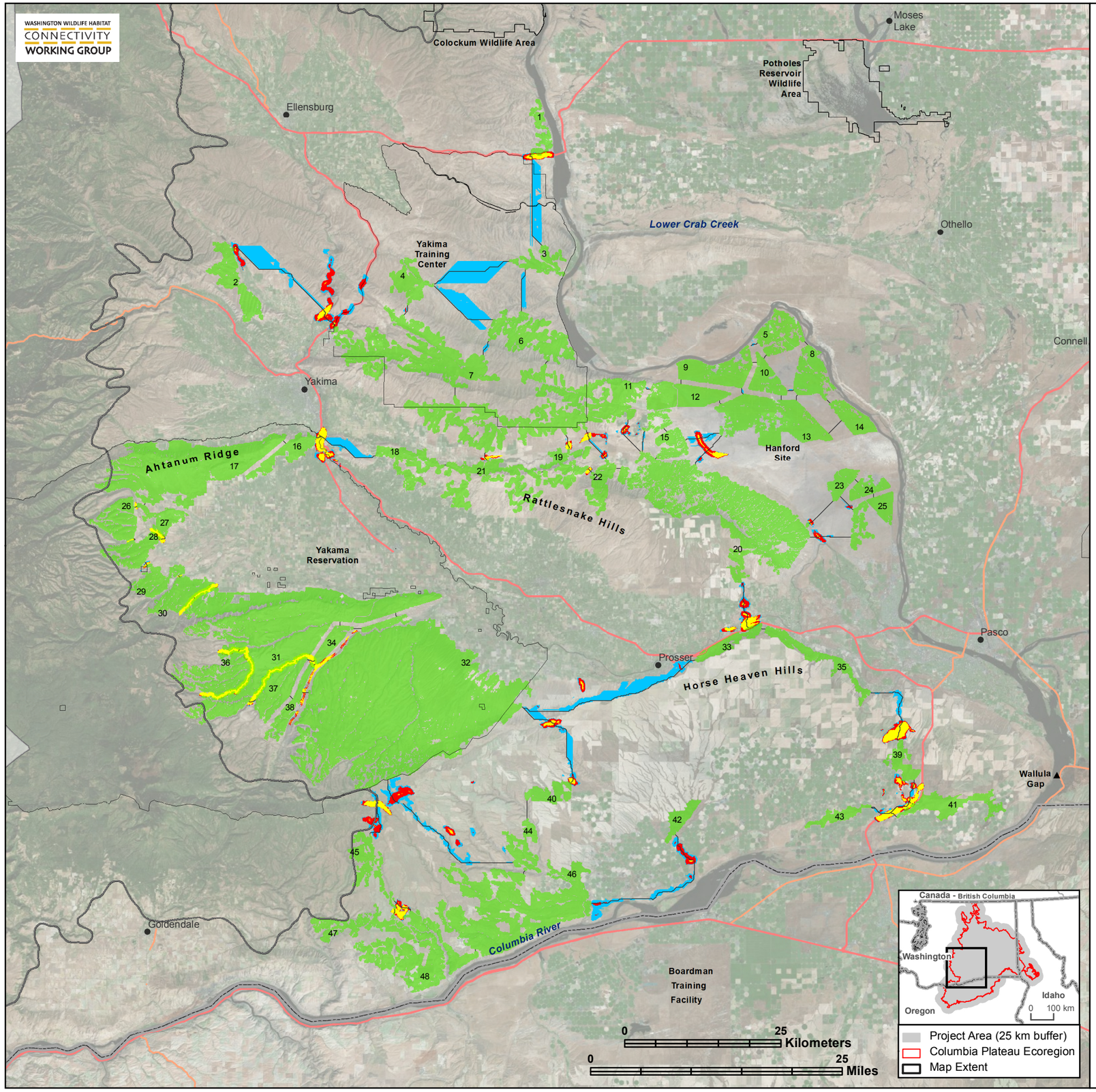

Figure 6.5. Barriers and Restoration Opportunities for Townsend's Ground Squirrel (*Urocitellus townsendii*).

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

- Two distinct clusters of High to Highest centrality HCAs are located on opposite sides of the Yakima River (Fig. 6.6). The Yakima River may be a natural barrier for the Townsend's ground squirrel; however, it may be crossable for other species for which the ground squirrel serves as a focal species.
- The modeled linkages between these two distinct HCA clusters have high importance for keeping the groups connected, and thus the broader connectivity network intact (Fig. 6.6).

Linkage Pinch-Points

- Prominent pinch-points are located between the Ahtanum Ridge and Rattlesnake Hills HCAs, and in the southern portion of the Townsend's ground squirrel connectivity network (Fig. 6.7).
- A substantial constrained area near Prosser results from a combination of urbanization, agriculture, highways, and the Yakima River (Fig. 6.8).

Barriers and Restoration Opportunities

- Potential movement barriers or restoration opportunities (yellow, red, and blue areas) identified for Townsend's ground squirrel can be a result of natural features as well as human-made features (Fig. 6.9).
- Highway crossings within the Hanford Site may provide an opportunity to test the barrier effect of the highways on connectivity for Townsend's ground squirrel (Fig. 6.10).

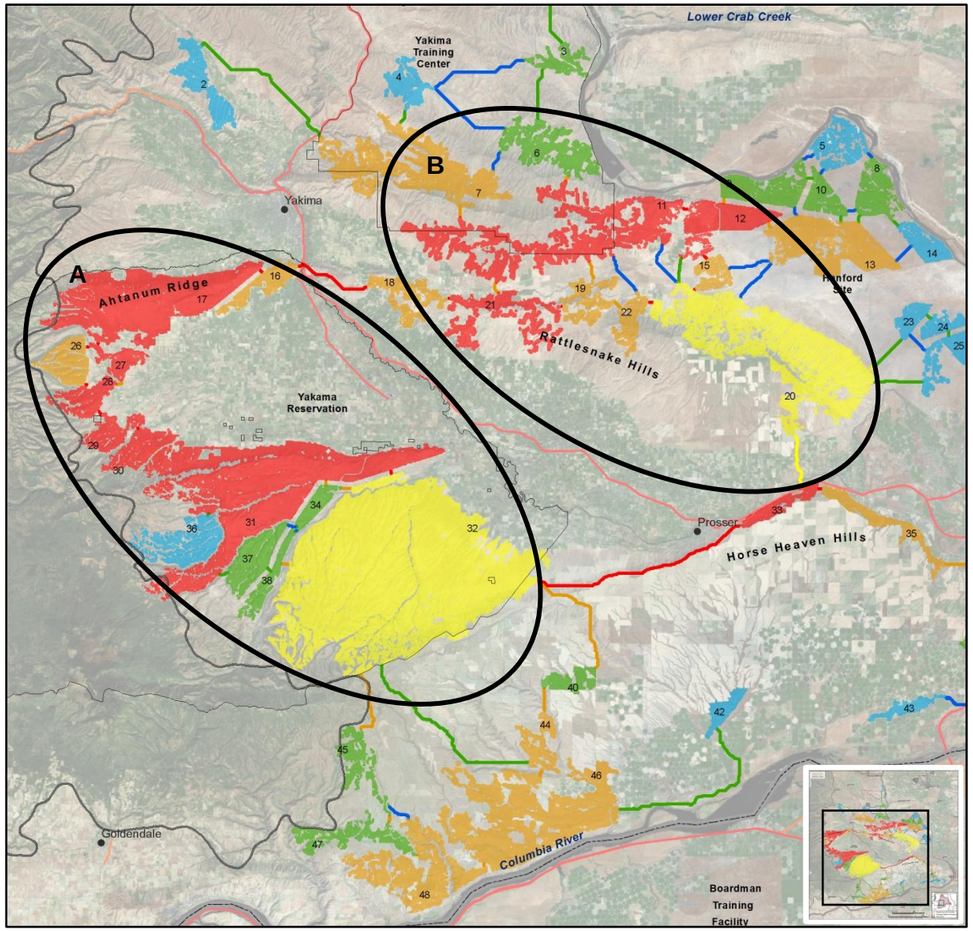

Figure 6.6. Townsend's ground squirrel zoom-in map of HCAs and linkages with Very High to Highest centrality (i.e., red or yellow HCAs or linkages).

- The linkage network for Townsend's ground squirrel has two distinct clusters separated by the Yakima River. The cluster west of the river is in the Ahtanum Ridge–Yakama Nation area. The cluster east of the river is in the Yakima Training Center–Rattlesnake Hills area. The HCAs and linkages ranked Very High (red areas) and Highest (yellow areas) for centrality are noted for each cluster (ovals labeled "A" and "B").
- Linkages connecting the two clusters, e.g., between the Ahtanum Ridge and Rattlesnake Hills (on the north side), and between HCAs 32 and 20 via the Horse Heaven Hills vicinity (on the south side), are indicated as having high importance for keeping these distinct clusters connected.
- The Yakima River may be a natural barrier for Townsend's ground squirrel. However, the river may be crossable for other species for which the ground squirrel serves as a focal species.

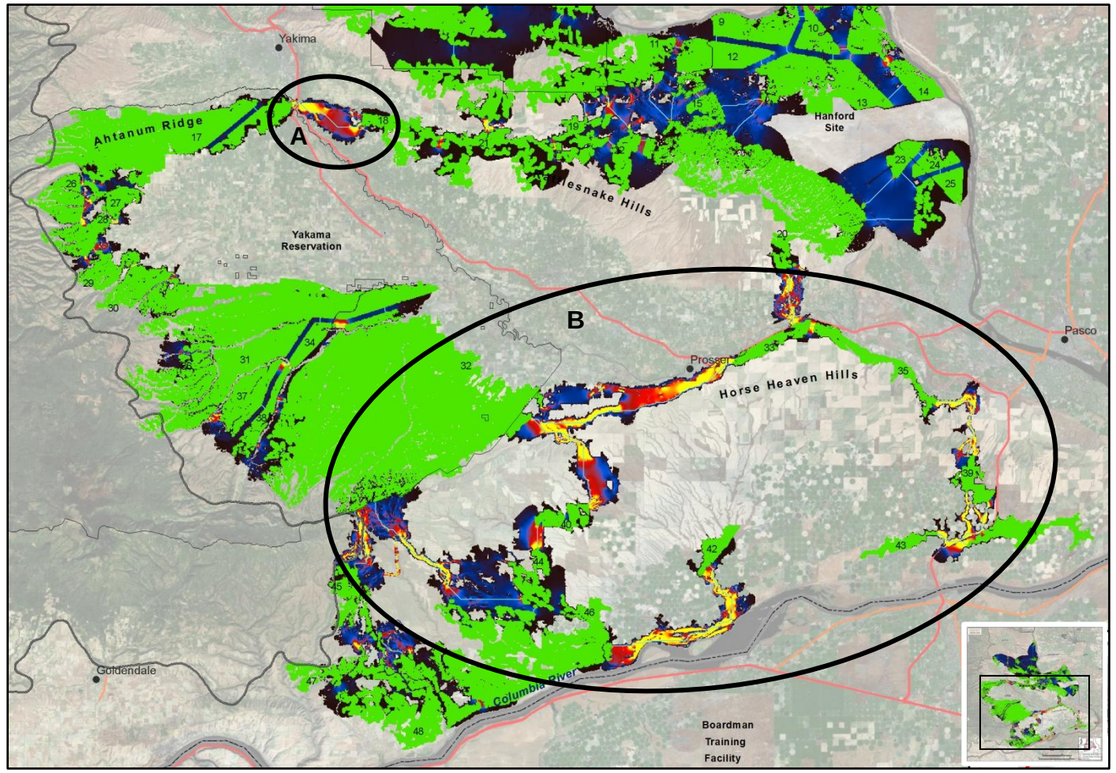

Figure 6.7. Highly constrained linkage pinch-points for Townsend's ground squirrel.

- While the linkage pinch-point map (Fig. 6.4) indicates linkages in large areas of the connectivity network may be unconstrained, particularly for the cluster east of the river, there are substantial numbers of pinch-points identified by the model that can be further evaluated for local significance.
- The Ahtanum Ridge and Rattlesnake Hills HCAs are connected by a linkage with a substantial pinch-point (bright yellow area in oval "A"). Two highways, the Yakima River, and agricultural development are features associated with this pinch-point.
- The southern area of the connectivity network (oval "B"), includes numerous long and highly constrained linkages. These linkages are constrained by agriculture, highways, and natural features such as rivers.

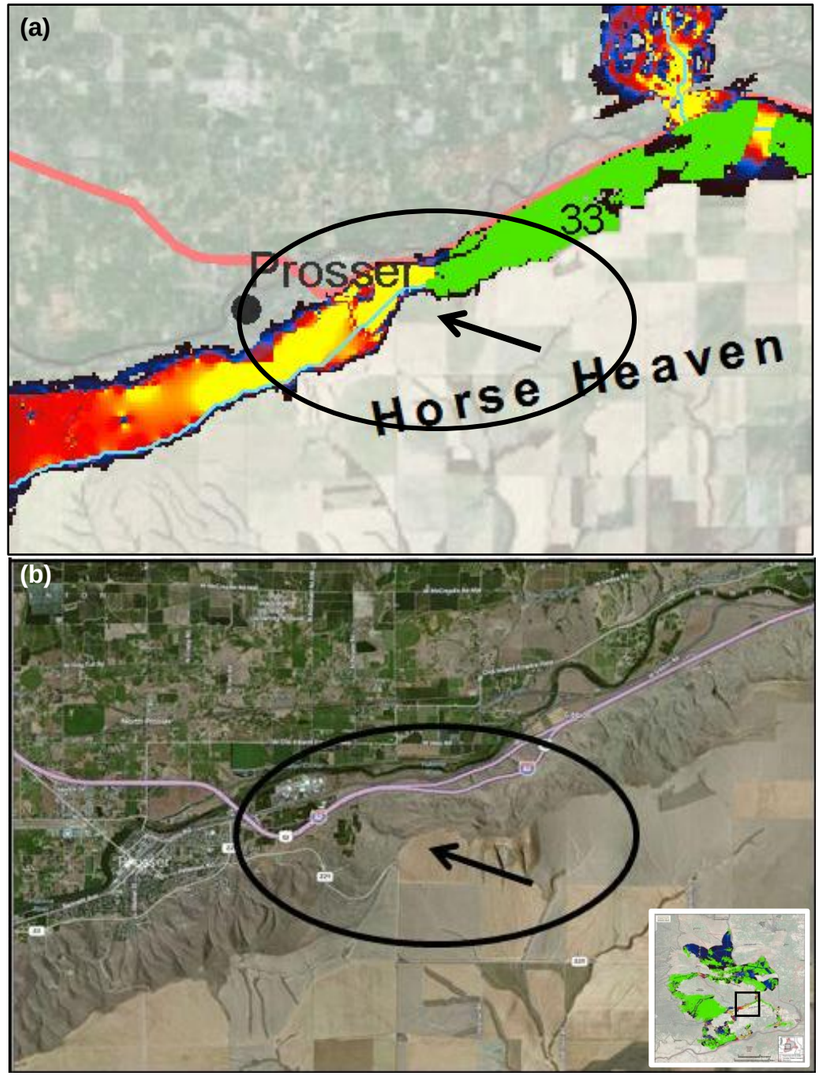

Figure 6.8. Zoom-in map (panel "a"), and aerial imagery (panel "b"), of the linkage pinch-point for Townsend's ground squirrel near Prosser, Washington.

- For panels "a" and "b," the same pinch-point is shown within the oval. The arrow points to the narrowest part of the pinch-point.
- Urbanization, agriculture, highways, and the Yakima River constrain the northern side of the linkage.
- Agriculture constrains this linkage on the southern side of the hills.

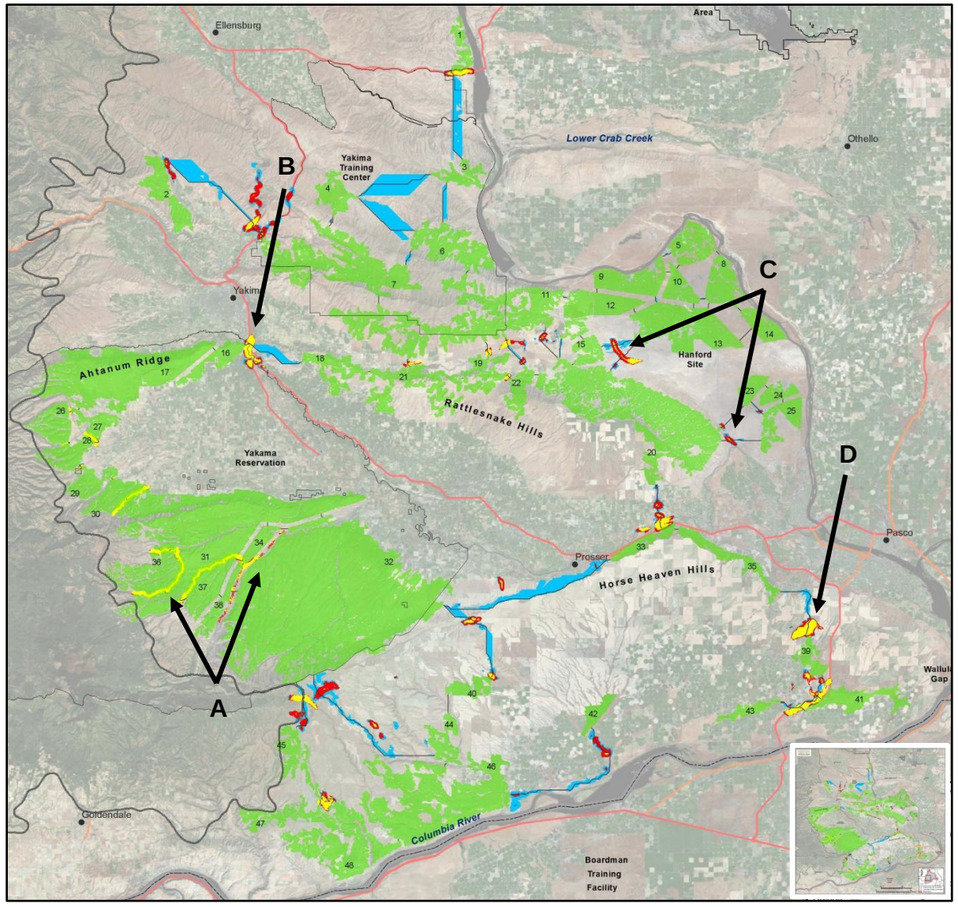

Figure 6.9. Examples of potential movement barriers (yellow, red, and blue areas) identified for Townsend's ground squirrel.

- Natural barriers to potential movement by Townsend's ground squirrel may be a result of topography such as canyons and rivers (arrows "A").
- Some barriers, such as the area at Union Gap identified in the linkage between the Ahtanum Ridge and Rattlesnake Hills HCAs (arrow "B"), can result from a combination of natural topography, rivers, and human-created features such as highways and agricultural development.
- Examples of human-made barriers include highways (arrows "C") and agricultural lands (arrow "D").

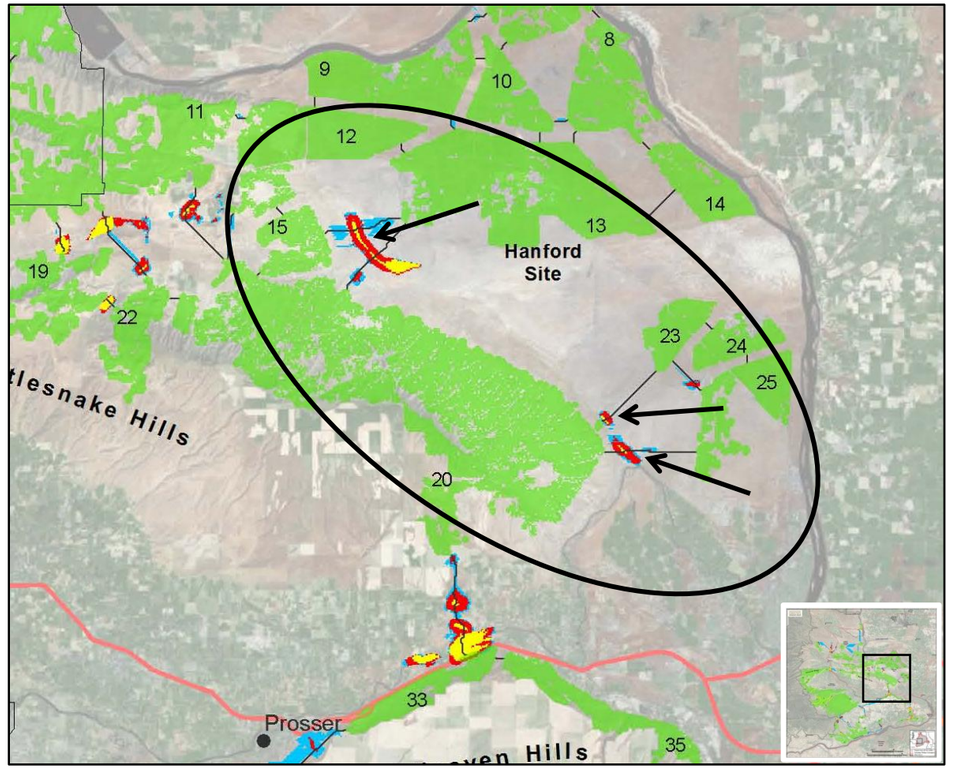

Figure 6.10. Zoom-in depiction of potential barriers to Townsend's ground squirrel created by State Route 240 within the Hanford Site.

- Linkage locations (arrows) identified by the barrier/restoration opportunity analysis that are along SR 240 within the Hanford Site.
- Two-lane highways such as SR 240 may be a minor barrier for this species. As such, the Hanford Site may provide a valuable opportunity to test the barrier effect of highways for Townsend's ground squirrel.

Acknowledgements

Howard Ferguson (WDFW), Brian Hall (WDFW), Kelly McAllister (WSDOT), Leslie Robb (Independent Researcher), and Joanne Schuett-Hames (WDFW) participated in an interpretation session for the maps in this chapter. Special thanks to Leslie Robb and Joanne Schuett-Hames for preparing figures and providing document information and review.