Chapter 5. Network Centrality, Pinch-Points, and Barriers and Restoration Opportunities for White-tailed Jackrabbit (*Lepus townsendii*)

Prepared by Howard L. Ferguson (WDFW)[1]

Modeling and GIS analysis by Brian Cosentino (WDFW), Brian Hall (WDFW), Brad McRae (TNC), Darren Kavanagh (TNC), and Andrew Shirk (UW)

This chapter is an addendum to the *Washington Connected Landscapes Project: Analysis of the Columbia Plateau Ecoregion* (2012). It includes supplemental connectivity maps for white-tailed jackrabbit (*Lepus townsendii*) that can be used to help prioritize and implement conservation actions. We have also included the linkage network (Fig. 5.1) and cost-weighted distance surface (Fig. 5.2) previously modeled for white-tailed jackrabbit (See Appendix A.4 WHCWG 2012, available from http://waconnected.org).

White-tailed jackrabbit, photo by Michael A. Schroeder

Addendum Connectivity Maps

The supplemental connectivity products developed for white-tailed jackrabbit include maps of (1) linkage network centrality (Fig. 5.3), (2) linkage pinch-points (Fig. 5.4), and (3) barriers and restoration opportunities (Fig. 5.5). 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. 5.6–5.17).

Conservation of Connectivity for White-tailed Jackrabbit

- Although the White-tailed Jackrabbit appears to be widely distributed across the western portion of the Columbia Plateau, many of the potential movement corridors appear to be narrow and/or highly constrained and sometimes, singular. This condition highlights the need to conserve or restore the integrity of this network.
- Without some intervention, there is a high likelihood that the distribution of the white-tailed jackrabbits within Washington State may become separate isolated sub-populations (e.g., northern and southern; northern, central, and southern).
- A large percentage of the areas ranked Highest for centrality are located on public lands. The need to conserve and manage these lands for the white-tailed jackrabbit is critical for its viability in Washington.
- The most common barrier types for the white-tailed jackrabbit in the Columbia Plateau appear to be agriculture and roads.
- In some links (identified as pinch-points and barriers) it may be most efficient and cost-effective to identify smaller areas that can be restored or preserved as "stepping stone" HCAs.

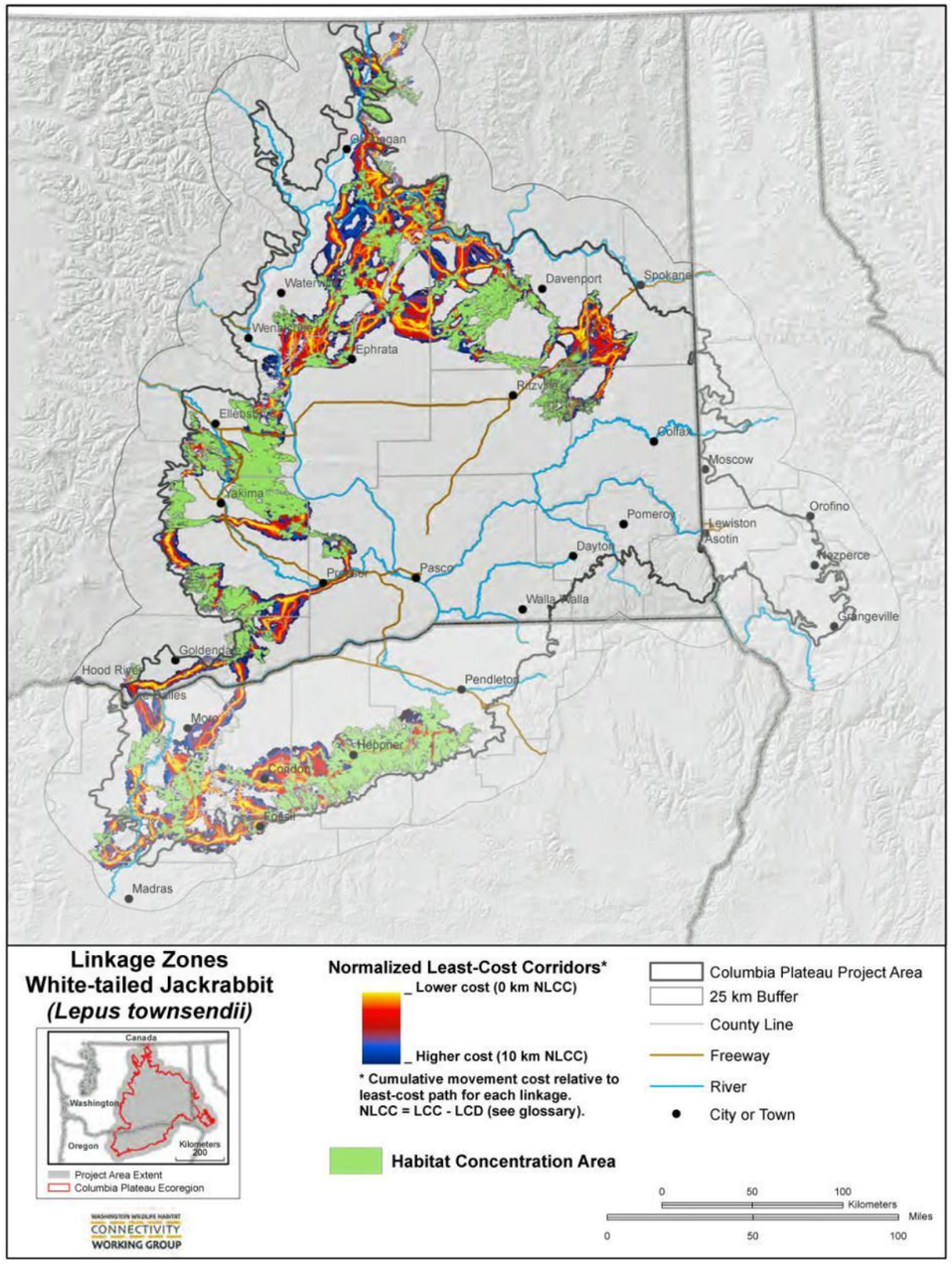

Figure 5.1. Linkage network modeled for white-tailed jackrabbit in the Columbia Plateau Ecoregion (Appendix A.4, WHCWG 2012). Green polygons represent habitat concentration areas (HCAs) for white-tailed jackrabbit. Linkages between HCAs are shown in bright colors; the least-cost pathways are highlighted yellow.

[1]Addendum to Appendix A.4, WHCWG 2012 prepared by Howard Ferguson (WDFW) and Michael Atamian (WDFW)

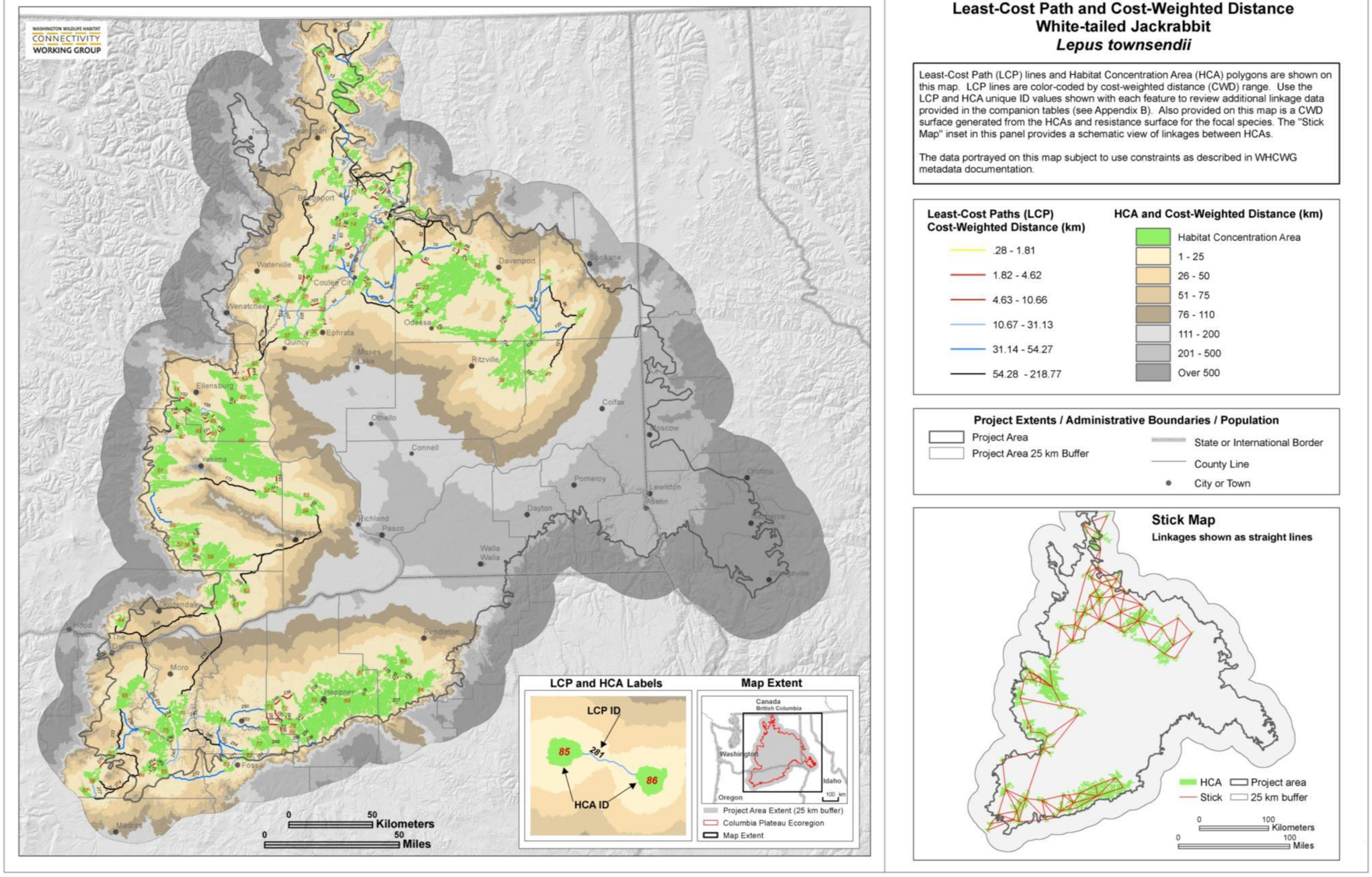

Figure 5.2. The cost-weighted distance map with numbered habitat concentration areas (HCAs) and least-cost paths for white-tailed jackrabbit in the Columbia Plateau Ecoregion (Appendix A.4, WHCWG 2012).

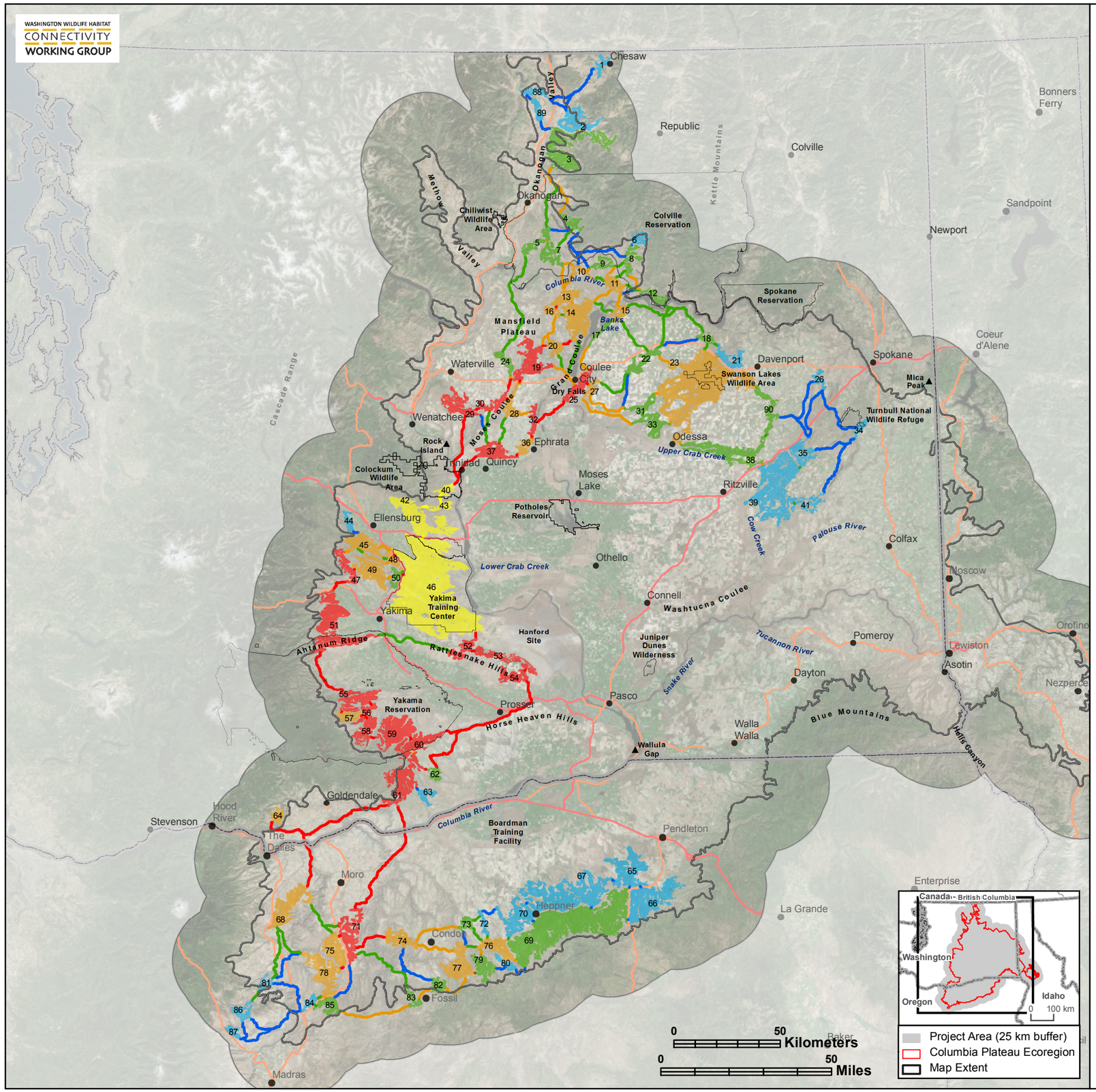

Figure 5.3. Linkage Network Centrality for White-tailed Jackrabbit (*Lepus townsendii*).

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

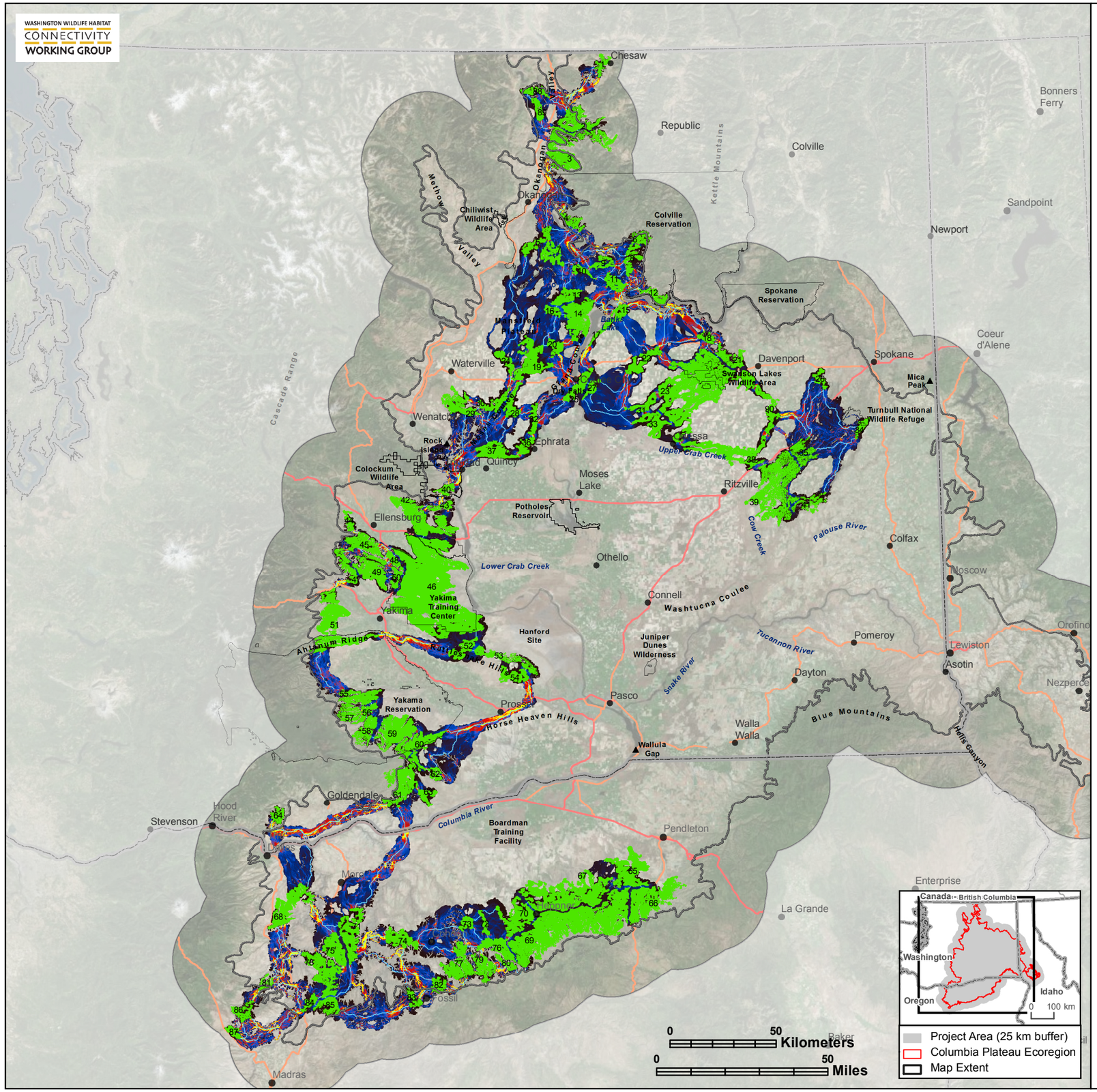

Figure 5.4. Linkage Pinch-Points for White-tailed Jackrabbit (*Lepus townsendii*).

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

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

WASHINGTON WILDLIFE HABITAT CONNECTIVITY WORKING GROUP

Figure 5.5. Barriers and Restoration Opportunities for White-tailed Jackrabbit (*Lepus 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

Example Areas of Interest for Connectivity

Linkage Network Centrality

- The area of greatest centrality in the white-tailed jackrabbit linkage network occurs in Kittitas and Yakima counties. In addition, a very high percentage of the network in Washington is ranked from High to Highest reflecting the critical narrow, linear north–south network that exists for habitat available for white-tailed jackrabbits (Fig. 5.6).
- Low centrality areas are also important for conserving range, connectivity, and potentially genetic diversity of white-tailed jackrabbit (Fig. 5.6).
- Almost 80% of the land ranked Highest for centrality is managed by the Yakima Training Center (YTC; Fig. 5.7).

Linkage Pinch-Points

- The following areas could become isolated due to constrained links:
    - HCAs on the Yakima Nation Reservation as linkages to other HCAs on Department of Energy (DOE) Hanford and Department of Defense (DOD) YTC are long and have highly constrained pinch-points (Fig. 5.8).
    - HCAs north and south of the Crescent Bar area just west of Quincy as the only linkage connecting these areas is very narrow and highly constrained (Fig. 5.9).
    - HCAs in the area where four counties meet—Okanagan, Douglas, Grant and Lincoln (Fig. 5.10).
    - HCAs in the most northern range of the white-tailed jackrabbit in Okanagan County (Fig. 5.11).

Barriers and Restoration Opportunities

- The model identified many opportunities to eliminate or lessen the effects of barriers (Fig. 5.5).
- Typical barriers for the white-tailed jackrabbit are agricultural fields and roads (Figs.5.12, 5.13).
- In some areas, where restoration is possible, alternate linkage pathways could be established. This may be the most cost-effective approach to restoration for many areas within the Columbia Plateau (Figs. 5.12, 5.13).
- Human-created barriers, such as roads, canals, railroads, and human development pose a challenge to restore. Natural barriers such as rivers are also identified by the model, but are not restorable. (Figs. 5.12–5.16).
- In some links (those identified as having pinch-points and barriers) it may be most efficient and cost-effective to identify smaller areas that can be restored or preserved to establish "stepping stone" habitats or HCAs (Figs. 5.14, 5.15).

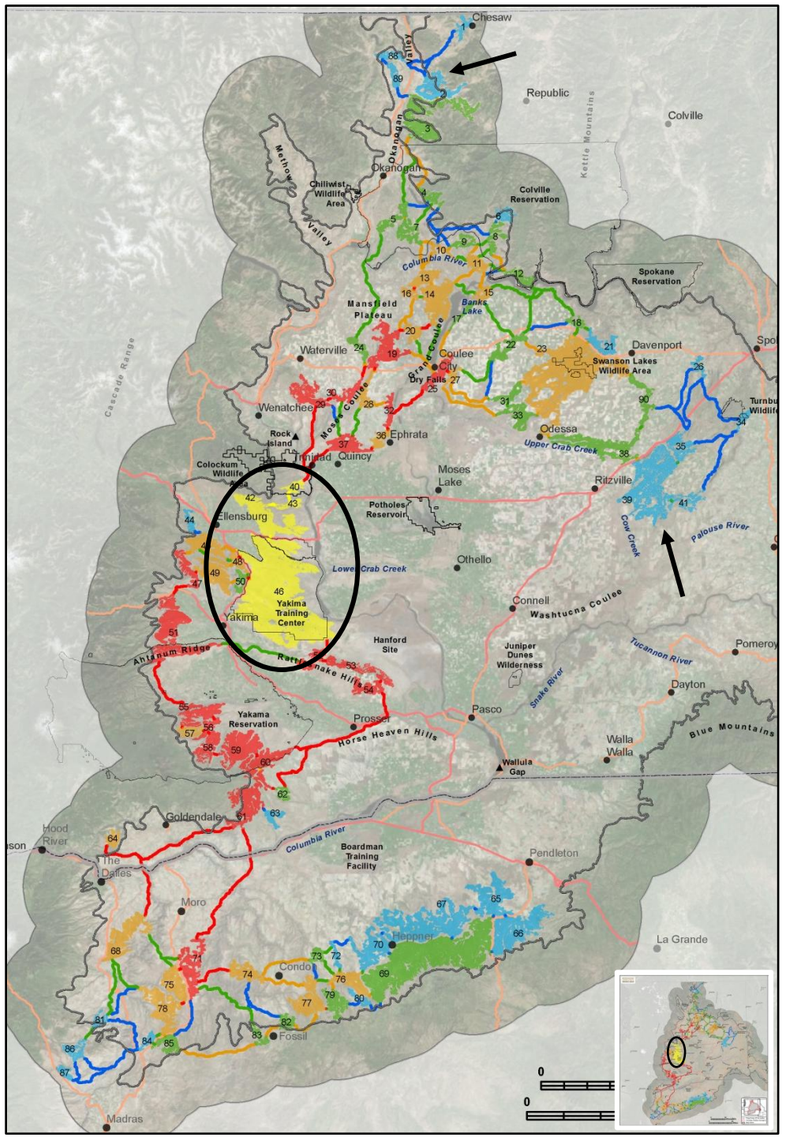

Figure 5.6. Area ranked Highest for network centrality for white-tailed jackrabbit (oval) and example peripheral HCAs (arrows).

- The area ranked Highest for centrality in the white-tailed jackrabbit linkage network occurs in the southern area of Kittitas County and northeastern area of Yakima County (oval).
- Because of their centrality, HCAs 40, 42, 43, and 48 are priorities for conservation to ensure the white-tailed jackrabbits are not severed into north and south subpopulations.

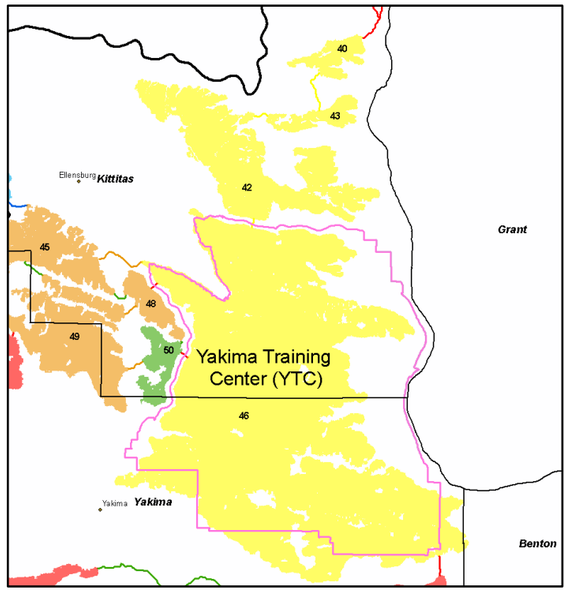

Figure 5.7. Almost 80% of the area ranked Highest for network centrality (yellow HCAs) for white-tailed jackrabbit is found on the Yakima Training Center.

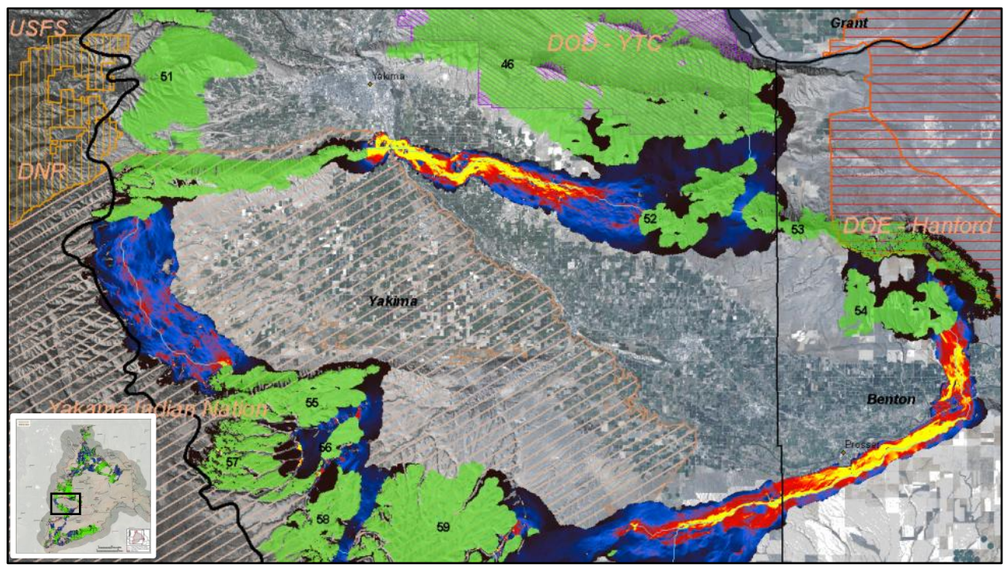

Figure 5.8. Long, highly constrained linkages with severe pinch-points connect HCAs on the Yakama Nation Reservation, DOE Hanford Site, DOD Yakima Training Center, and private lands. Development and agricultural lands constrain these links.

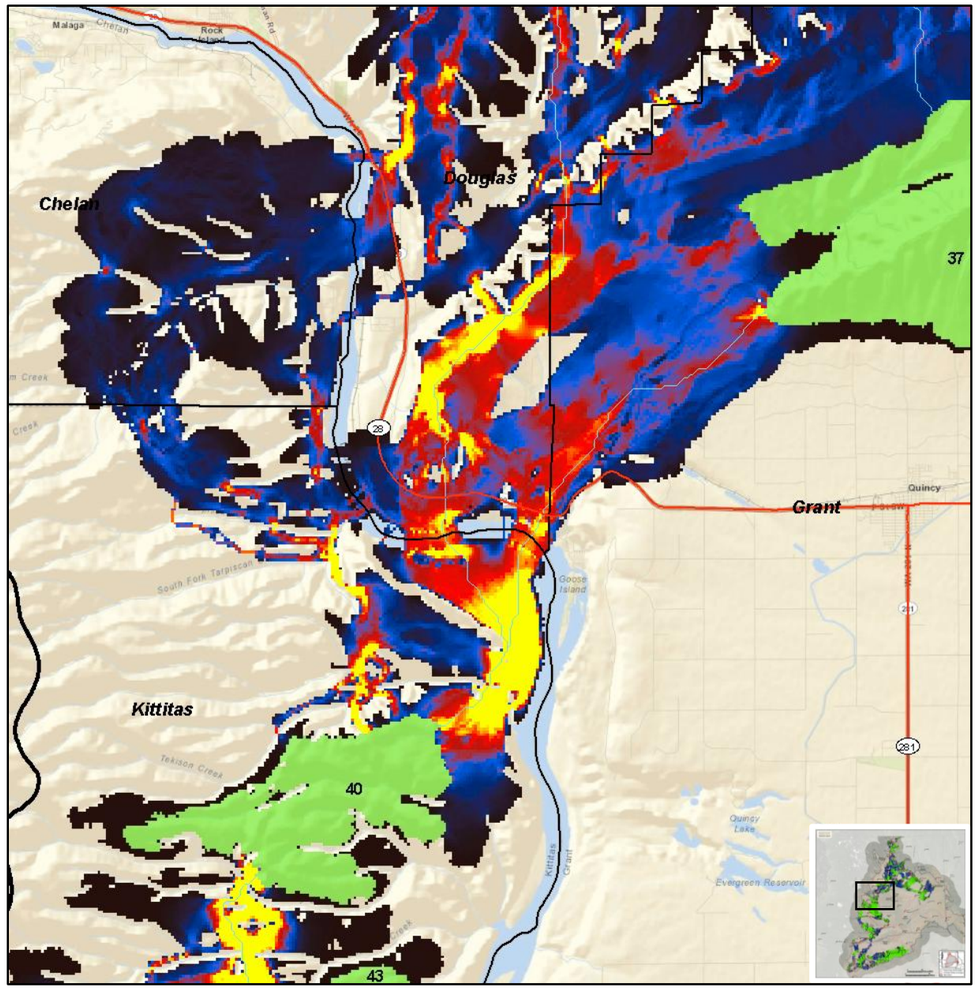

Figure 5.9. Linkages (in the Crescent Bar area west of Quincy) connecting HCA 40 northward to HCAs 29 and 37 are complex and highly constrained.

- This critical pinch-point needs further investigation to determine if it is functional and if there is potential for habitat improvement and preservation.
- Identification of alternate linkage pathways in this area could be beneficial.
- This location functions as a movement “gatekeeper”: without a functional linkage through this area the northern and southern parts of the white-tailed jackrabbit networks will not remain connected.

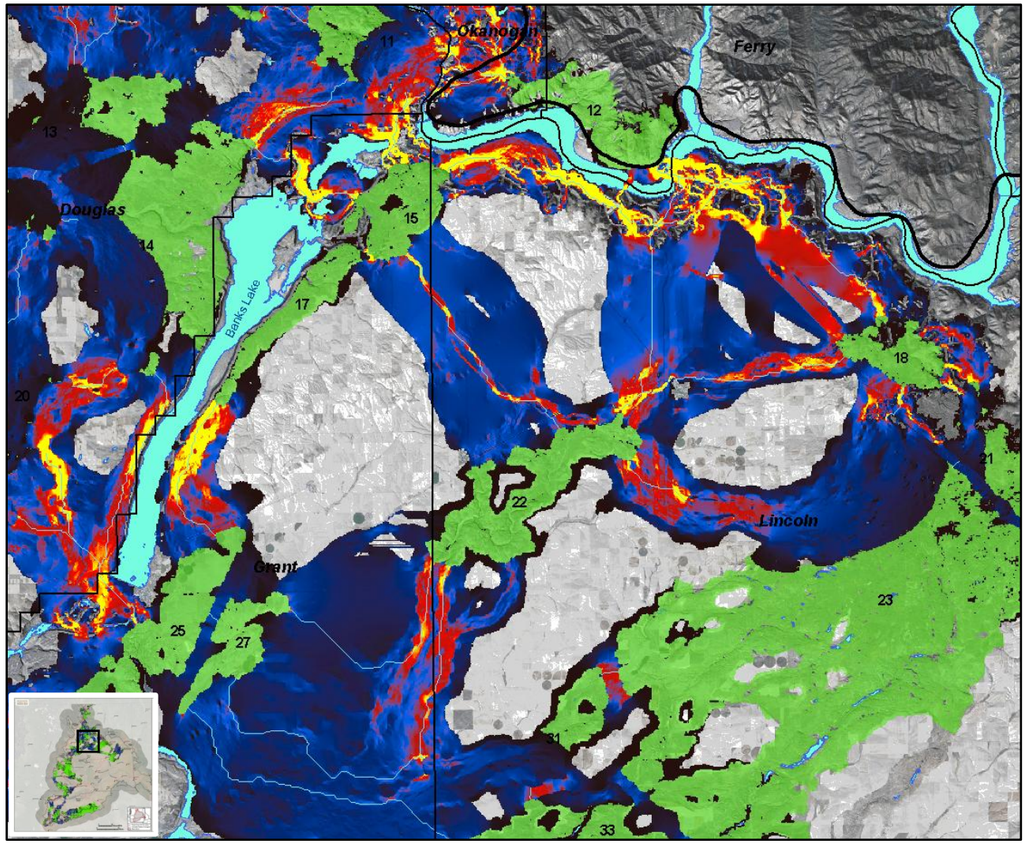

Figure 5.10. A series of important pinch-points in the area where Okanogan, Douglas, Grant, and Lincoln counties meet.

- It is important to address these links since there are known populations of white-tailed jackrabbits in HCAs across this region (HCAs 13, 14, 16, 19, 20, 22, and 23).
- Many of the links in this area are 18–20 km (Euclidean length) and cross a myriad of agricultural fields and several highways (e.g., US Hwy 2, State Hwy 21 and 17).
- Some of the pinch-points in this area are due to either natural or man-made waterways, e.g., the Columbia River and Banks Lake.

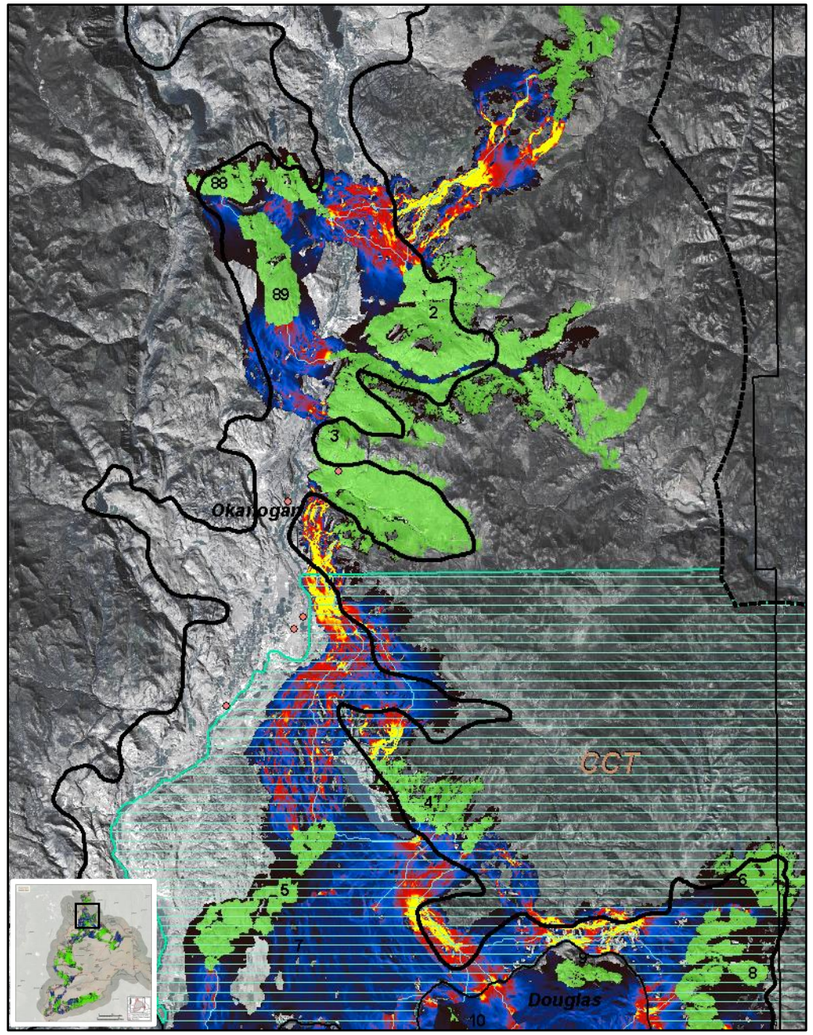

Figure 5.11. A series of important pinch-points occur in the most northern range of HCAs in Okanagan County. Several of these pinch-points occur on Colville Reservation lands.

- These northern pinch-points are critical to address since the elimination of any of these links will reduce the potential range of the white-tailed jackrabbits in Washington. This area has historical records of the jackrabbit but no recent records. However, no formal surveys have been conducted in this area.

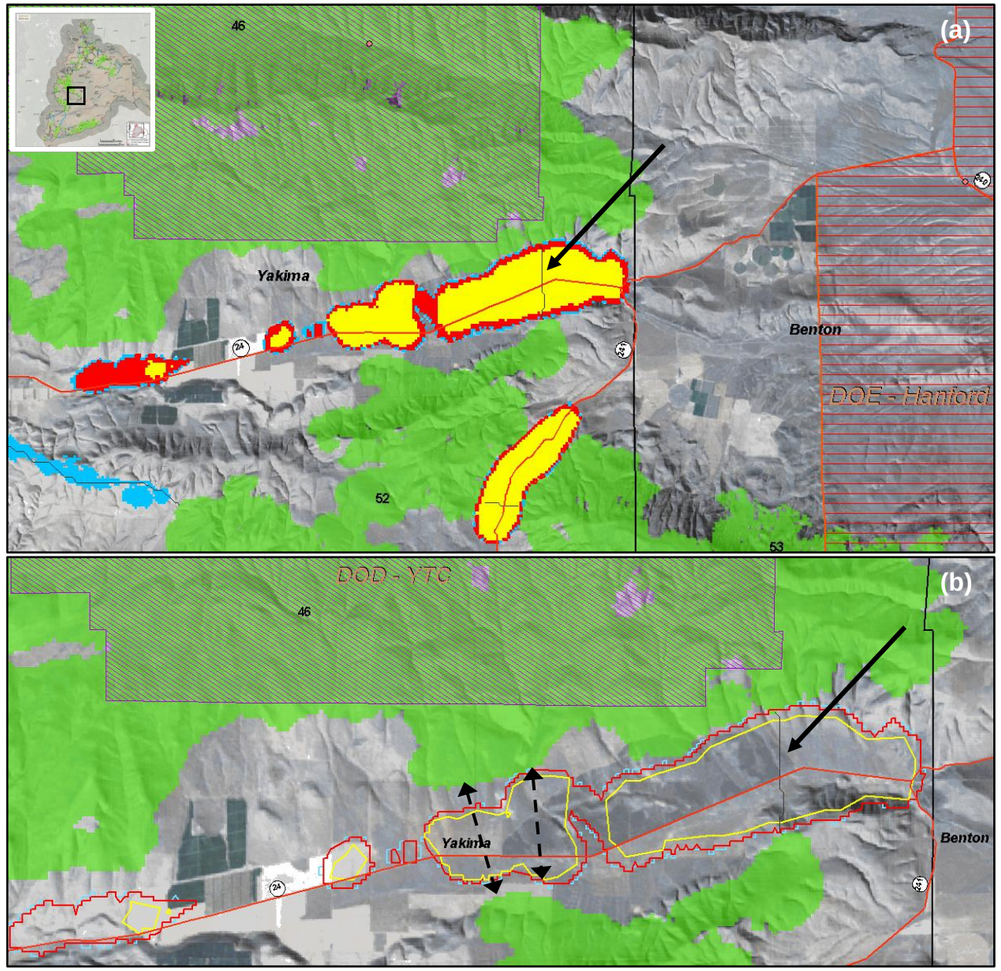

Figure 5.12. Barriers identified on links near the Rattlesnake Hills area of Yakima County.

- Panel "a" shows barriers identified for links near the Rattlesnake Hills, solid arrow points to the least-cost path between HCAs 52 and 46 (green polygons).
- Panel "b" zooms to barriers between HCAs 52 and 46. Those areas colored yellow are identified by the model as providing a strong improvement to the quality of the linkage should they be restorable. Landscape features within the modeled barrier consist of a variety of agricultural fields (e.g., hay-pasture, irrigated, and non-irrigated), powerlines, and roads (State Hwy 24).
- Alternative paths (panel "b," dashed arrows) could be looked at to increase the robustness of this linkage and restoration decisions made depending on feasibility and cost of these alternate paths.

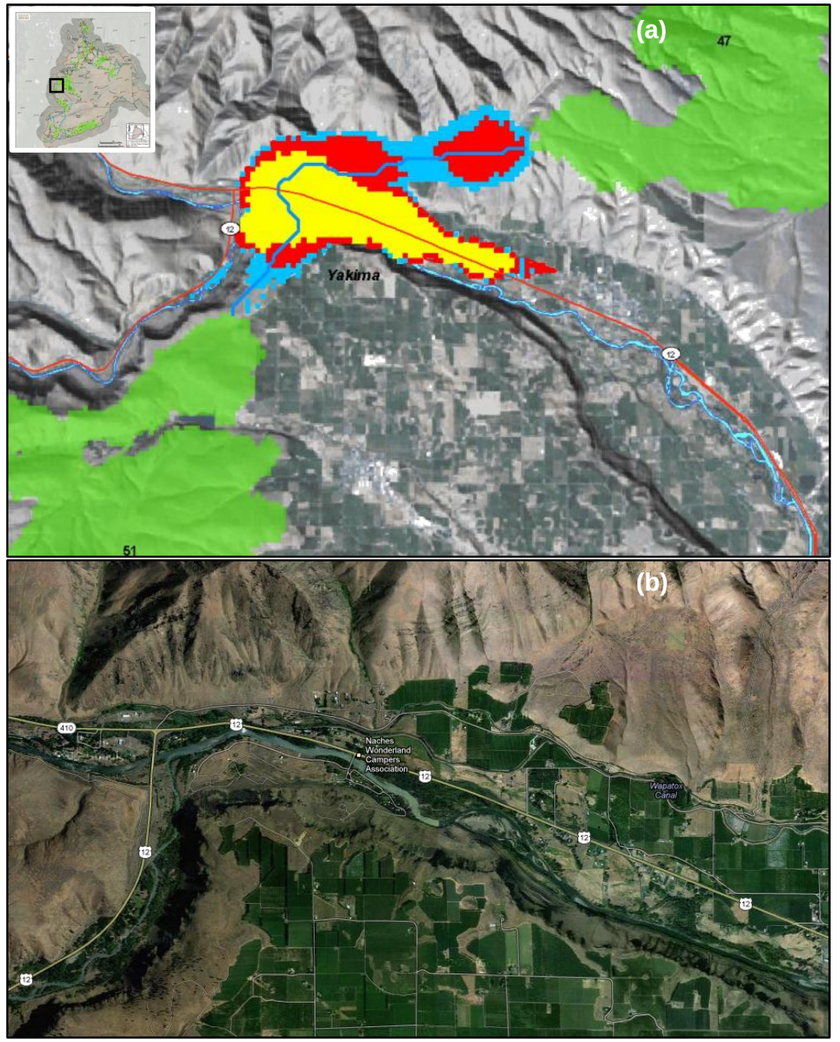

Figure 5.13. A barrier identified near Naches, Yakima County. Panel "a" shows the modeled barrier and panel "b" is a satellite image of the same area.

- Panel "a" shows an identified barrier near Naches, Yakima County. Panel "b" shows several features with high resistance for white-tailed jackrabbits: State Highways 12 and 410; the Tieton and Naches rivers; several irrigation canals, a trailer park and agriculture lands.
- Considerable effort would be needed to determine if this area is restorable, which barrier (s) are the most important to address, and if alternative routes are possible.

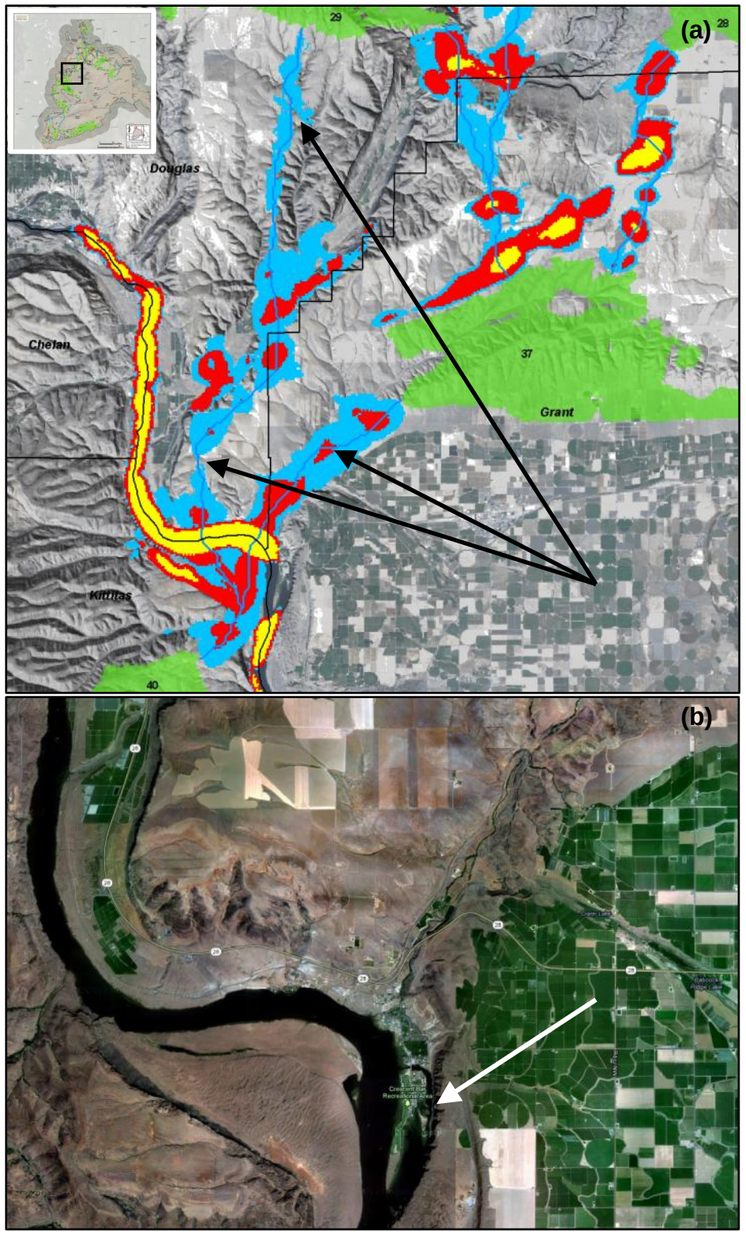

Figure 5.14. A challenging area to restore is the critical pinch-point area discussed earlier—the Crescent Bar area, just west of Quincy, Grant County (See also Fig. 5.9). Arrows in panel "a" point to the groups of yellow, red, and blue modeled barriers between HCA 40 and 29, and HCA 40 and 37. Panel "b" is a zoomed-in satellite image of the same area.

- Figure 5.14 illustrates a mix of barriers, some natural and some man-made. There isn't much that can be done trying to address either the Columbia River or the steep cliffs found on the west side of the river in Kittitas County.
- The challenge for white-tailed jackrabbits crossing the Columbia River is likely best addressed by ensuring that there is suitable habitat present on both sides of the river in the narrowest sections. One suggestion would be to look in and around the Crescent Bar area (white arrow, panel "b," Fig. 5.14) which extends out into the river and thus provides a small "finger" of habitat. Restoration efforts could be focused on ensuring human development is kept to a minimum in this area and on the other side of the river and that native habitat is either restored or protected in the area.
- Possibly, the best way to address the extremely long links, ranging from 18 to 38 km long (Fig. 5.14 black arrows top photo) connecting the HCAs in this area may be to use the "stepping stone" approach. As the upper photo of Fig. 5.14 shows, there multiple barriers along these paths. Rather than attempting restoration of the entire path a possible conservation strategy may be to pick out those areas in "most" need of restoration and leave the areas that may already have suitable habitat, or at least tolerable habitat, like pasture-hay alone. See Fig. 5.15 for another example where this approach may be most effective.

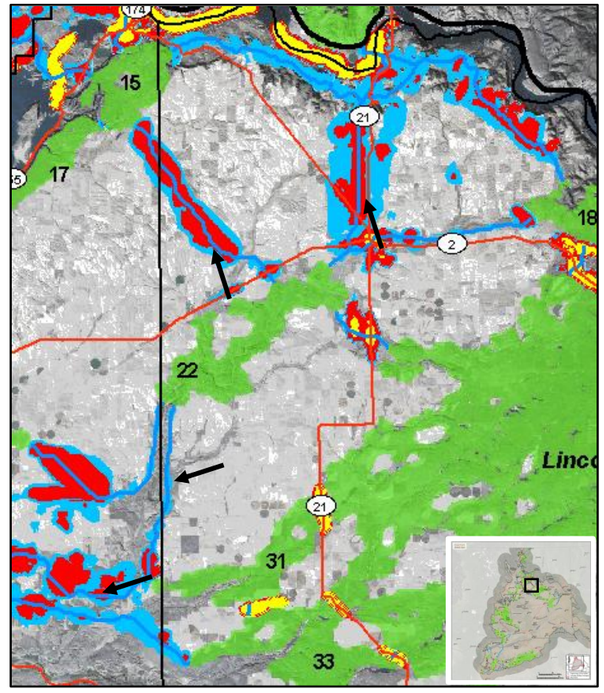

Figure 5.15. This area in Lincoln and Grant counties has several long links (arrows) with barriers along the entire length of these links. A possible conservation approach could be to restore or preserve "stepping stone" habitat, i.e., adequate scattered plots of suitable habitat along these long links.

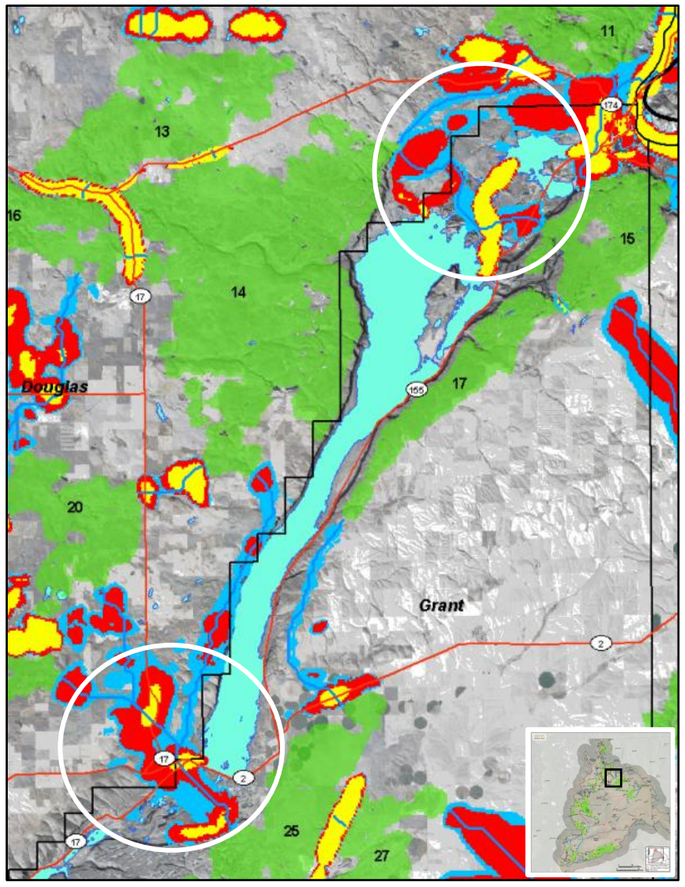

Figure 5.16. Two areas in Douglas and Grant counties (white circles) near Banks Lake that are of high importance for restoration of identified barriers.

- The 35-km-long Banks Lake creates an area of high resistance to white-tailed jackrabbit movement and effectively funnels east or west directional movement to the ends of the long lake (see white circles). This lake in conjunction with the Columbia River to the north, and a series of lakes and steep cliffs to the south side, creates an extremely long barrier. The two areas identified by circles on are critical for east–west movement of white-tailed jackrabbit.
- At the north end of Banks Lake barriers consist of roads, housing development, and a canal.
- At the south end of Banks Lake barriers consist of canals, roads, and steep cliffs.

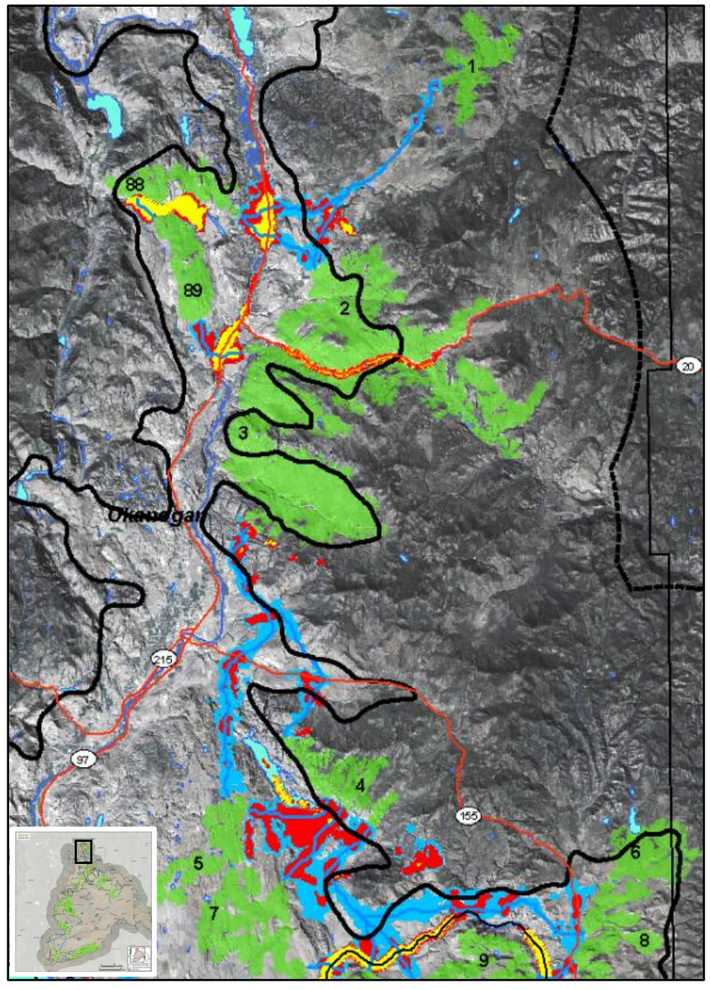

Figure 5.17. The barrier/restoration opportunities analysis for this area in Okanagan County indicates multiple areas that can be reviewed for restoration potential.

- There is potential for restoration of barriers in Okanogan County. However, there are no recent observations of jackrabbits in this area; the last record being at a site that has recently been converted to a large box store. Formal surveys are needed to evaluate the presence of rabbits. If present, restoration opportunities can be considered; if not, habitat can be evaluated and if suitable habitat remains perhaps translocation efforts could be considered.

Acknowledgements

Special thanks to Michael Atamian (WDFW), Karen Bicchieri (TNC), Brian Hall (WDFW), Brad McRae (TNC), Leslie Robb (Independent Researcher), and Joanne Schuett-Hames (WDFW) for model review.