

Chapter 4. Network Centrality, Pinch-Points, and Barriers and Restoration Opportunities for Black-tailed Jackrabbit (*Lepus californicus*)

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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 black-tailed jackrabbit (*Lepus californicus*) that can be used to help prioritize and implement conservation actions. We have also included the linkage network (Fig. 4.1) and cost-weighted distance surface (Fig. 4.2) previously modeled for black-tailed jackrabbit (See Appendix A.3 WHCWG 2012, available from <http://wacconnected.org>).



Black-tailed jackrabbit, photo by Michael Schroeder

Addendum Connectivity Maps

The supplemental connectivity products developed for black-tailed jackrabbit include maps of (1) linkage network centrality (Fig. 4.3), (2) linkage pinch-points (Fig. 4.4), and (3) barriers and restoration opportunities (Fig. 4.5). 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. 4.6–4.18).

Conservation of Connectivity for Black-tailed Jackrabbit

- Although the black-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. This condition highlights the need to maintain the current integrity of this network by conservation and/or restoration efforts.
- Without some intervention, there is a high likelihood that the distribution of the black-tailed jackrabbits in Washington State would become separate isolated sub-populations (e.g., northern and southern; northern, central and southern).
- A large percentage of areas with greatest centrality are located on public lands. The need to conserve and manage these lands for the black-tailed jackrabbit is critical for its viability in Washington.
- The most common barrier types for the black-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.

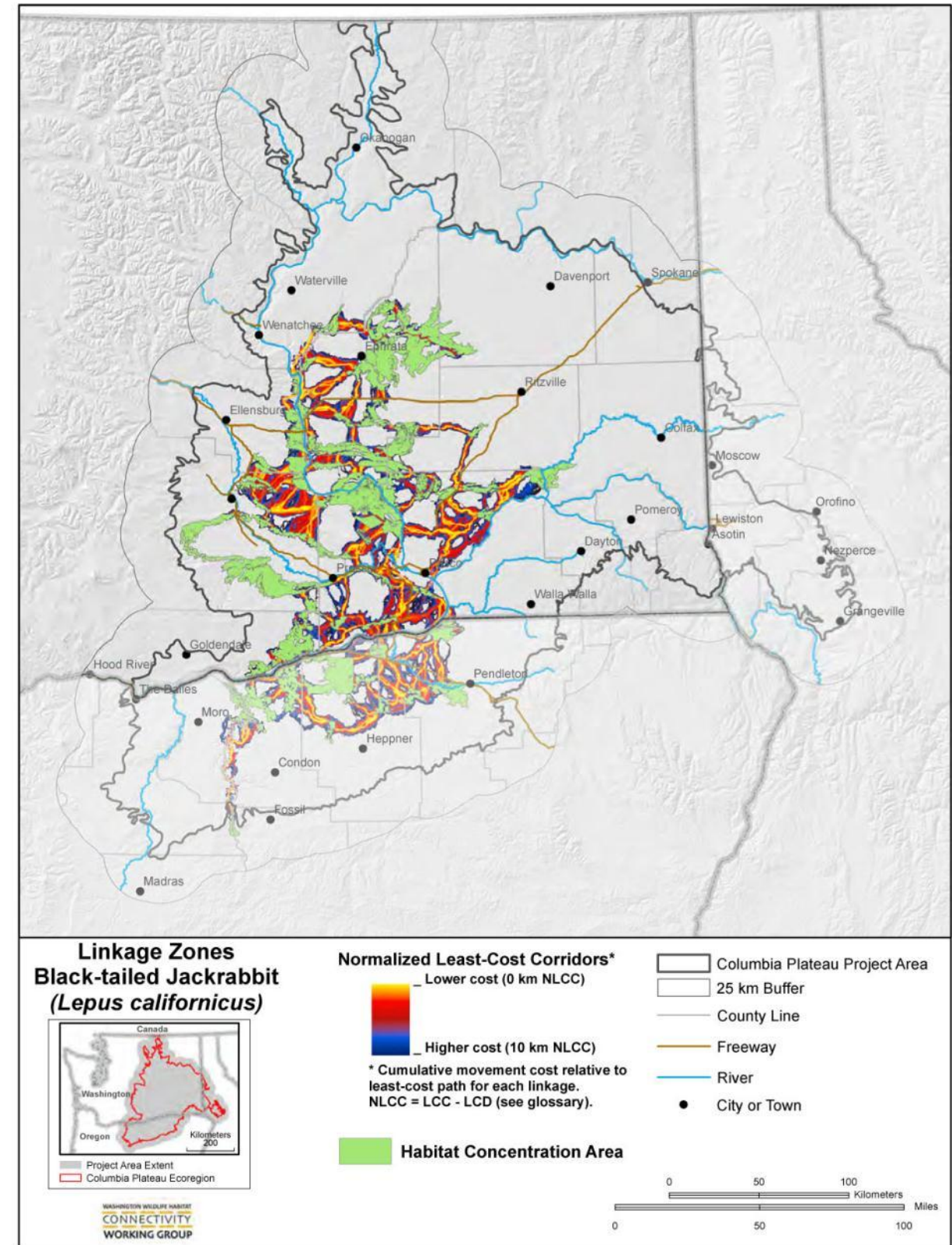


Figure 4.1. Linkage network modeled for black-tailed jackrabbit in the Columbia Plateau Ecoregion (Appendix A.3, WHCWG 2012). Green polygons represent habitat concentration areas (HCAs) for black-tailed jackrabbit. Linkages between HCAs are shown in bright colors; the least-cost pathways are highlighted yellow.

¹ Addendum to Appendix A.3, WHCWG 2012 prepared by Howard Ferguson (WDFW) and Michael Atamian (WDFW)

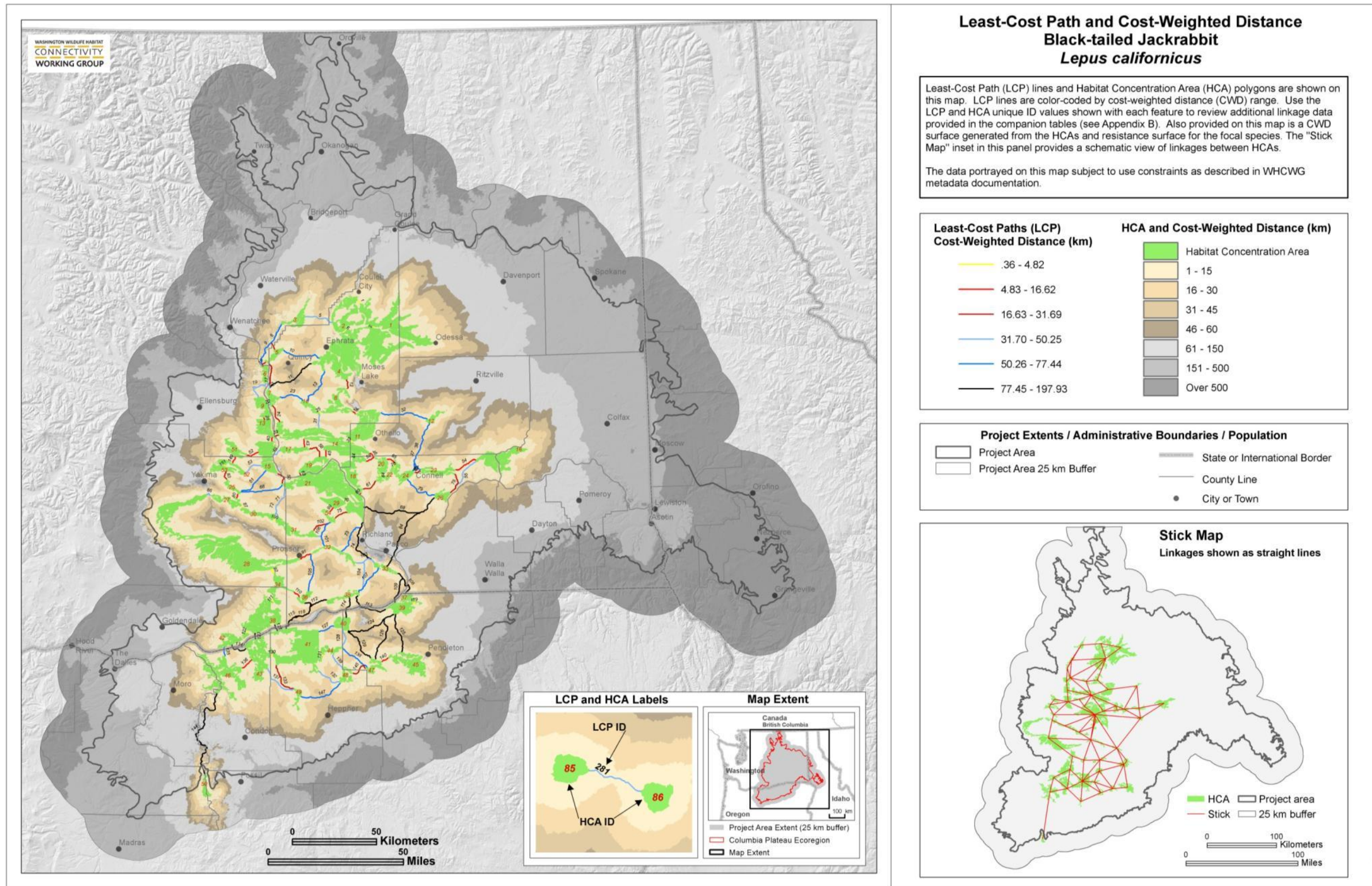
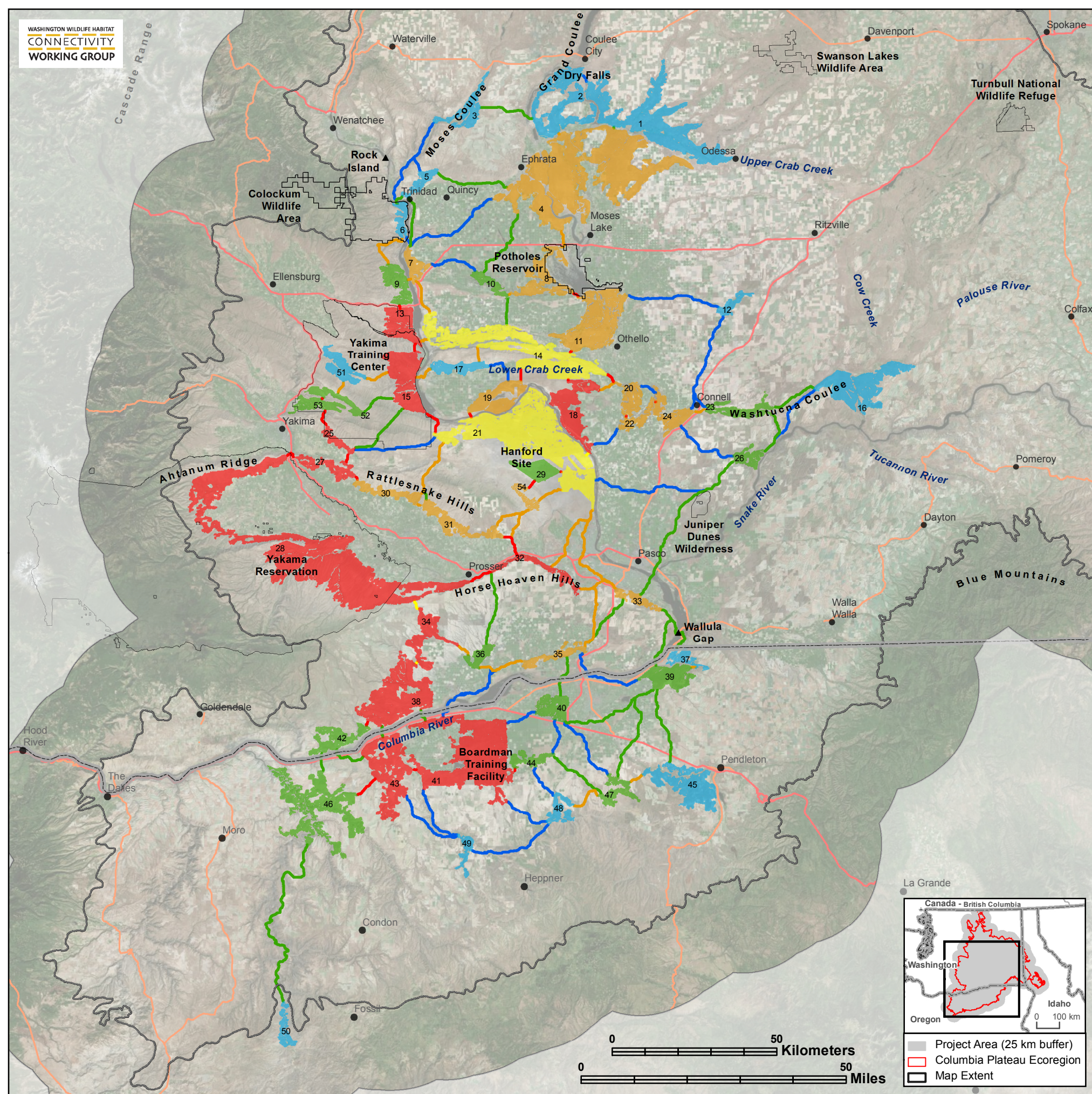


Figure 4.2. The cost-weighted distance map with numbered habitat concentration areas (HCAs) and least-cost paths for black-tailed jackrabbit in the Columbia Plateau Ecoregion (Appendix A.3, WHCWG 2012).

Figure 4.3. Linkage Network Centrality for Black-tailed Jackrabbit (*Lepus californicus*).



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*	Least-Cost Path (LCP) Centrality
Highest	Highest
Very High	Very High
High	High
Medium	Medium
Low	Low
Not Connected	

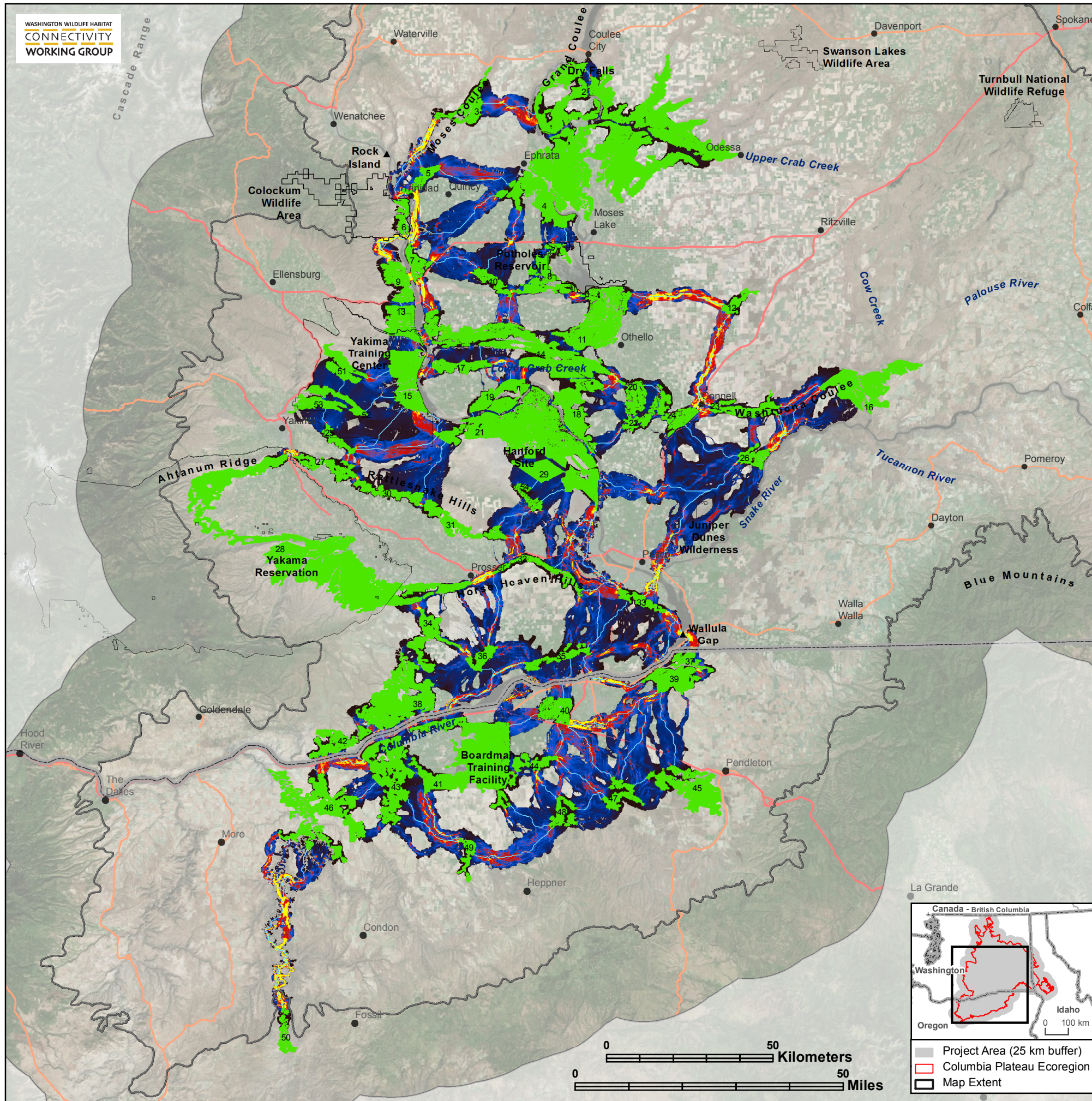
*Habitat Concentration Area (HCA) polygon labels on the map indicate HCA ID number.

Boundaries and Population Centers

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

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

Figure 4.4. Linkage Pinch-Points for Black-tailed Jackrabbit (*Lepus californicus*).



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

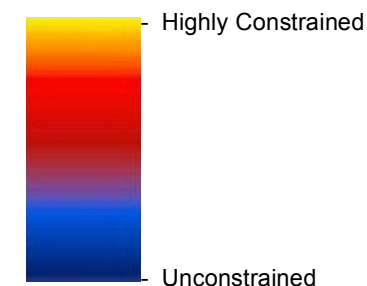
- Where along linkages is potential movement highly or moderately constrained?
- Are there areas where alternative movement routes may not be available?

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



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

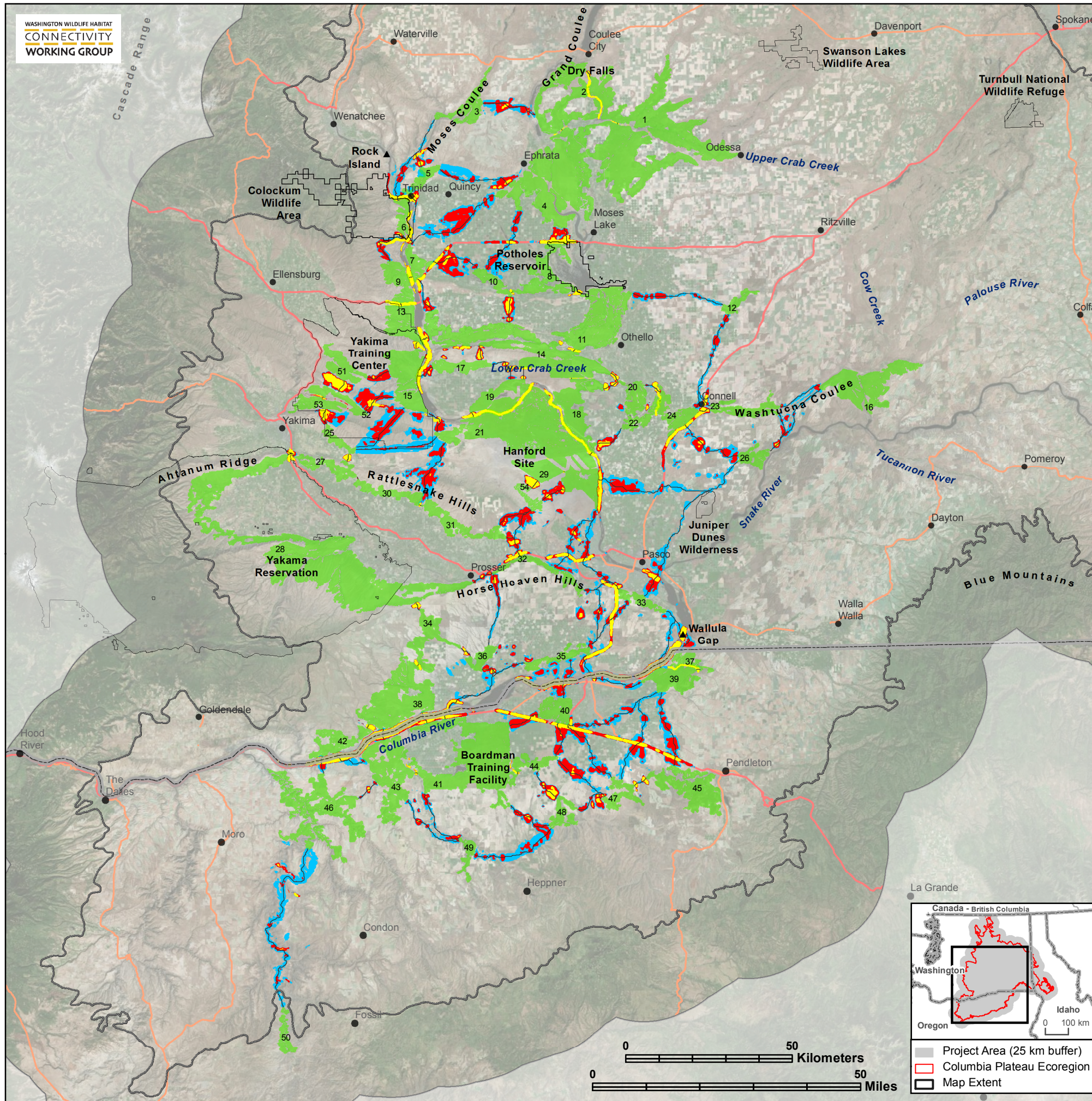
*Habitat Concentration Area (HCA) polygon labels on the map indicate HCA ID number.

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 4.5. Barriers and Restoration Opportunities for Black-tailed Jackrabbit (*Lepus californicus*).



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

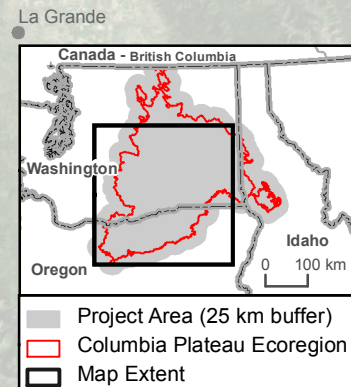
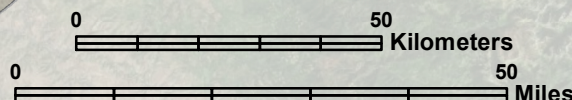
- Habitat Concentration Area (HCA)*
- Least-Cost Path (LCP)

*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
- Project Area (25 km buffer)
- Columbia Plateau Ecoregion
- Map Extent
- 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 area ranked Highest for centrality in the black-tailed jackrabbit linkage network occurs in the southern part of Grant County and northern Benton County (Fig. 4.6).
- Low centrality areas are also important for conserving connectivity and potentially genetic diversity of black-tailed jackrabbit (Fig. 4.6).
- Although HCA 4 is designated only as an area with High centrality, it is a very important (large in size with a verified population) HCA in the “northern” distribution of black-tailed jackrabbit (Fig. 4.6).
- A large percentage of highest centrality areas are located on public lands highlighting the need to conserve and manage these lands for the black-tailed jackrabbit (Fig. 4.7).
- Loss of the Highest centrality link between HCA 28 (Yakama Reservation) and HCA 34 would adversely affect (isolate) multiple HCAs (Fig. 4.7).

Linkage Pinch-Points

- There are multiple highly constrained pinch-points linking the rest of the black-tailed jackrabbit HCAs to the HCAs ranked Highest for centrality (Fig. 4.8).
- The following areas could become isolated due to constrained links:
 - The north-south linkages, mainly in Grant County, are overall highly constrained (Fig. 4.9)
 - The Yakama Reservation (Fig. 4.10).
 - The most eastern HCAs in Franklin County (Fig. 4.11).

Barriers and Restoration Opportunities

- Because of the overall presence of highly constrained links there are plenty of opportunities to eliminate or lessen the effects of barriers (Fig. 4.5).
- Typical barriers for the black-tailed jackrabbit are extensive agricultural fields (Figs. 4.12, 4.16, 4.18).
- Some barriers, such as a borrow pit, may be quickly addressed by restoration efforts (Fig. 4.13).
- Other barriers, such as roads, rivers, railroads, and human development will pose a challenge to reduce resistance (Figs. 4.14, 4.15, 4.17).
- Corresponding to the pinch-point analysis, barriers have been identified at links for the Yakama Reservation (HCA 28; Figs. 4.15, 4.16) and also the most eastern HCAs in Franklin County (HCAs 16, 20, 23, 24, and 26; Figs. 4.17, 4.18).

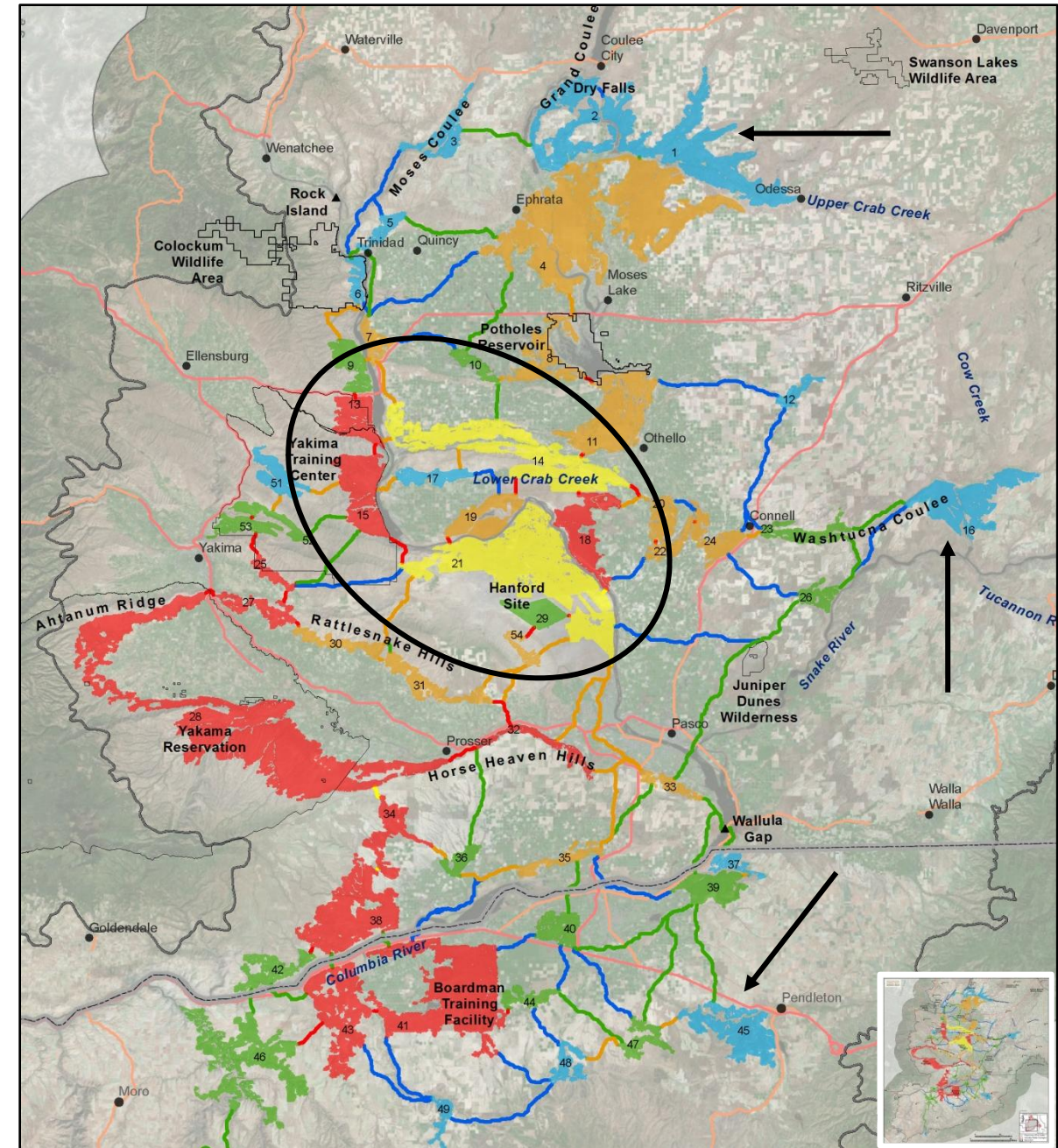


Figure 4.6. Black-tailed jackrabbit area of High–Highest network centrality (oval), and peripheral HCAs (arrows).

- The area of High–Highest centrality in the black-tailed jackrabbit linkage network occurs in the southern area of Grant County and northern area of Benton County (oval).
- Loss of HCAs 13, 14, 15, 21 and 28 could severely impact the integrity of the black-tailed jackrabbit linkage network potentially severing into north and south subpopulations, and creating several small islands.

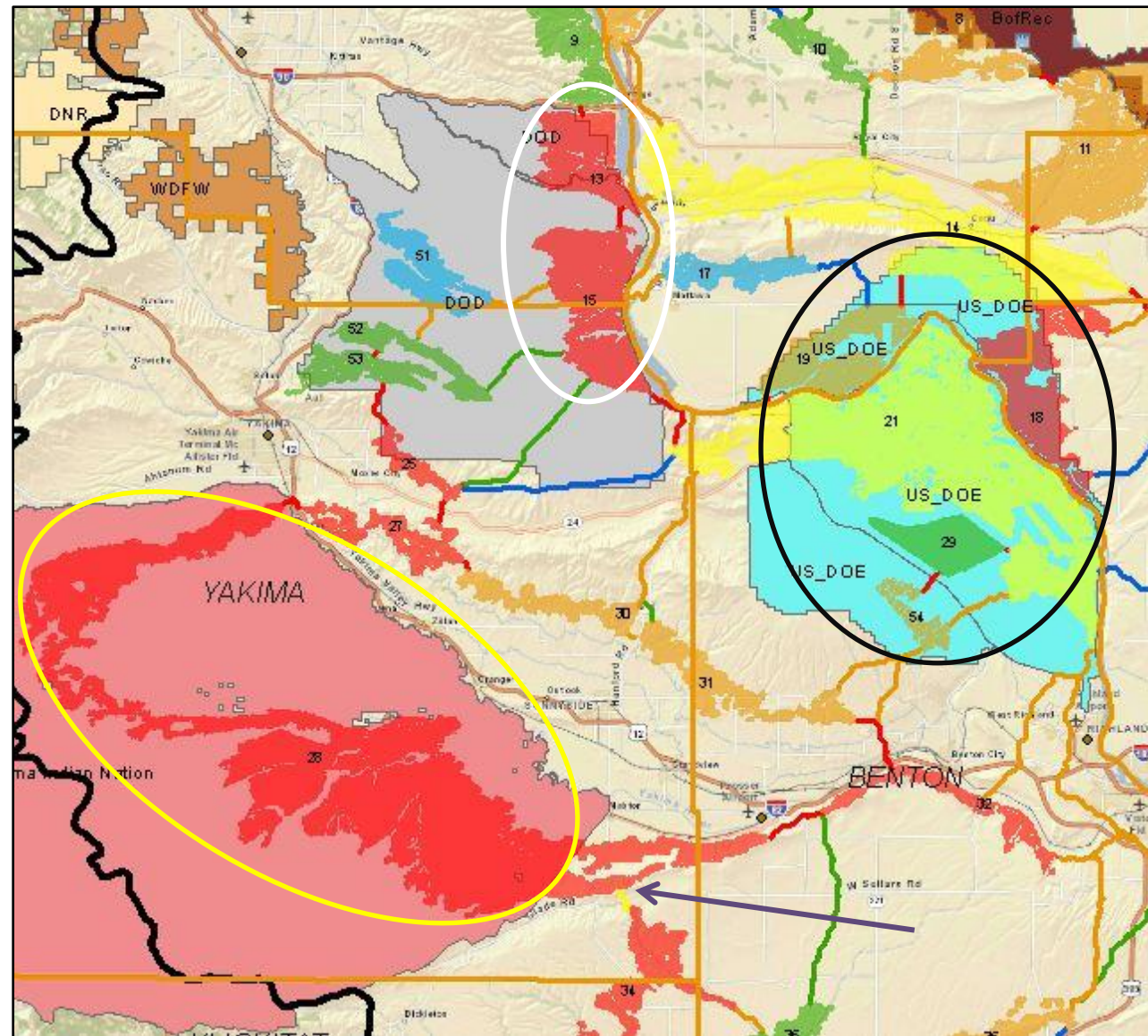


Figure 4.7. A large proportion of the areas showing greatest centrality are located on public or tribal lands.

- Areas of High to Highest centrality (parts of HCAs 14, 18, 19, 21, and all of HCA 54) in the black-tailed jackrabbit linkage network occur on DOE lands at Hanford (black oval).
- Areas of Very High centrality (HCAs 13 and 15) in the black-tailed jackrabbit linkage network occur in east Kittitas County on DOD land on the Yakima Training Center (YTC, white oval).
- Another area of Very High centrality (HCA 28) in the black-tailed jackrabbit linkage network occurs in Yakima County on the Yakama Reservation (yellow oval).
- Loss of a Highest centrality link between HCA 28 (Yakama Reservation) and HCA 34 would adversely affect (isolate) multiple HCAs (purple arrow).

All three of the above areas have known and reportedly, high densities of black-tailed jackrabbit populations (David Blodgett [Yakama Reservation], Kevin White [YTC], personal communication).

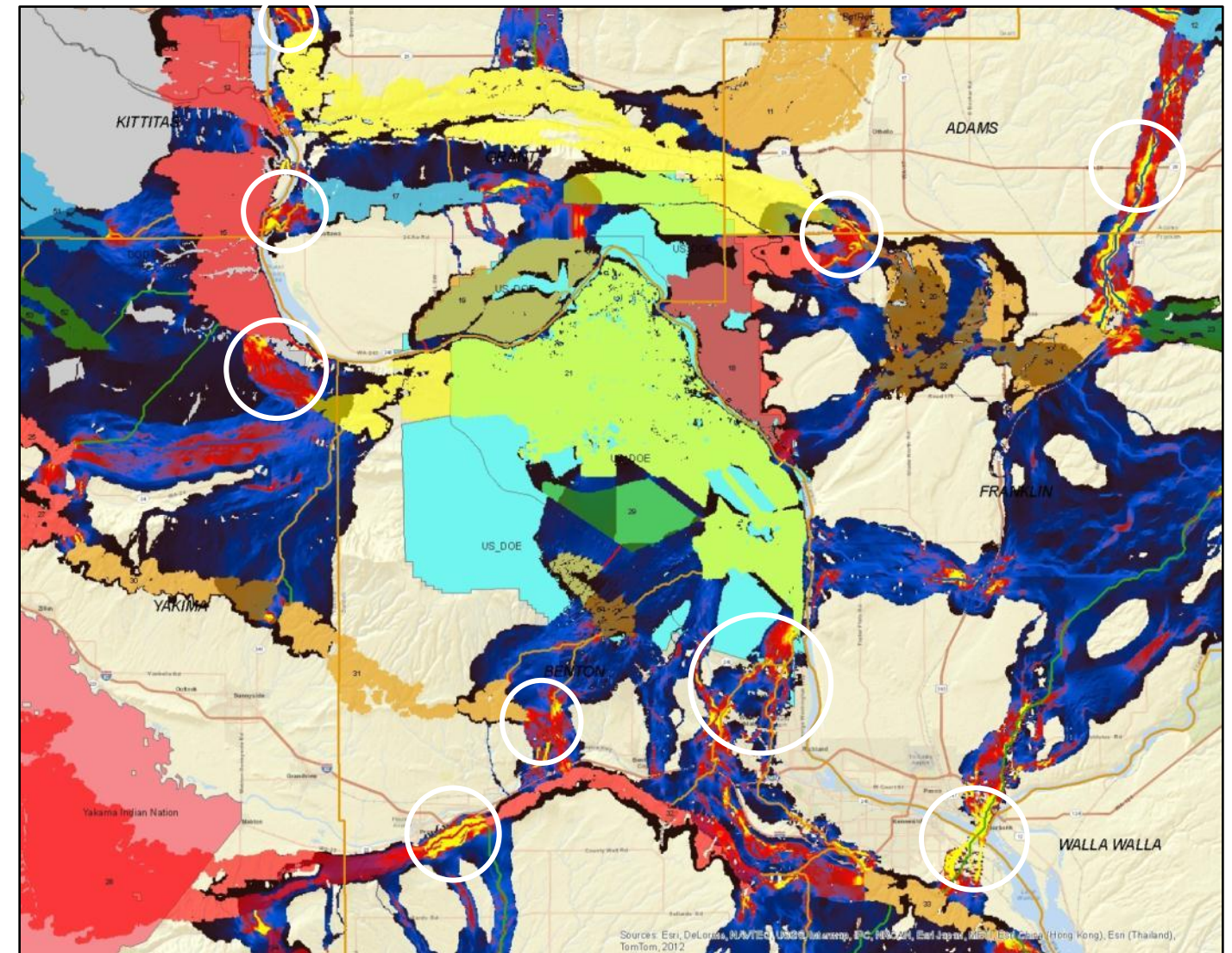


Figure 4.8. There are multiple highly constrained pinch-points (white circles) surrounding the Highest centrality HCAs (pale yellow) for the black-tailed jackrabbit.

- The areas with the Highest centrality, shown in pale yellow, are predominately connected to the rest of the network by highly constrained corridors or links (identified here by white circles).
- This is of concern and these links need to be investigated more closely to (1) determine their priority and the cause of the constraint, (2) determine alternatives to correct the constraint, and (3) implement the best approach to improve and preserve these corridors.

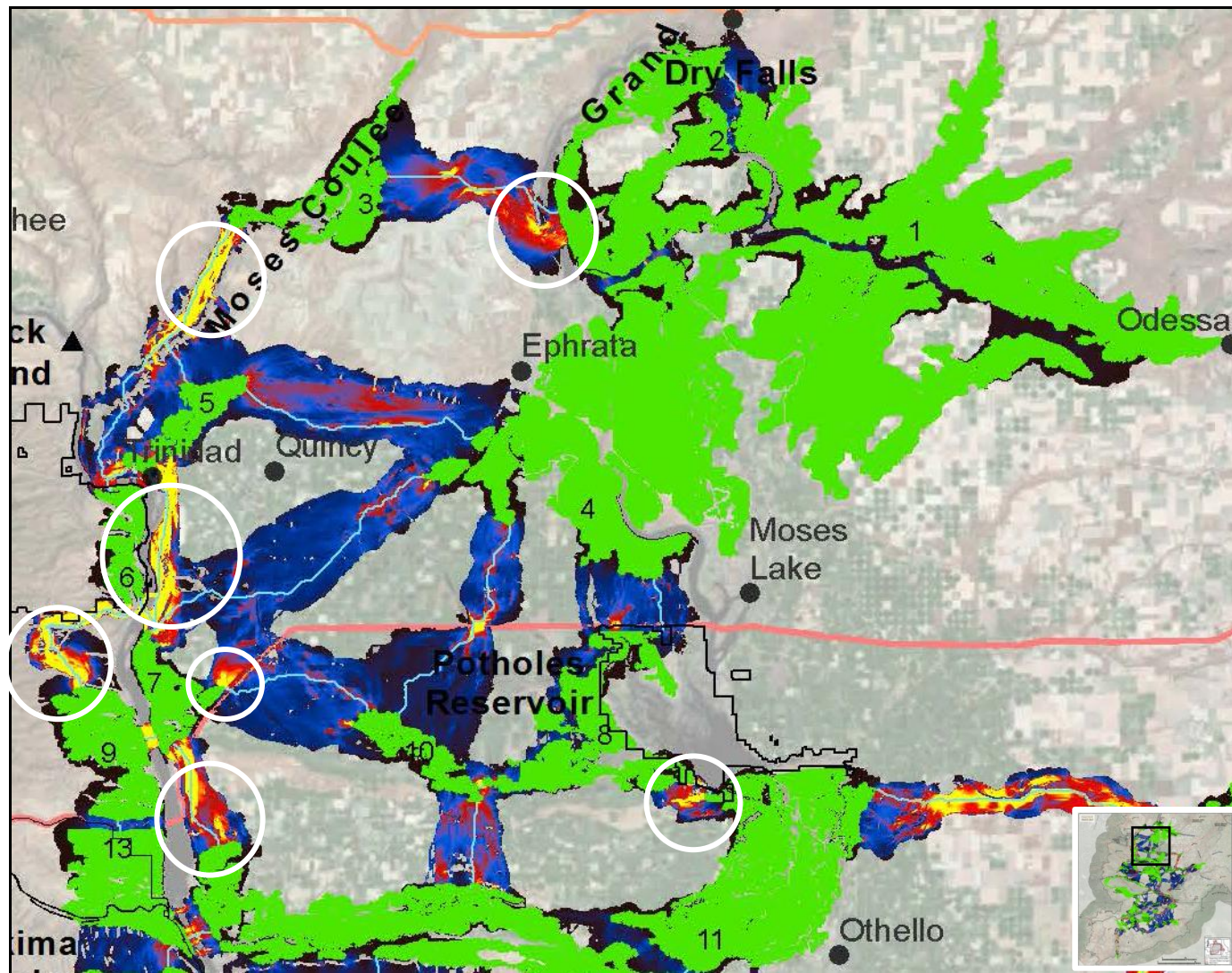


Figure 4.9. Northern section of the linkage network for black-tailed jackrabbits where connectivity is at risk due to narrow pinch-points (white circles).

- The northern third of the black-tailed jackrabbit HCAs within Washington are connected to the middle third by very constrained and narrow travel corridors.
- If any of these or especially if two or more links were severed this would result in the isolation of this northern group of HCAs 1–4.

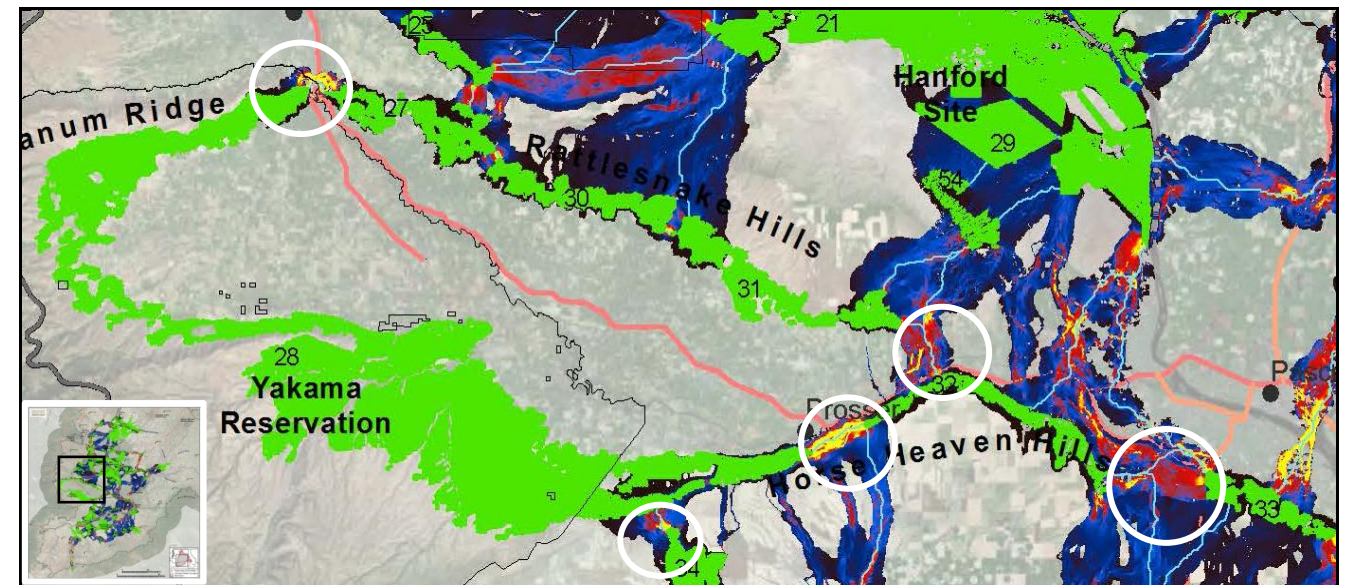


Figure 4.10. Southern section of the linkage network for black-tailed jackrabbits where connectivity is at risk due to pinch-points (white circles).

- This figure provides a closer look at the threat of the southern third of the black-tailed jackrabbit HCAs becoming isolated from the middle third of the population in Washington.
- There is a very high threat of the black-tailed jackrabbit HCA numbered 28 located on the Yakama Reservation becoming isolated.

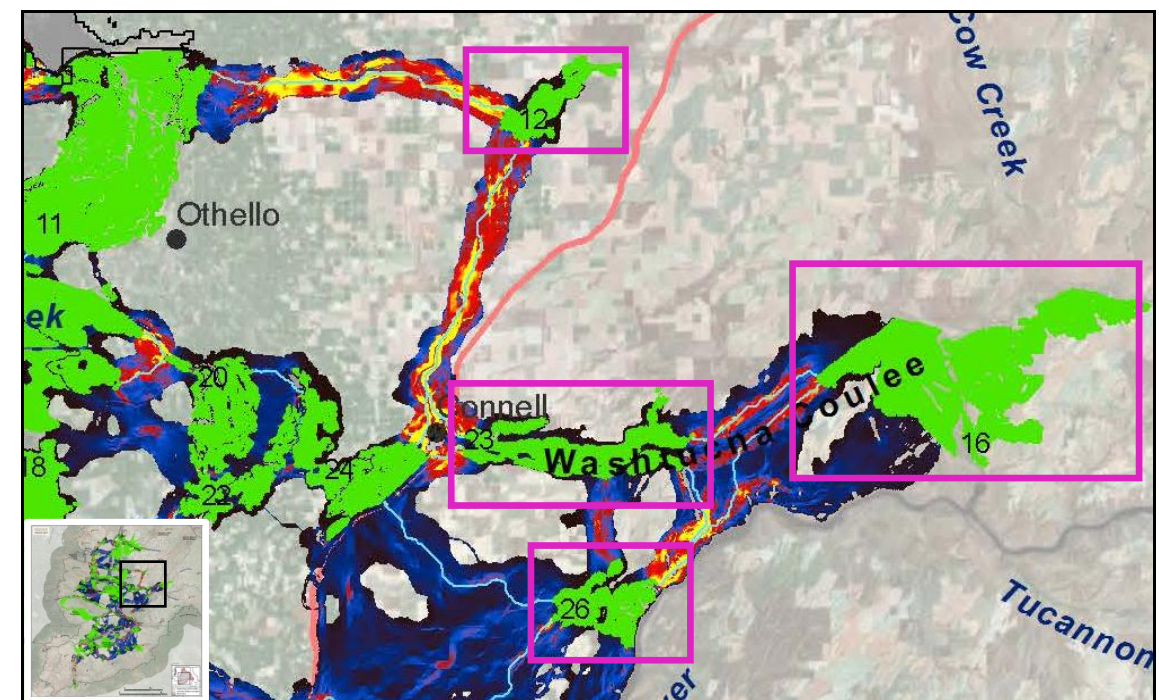


Figure 4.11. Several HCAs (e.g., 12, 16, 23 and 26; purple boxes) in the Othello and Connell areas are connected by linkages with highly constrained pinch-points. These HCAs are at risk of becoming small, isolated HCAs.

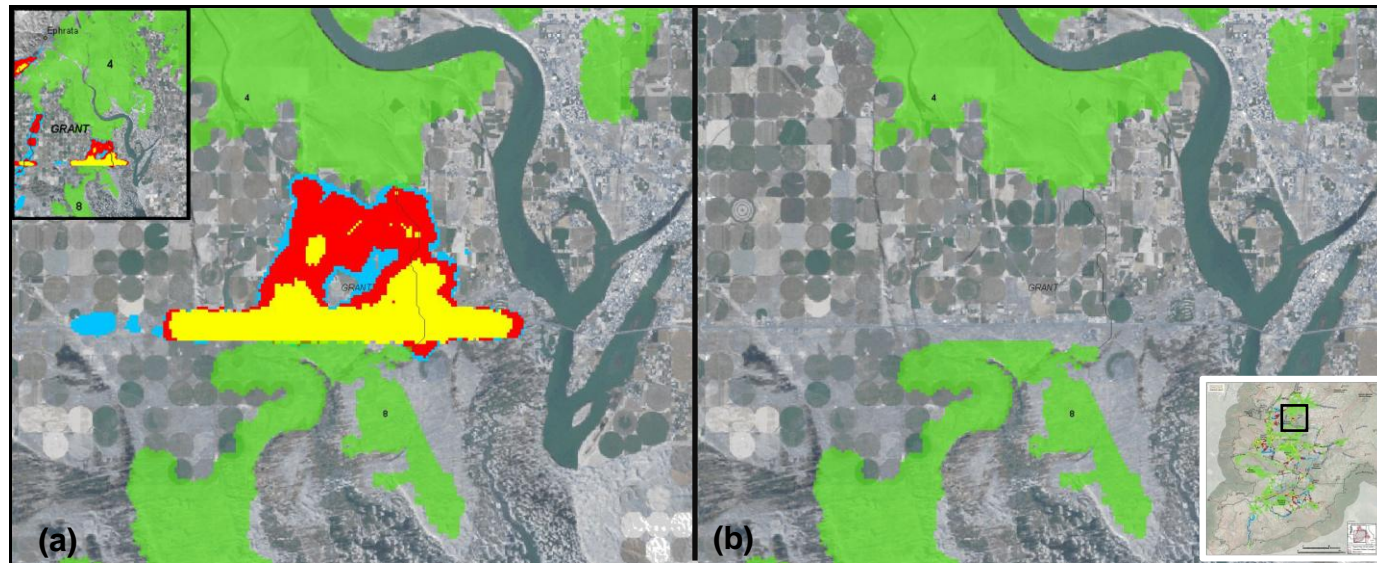


Figure 4.12. Typical barrier for black-tailed jackrabbit found in the Columbia Plateau.

- This barrier separates HCAs 4 and 8 in Grant County.
- Panel “a” shows the barrier (yellow) and panel “b” indicates this barrier is created by irrigated agricultural fields.

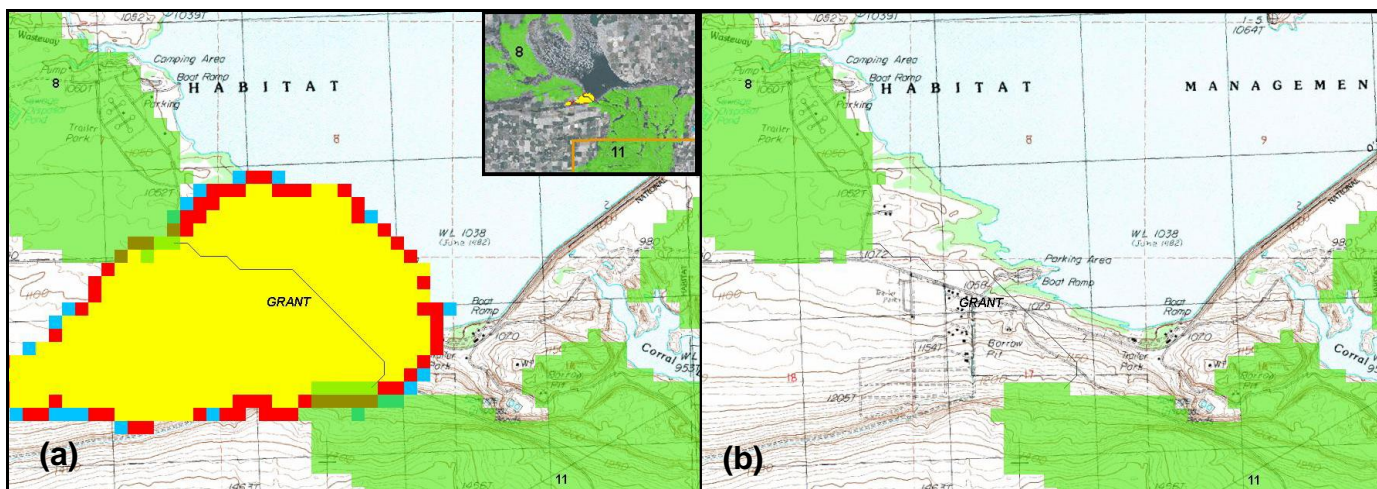


Figure 4.13. Black-tailed jackrabbit barrier identified in Grant County near Potholes Reserve may provide a restoration opportunity.

- The barrier near Potholes Reserve (USFWS) in Grant County may be a good candidate for restoration (panel “a”).
- Primary barriers appear to be small 2-track roads, a borrow pit and a nearby trailer park (panel “b”).
- With restoration of the borrow pit, replanting with native vegetation, and future planning limiting the expansion of the trailer park, this barrier could be removed.

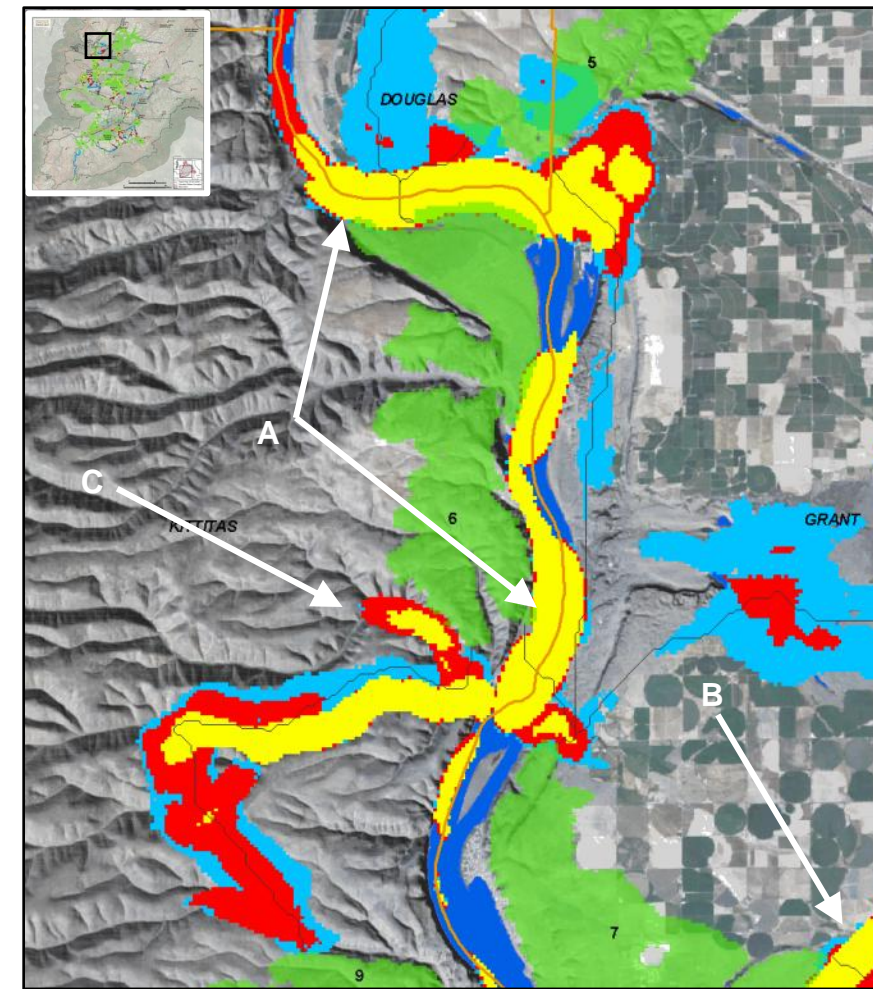


Figure 4.14. Barriers identified for black-tailed jackrabbit that may be challenging to restore.

- Arrows indicate barriers that if removed would greatly improve connectivity.
- However, the barrier identified by arrows labeled “A” is the Columbia River and the barrier identified by arrow labeled “B” is primarily I-90.
- A natural barrier, like the river, is not likely to be altered and wildlife crossing structures typically constructed for roads are expensive.
- However, these types of barriers are important to consider for connectivity as they may be places to avoid incurring additional resistance to movement or may indicate the need to look at an alternate route such as identified by arrow labeled “C”.

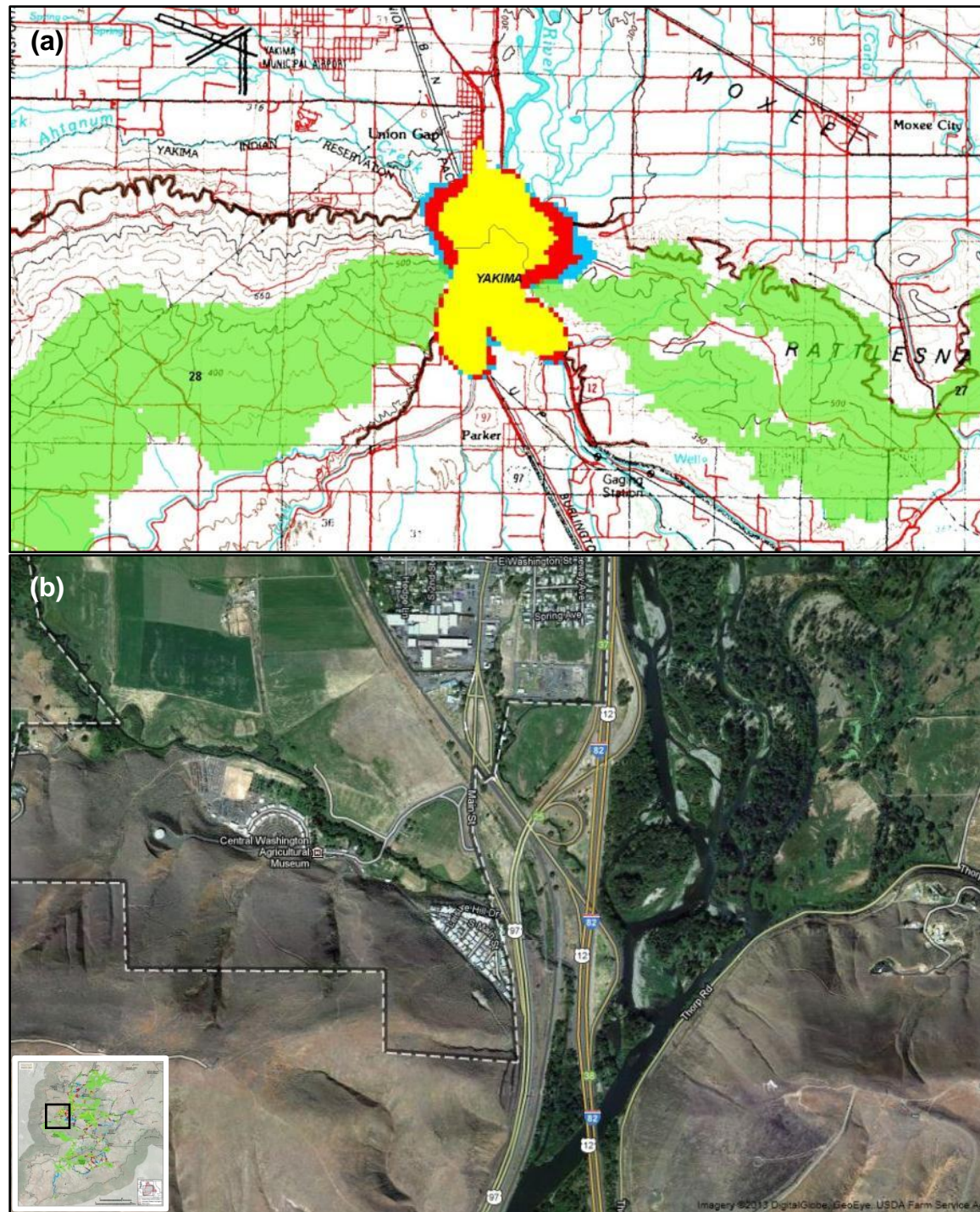


Figure 4.15. Black-tailed jackrabbit barrier complex identified on NW corner of Yakama Reservation near Union Gap, Yakima County.

- The barrier identified on the NW corner of the Yakama Reservation near Union Gap (panels “a” and “b”) will be a challenge to restore. It consists of a complex of natural and human-created barriers including several creeks merging with the Yakima River, railroad tracks, Highways 12, 82, 97 and 84, and increasing development. This barrier complex will likely entail difficult solutions, but it is the only northern link identified and is of key importance.

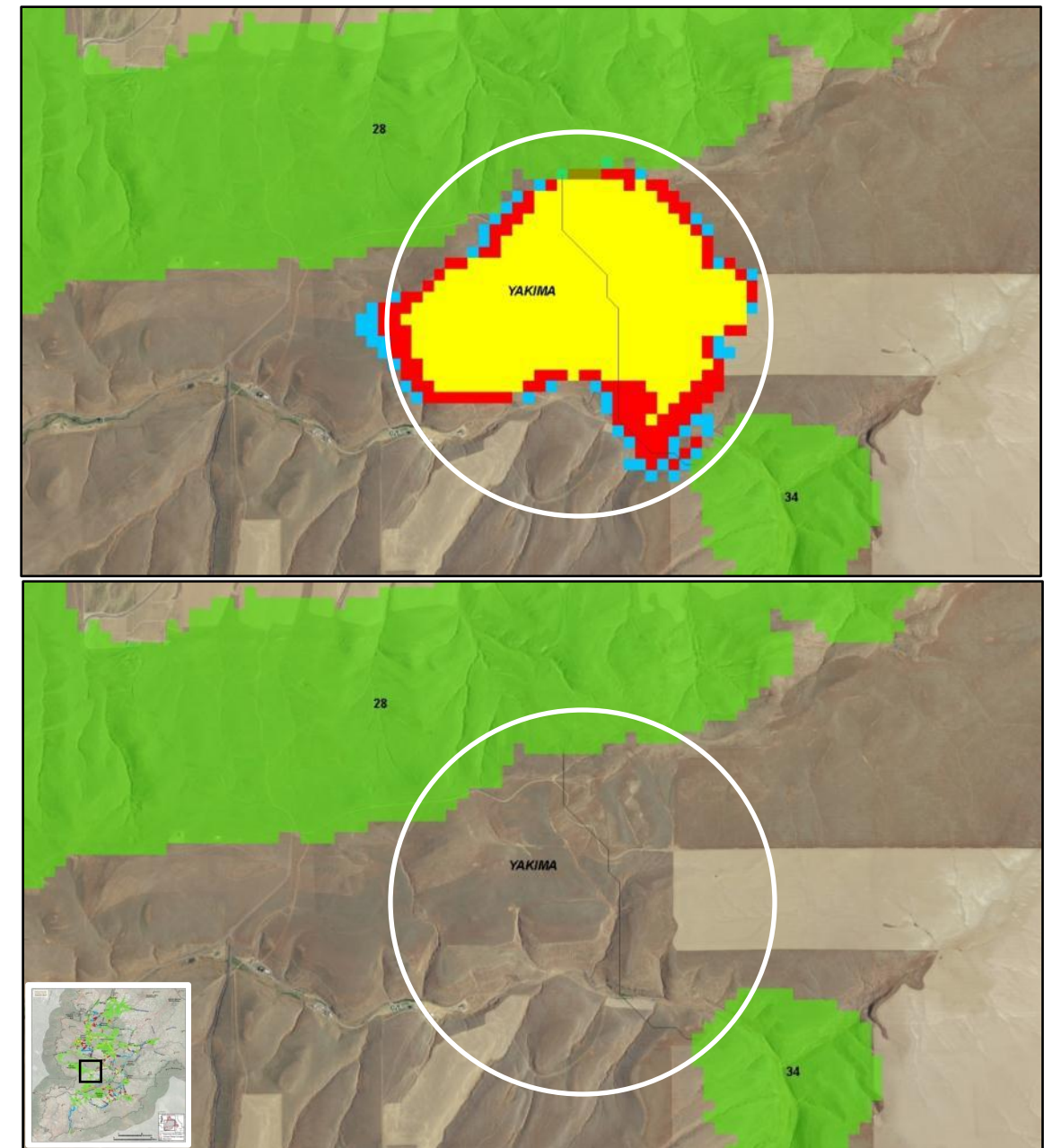


Figure 4.16. Black-tailed jackrabbit barrier (white circles) identified on the SE corner of Yakama Reservation near Glade Creek in Yakima County.

- This barrier may be easier to enhance for black-tailed jackrabbits since it appears to be primarily agricultural land.

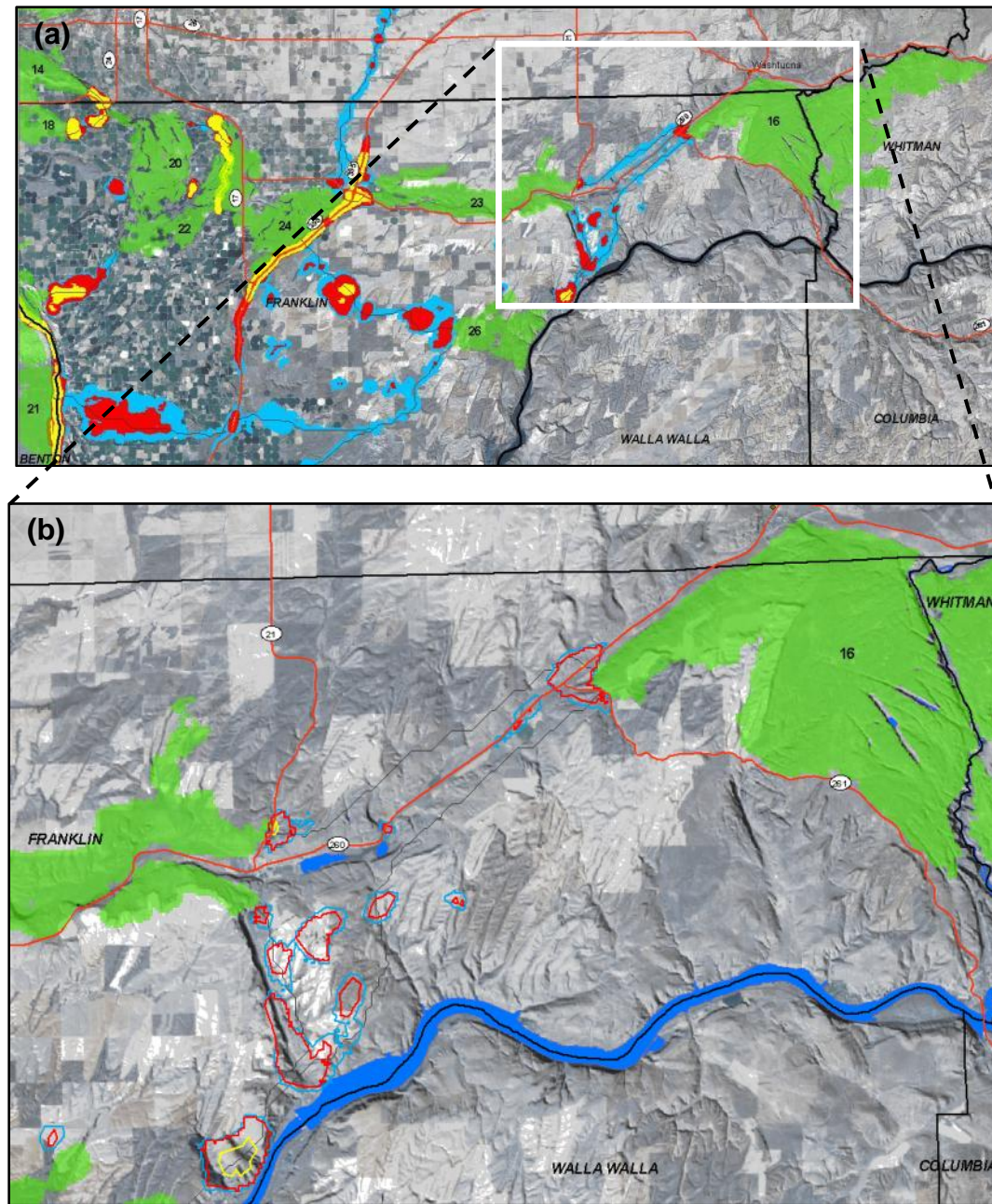


Figure 4.17. Linkage barriers (outlined) between HCAs that are susceptible to becoming isolated from other HCAs in eastern Franklin County.

- The black-tailed jackrabbit connectivity network could potentially benefit from restoration action in this area.
- Many barriers found between the most eastern HCAs (23 and 16) appear to be due to canals, railroads, highways, and roads, and could be a challenge to mitigate for black-tailed jackrabbits.

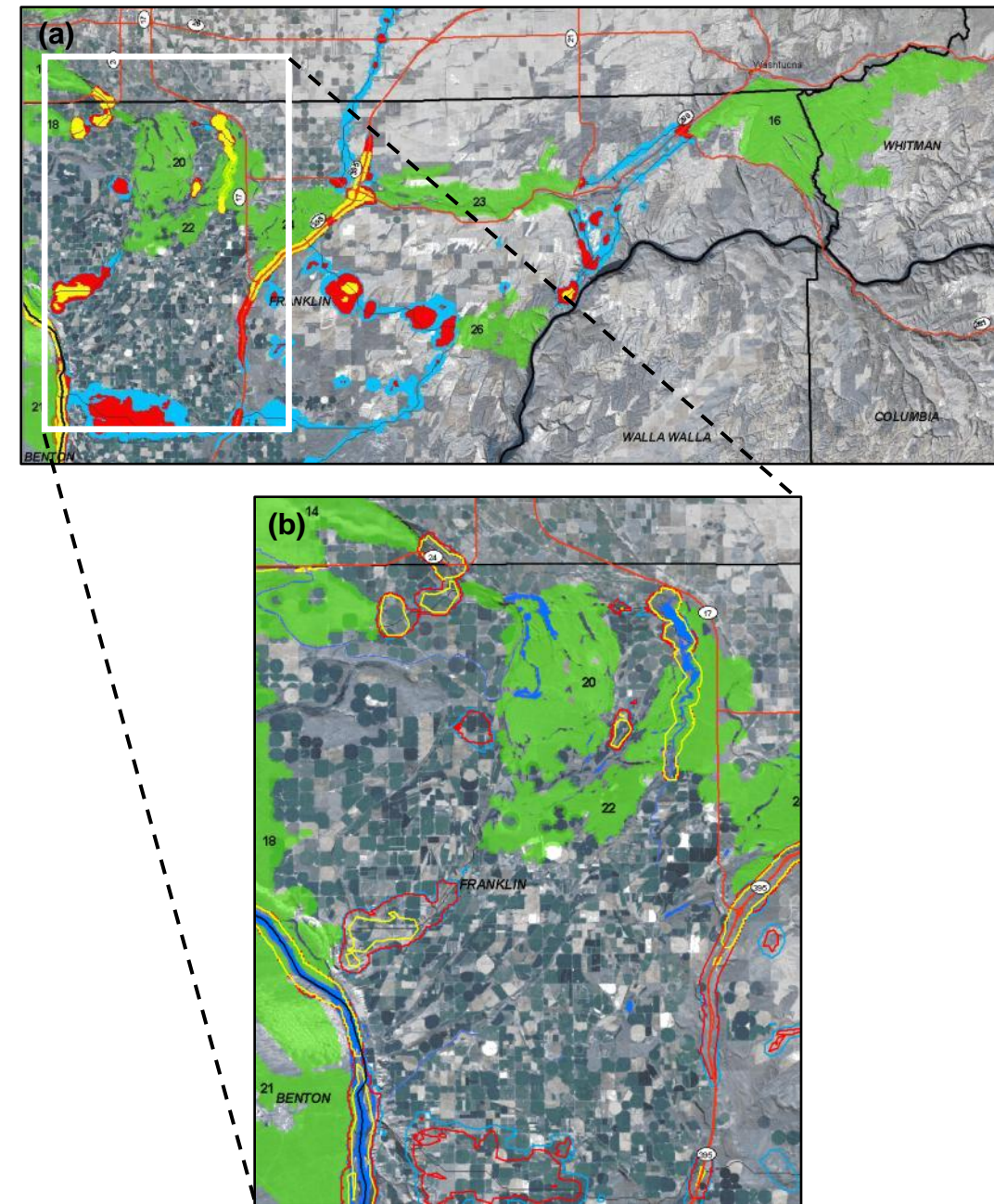


Figure 4.18. Barriers (outlined) in western Franklin County within linkages between HCAs that are susceptible to becoming isolated and could therefore benefit from possible restoration actions.

- Compared to the barriers found in eastern Franklin County (See Fig. 4.17), the barriers in Figure 4.18 are primarily agricultural fields and may be more easily restored.

Acknowledgements

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