Chapter 11. Network Centrality, Pinch-Points, and Barriers and Restoration Opportunities for Beaver (*Castor canadensis*)

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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 beaver (*Castor canadensis*) that can be used to help prioritize and implement conservation actions. We have also included the linkage network (Fig. 11.1) and cost-weighted distance surface (Fig. 11.2) previously modeled for beaver (See Appendix A.10, WHCWG 2012, available from http://waconnected.org).

Beaver, photo by Ginger Holser

Addendum Connectivity Maps

The supplemental connectivity products developed for beaver include maps of (1) linkage network centrality (Fig. 11.3), (2) linkage pinch-points (Fig. 11.4), and (3) barriers and restoration opportunities (Fig. 11.5). 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. 11.6 – 11.10).

Conservation of Connectivity for Beaver

- The main stem of the Columbia River is an important feature for connectivity of beaver in the Columbia Plateau. As well, the HCA east of Grand Coulee and the HCA in the vicinity of Pasco are identified as important for keeping the linkage network for beaver intact.
- Linkage pinch-points for beaver tend to reflect habitat adjacent to water features and many identified barriers are natural features of the landscape such as steep terrain and rocky areas.
- On-the-ground evaluation of identified barriers/restoration opportunities is especially important for beaver.
- Hydroelectric dams may be an important consideration for future evaluation of connectivity for beaver in the Columbia Plateau.

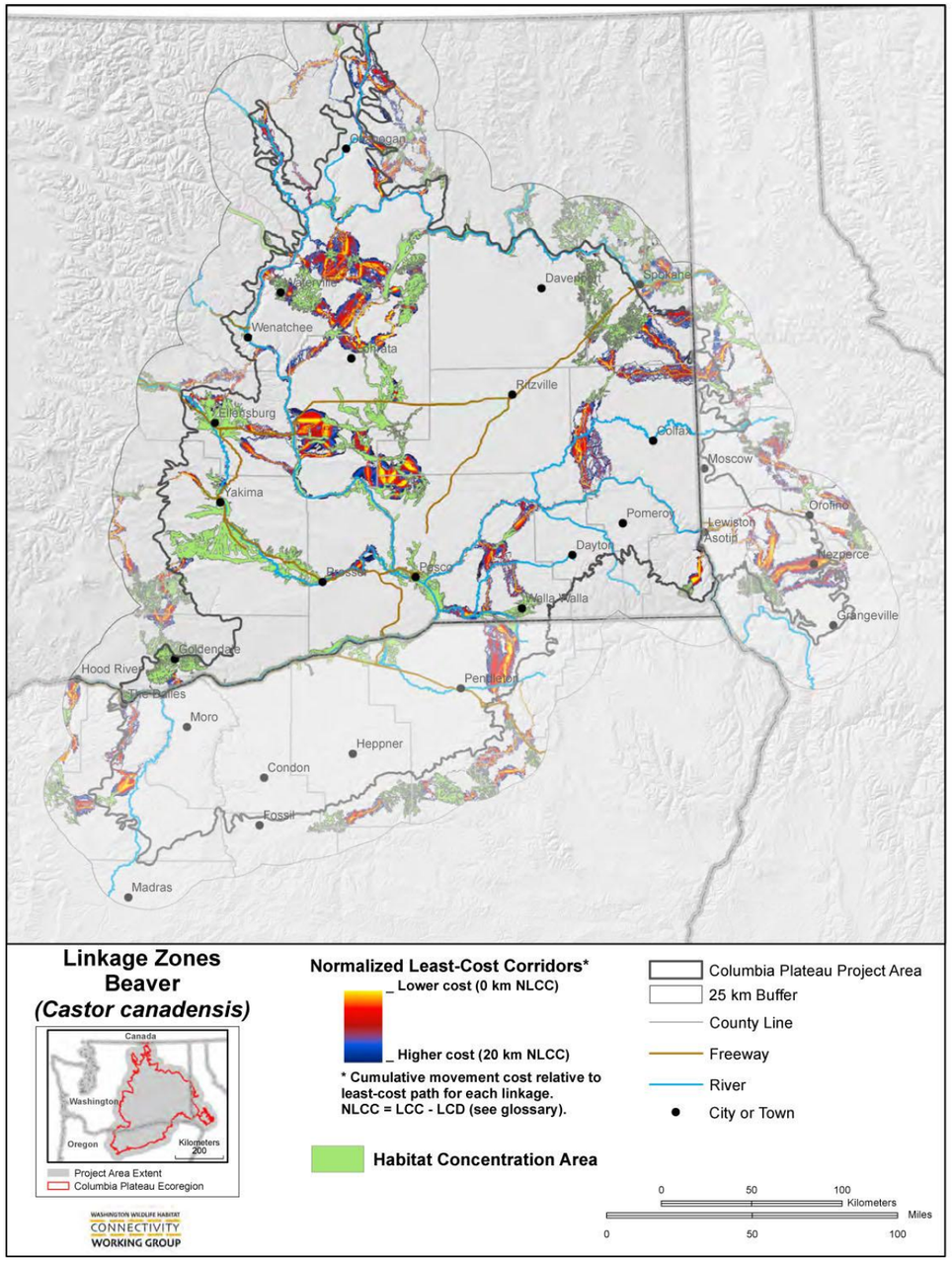
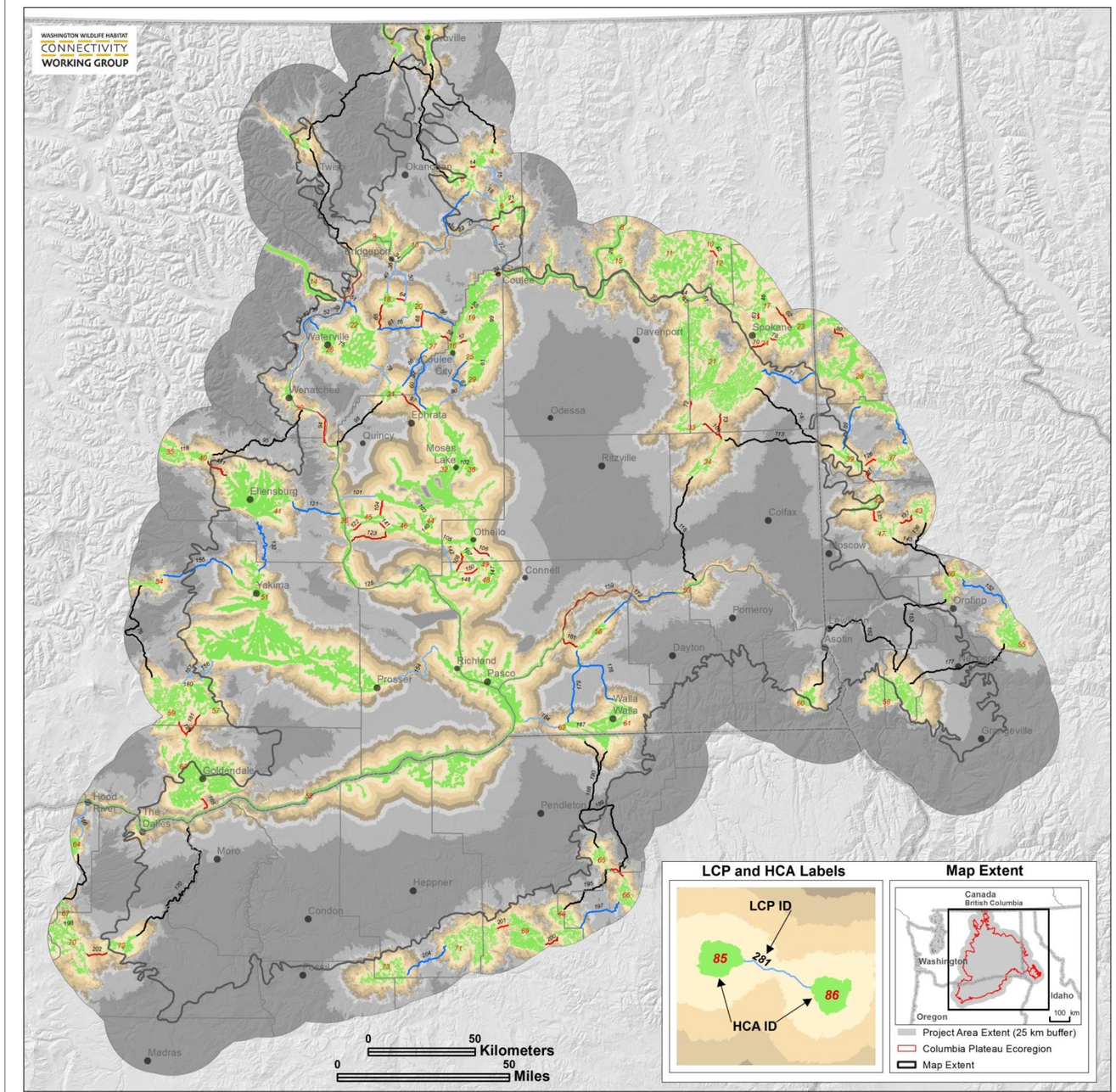


Figure 11.1. Linkage network modeled for beaver in the Columbia Plateau Ecoregion (Appendix A.10, WHCWG 2012). Green polygons represent habitat concentration areas (HCAs) for beaver. Linkages between HCAs are shown in bright colors; the least-cost pathways are highlighted yellow.



Least-Cost Path and Cost-Weighted Distance
Beaver
Castor canadensis

Least-Cost Path (LCP) lines and Habitat Concentration Area (HCA) polygons are shown on this map. LCP lines are color-coded by cost-weighted distance (CWD) range. Use the LCP and HCA unique ID values shown with each feature to review additional linkage data provided in the companion tables (see Appendix B). Also provided on this map is a CWD surface generated from the HCAs and resistance surface for the focal species. The "Stick Map" inset in this panel provides a schematic view of linkages between HCAs.

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

Least-Cost Paths (LCP) Cost-Weighted Distance (km)

- 1.55 - 12.77
- 12.78 - 49.93
- 49.94 - 83.78
- 83.79 - 138.98
- 138.99 - 240.03
- 240.04 - 560.52

HCA and Cost-Weighted Distance (km)

- Habitat Concentration Area
- 1 - 15
- 16 - 30
- 31 - 45
- 46 - 60
- 61 - 75
- 76 - 150
- Over 150

Project Extents / Administrative Boundaries / Population

- Project Area
- Project Area 25 km Buffer
- State or International Border
- County Line
- City or Town

Stick Map
Linkages shown as straight lines

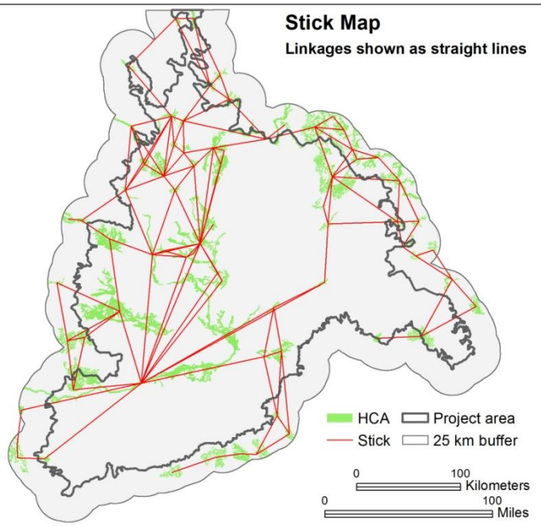


Figure 11.2. The cost-weighted distance map with numbered habitat concentration areas (HCAs) and least-cost paths for beaver in the Columbia Plateau Ecoregion (Appendix A.10, WHCWG 2012).

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Figure 11.3. Linkage Network Centrality for Beaver (*Castor canadensis*).

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

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

0 50 Kilometers
0 50 Miles

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

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Figure 11.4. Linkage Pinch-Points for Beaver (*Castor canadensis*).

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

Project Area (25 km buffer)

Columbia Plateau Ecoregion

Map Extent

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

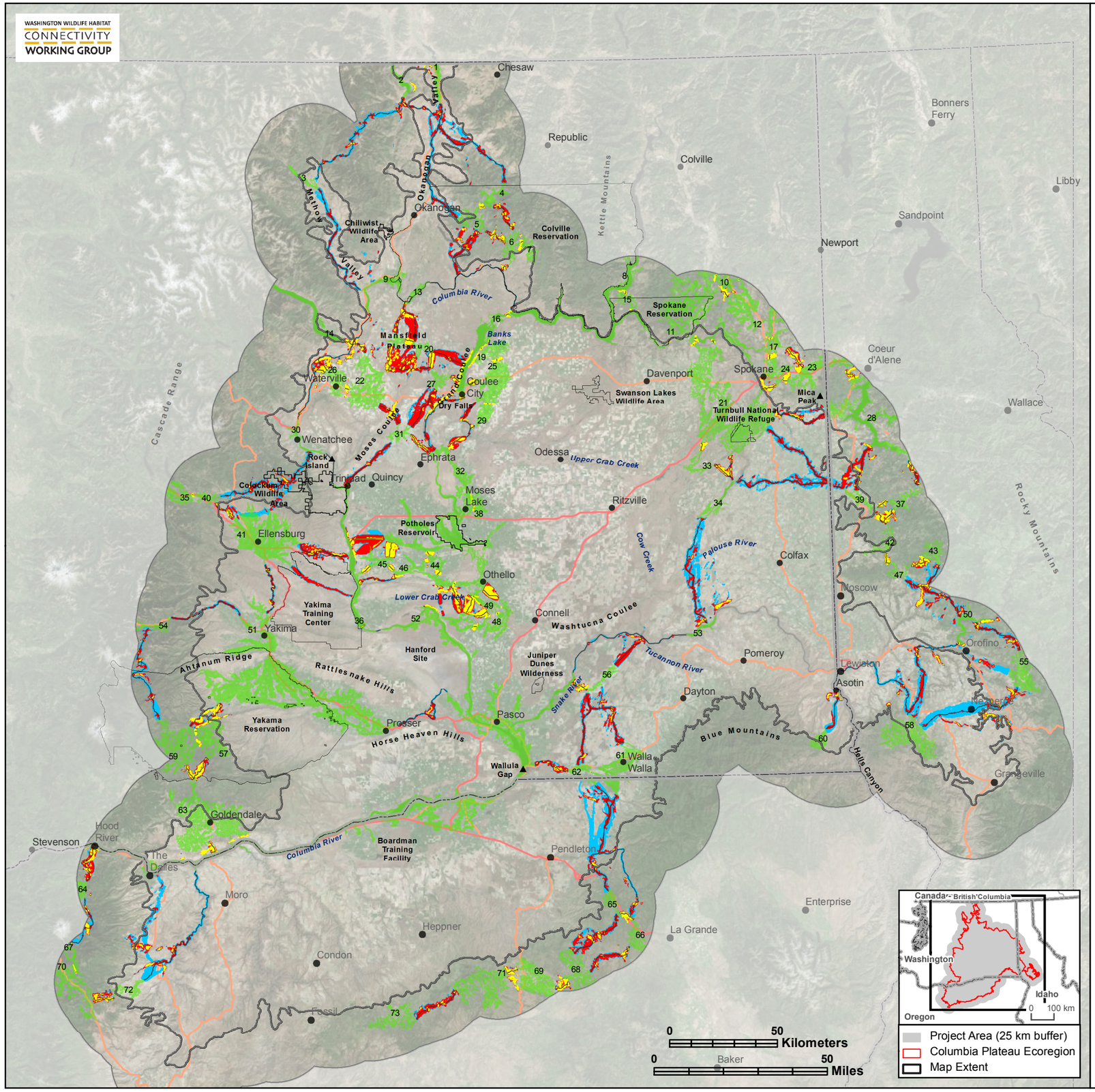

Figure 11.5. Barriers and Restoration Opportunities for Beaver (*Castor canadensis*).

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 main stem of the Columbia River is an important feature for connectivity of beaver in the Columbia Plateau (Fig. 11.6).
- The HCA east of Grand Coulee and the HCA in the vicinity of Pasco are identified as important for keeping the linkage network for beaver intact (Fig. 11.6).

Linkage Pinch-Points

- Linkage pinch-points for beaver tend to reflect habitat adjacent to water features (Fig. 11.7).

Barriers and Restoration Opportunities

- Many identified barriers for movement of beaver in the Columbia Plateau are created by natural features of the landscape such as steep terrain and rocky areas (Figs. 11.8, 11.9).
- Hydroelectric dams may be an important consideration for future evaluation of connectivity for beaver in the Columbia Plateau (Fig. 11.8).
- On-the-ground evaluation of identified barrier/restoration opportunities is especially important for beaver (Fig. 11.10).

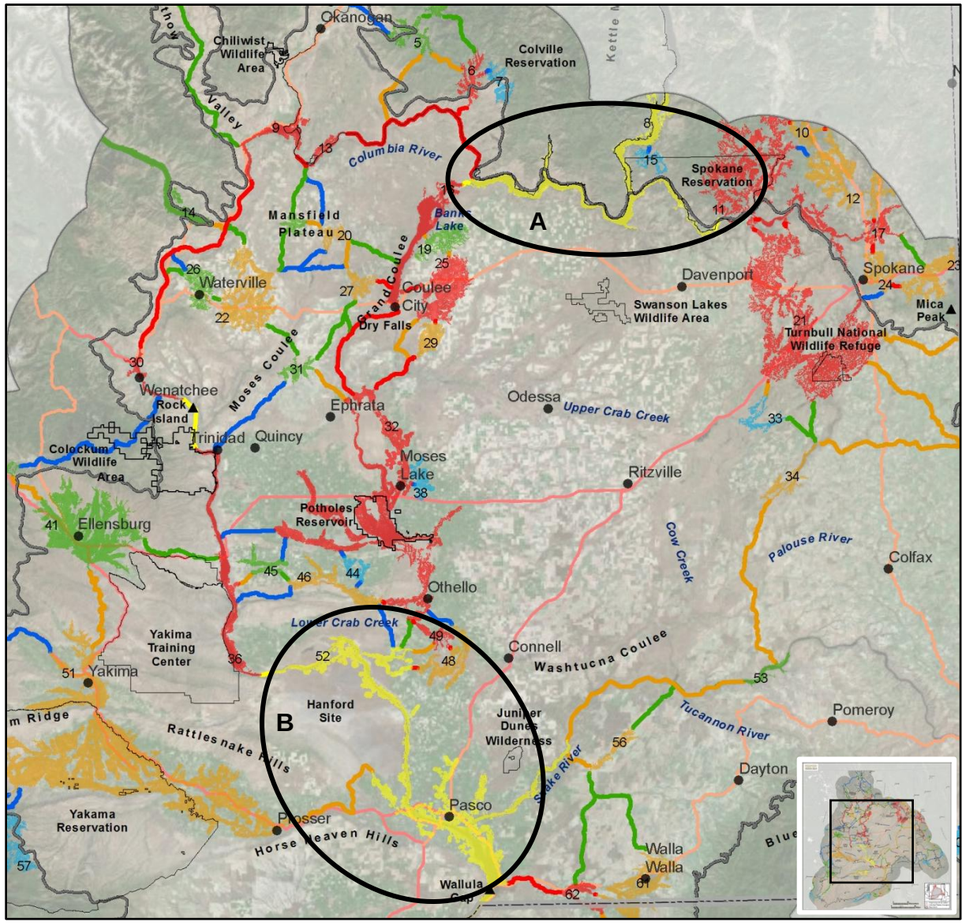

Figure 11.6. Close-up of the centrality map for beaver in the Columbia Plateau. Ovals indicate HCAs ranked Highest for centrality (yellow HCAs).

- The main stem Columbia River is an important feature for maintaining the linkage network for beaver. The HCAs and linkages along the river are ranked Very High (colored red) or Highest (colored yellow) for centrality.
- The HCA east of Grand Coulee (oval "A") is one of two HCAs ranked Highest for centrality. This HCA is important for maintaining connectivity between habitat west and south of Grand Coulee and areas to the east such as the Turnbull National Wildlife Refuge.
- HCA 52 in the vicinity of Pasco north to Lower Crab Creek (oval "B") also ranked Highest for centrality. This HCA is a key location for maintaining the linkage network. It provides connectivity to several areas for beaver including: (1) east along the Snake River, (2) north to Banks Lake, (3) north along the main stem of the Columbia River, and (4) west along the Yakima River.

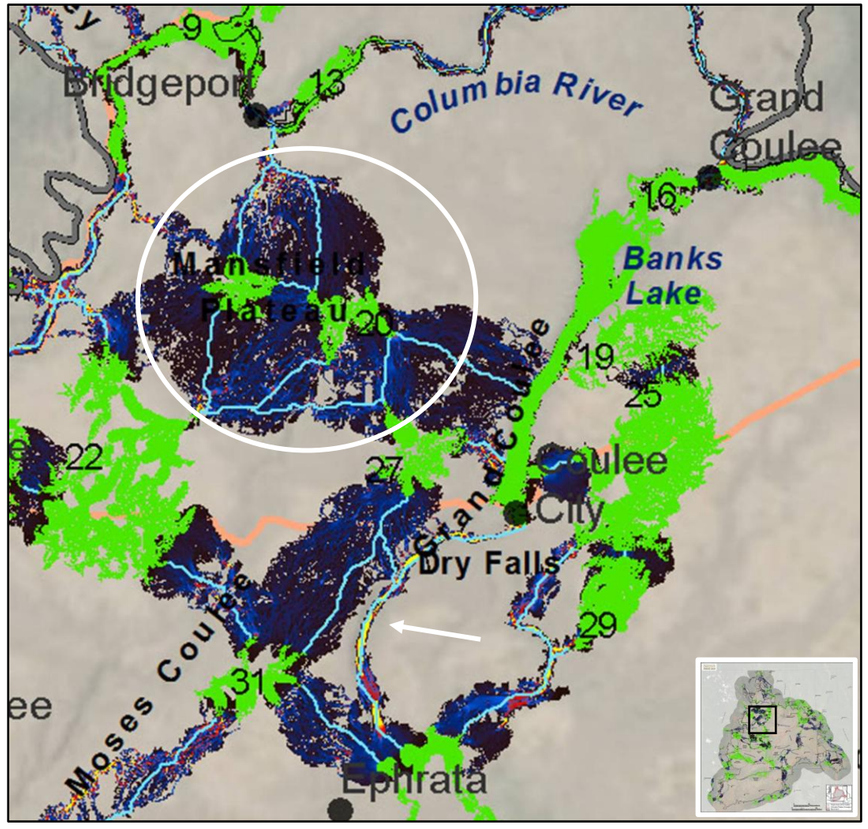

Figure 11.7. Examples of unconstrained and highly constrained linkages for beaver.

- Linkages for beaver in the area of the Mansfield Plateau (oval) tend to be relatively unconstrained as is shown by the broad extent of "blue."
- The linkage between HCA 16 (Banks Lake) and the HCA near Ephrata (arrow) is narrow and has pinch-points (areas highlighted yellow). The habitat on either side of this linkage is steep, rocky, and dry, and State Route 17 is along the east side.
- Pinch-points for beaver tend to reflect habitat adjacent to water features.

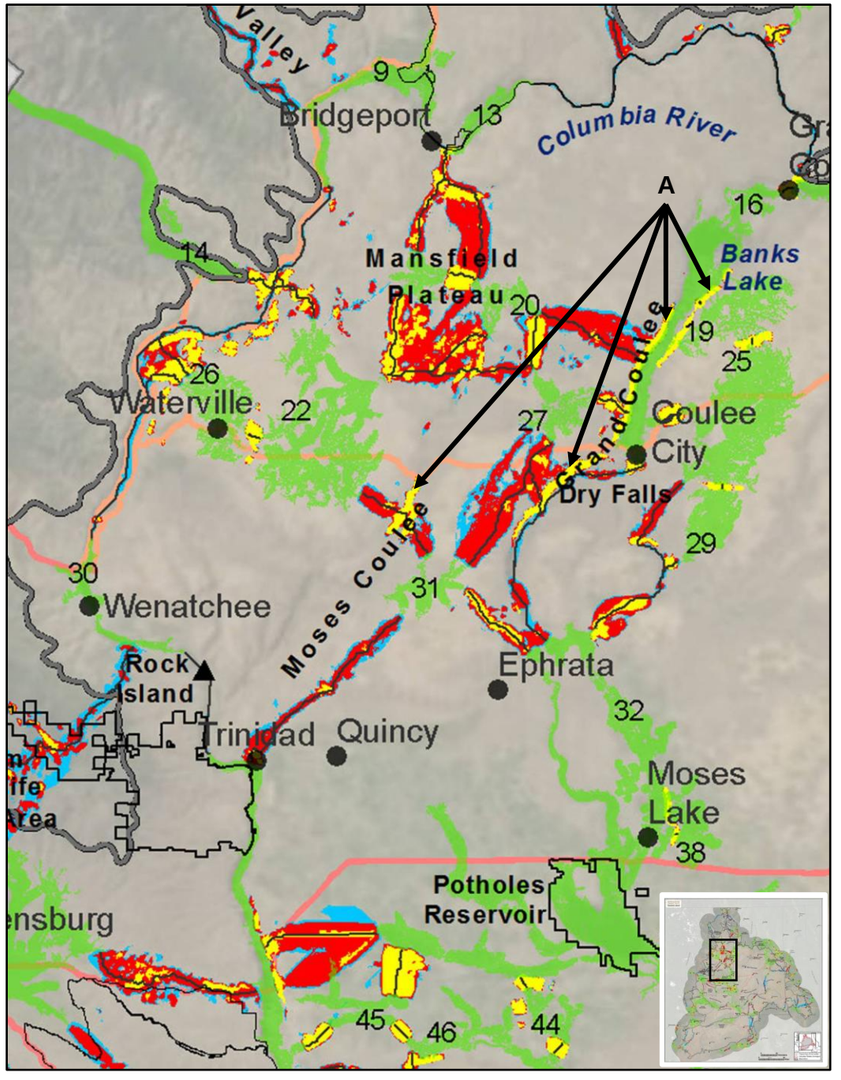

Figure 11.8. Close-up of barriers identified for linkages for beaver in the Columbia Plateau.

- Barriers identified for beaver are often natural features of the landscape such as steep terrain and dry rocky areas (arrows labeled "A").
- We were not able to address potential resistance to movement posed by Hydroelectric dams in our spatial data layers. However, the main stem of the Columbia River is a primary linkage route for beaver (Fig. 11.3), thus the potential effect of dams may be an important consideration for future evaluation of connectivity for beaver in the Columbia Plateau.

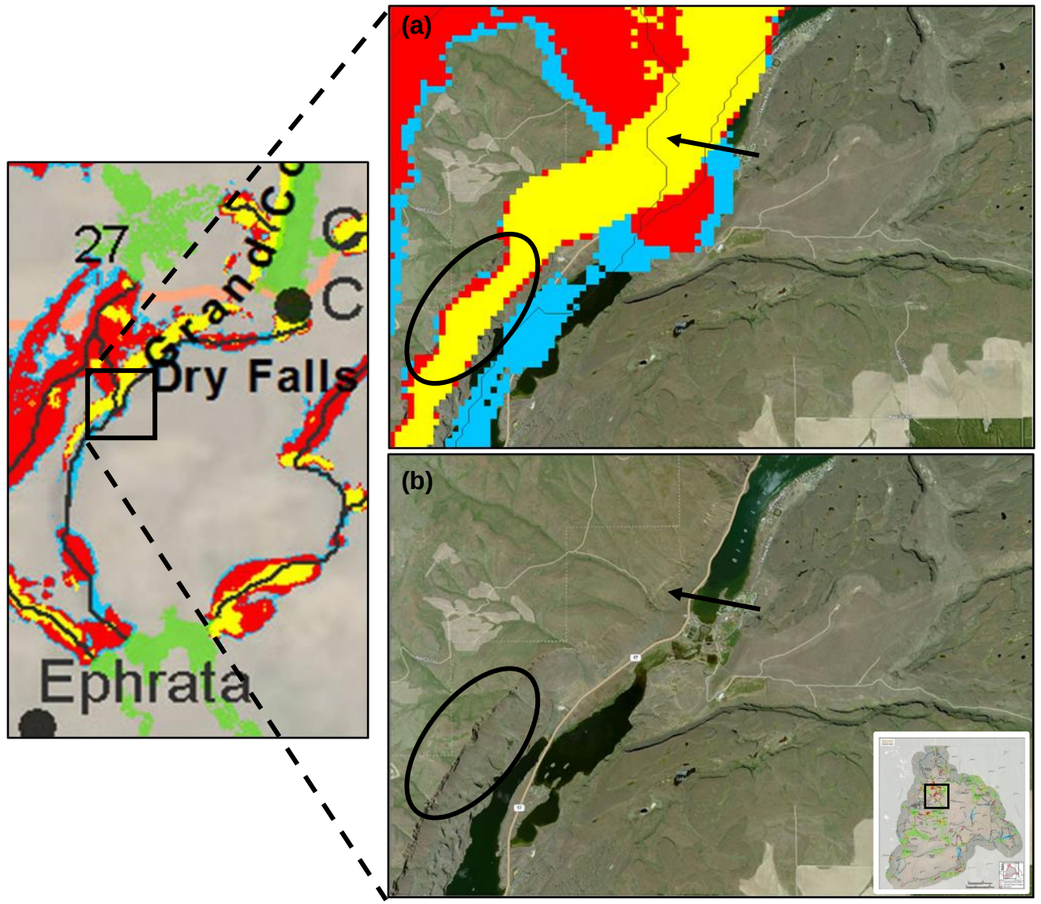

Figure 11.9. Close-up of barriers along linkages for beaver in the area near Dry Falls, north of Ephrata. Panel "a" depicts results of the barrier/restoration analysis overlaid on the aerial image. Panel "b" is the same area with the barrier/restoration analysis "removed." Arrows on both panels indicate least-cost pathways for beaver.

- Many identified barriers for movement of beaver in the Columbia Plateau are created by natural features of the landscape such as steep terrain and rocky areas.
- Panel "a" illustrates an identified barrier (area of yellow, red, and blue) in the linkage between Banks Lake and the HCA in the vicinity of Ephrata. Parts of the linkage highlighted yellow indicate areas that if restored would yield considerable improvement in connectivity for beaver. Panel "b" shows that the identified barrier is steep rugged terrain which is not "restorable."
- Ovals in panels "a" and "b" indicate steep cliffs which are identified as landscape features that constrain movement by beaver.

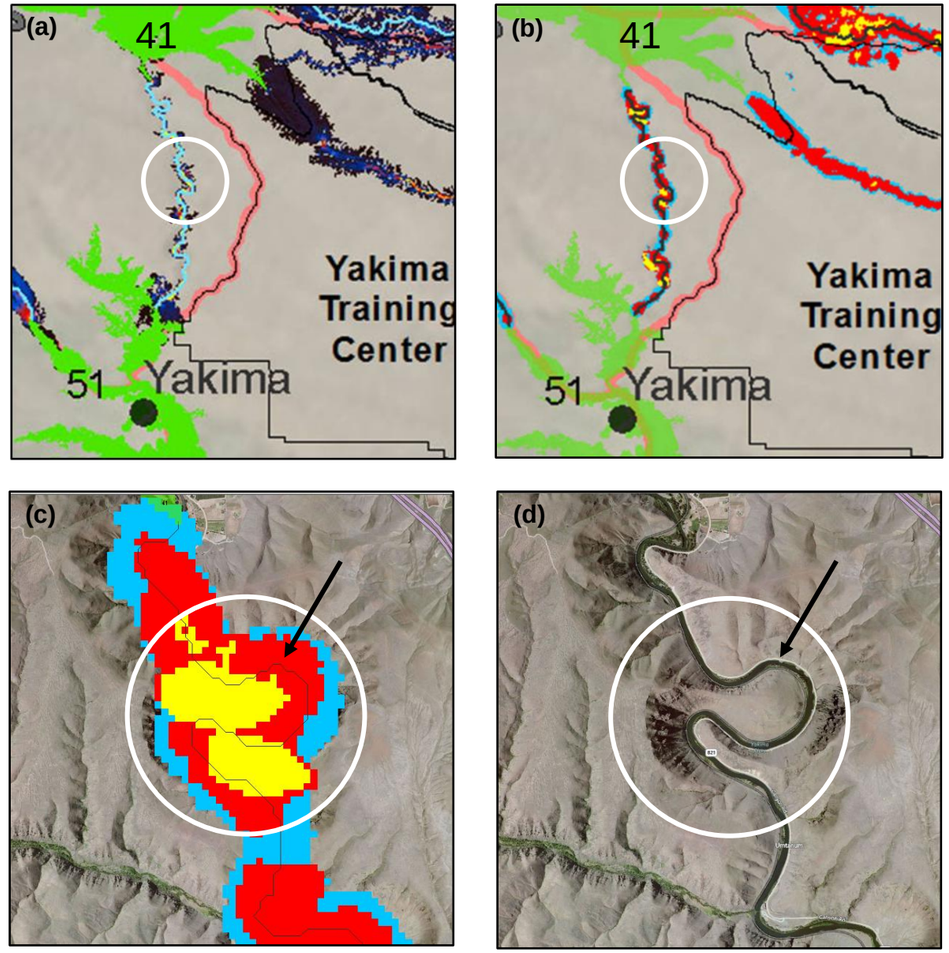

Figure 11.10. Close-up of the Yakima River linkage between HCA 51 near Yakima and HCA 41 near Ellensburg. Panel "a" is the pinch-point analysis for this linkage, panel "b" is the barrier analysis. Panels "c" and "d" are close-ups of ovals shown in panels "a" and "b." Arrow in panels "c" and "d" indicates least-cost pathway for beaver.

- The linkage between HCAs 41 and 51 is highly constrained and the barrier analysis (panels "b" and "c") identified several potential areas that if restored would improve the quality of this linkage.
- Panel "d" illustrates the barrier is created by steep terrain and would not be a conservation focus.

Acknowledgements

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