Chapter 3. Network Centrality, Pinch-Points, and Barriers and Restoration Opportunities for Greater Sage-Grouse (*Centrocercus urophasianus*)

Prepared by Leslie Robb (Independent Researcher) and Michael A. Schroeder (WDFW)

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 Greater Sage-Grouse (*Centrocercus urophasianus*) that can be used to help prioritize and implement conservation actions. We have also included the linkage network (Fig. 3.1) and cost-weighted distance surface (Fig. 3.2) previously modeled for Greater Sage-Grouse (See Appendix A.2 WHCWG 2012, available from http://waconnected.org).

Greater Sage-Grouse, photo by Michael A. Schroeder

Addendum Connectivity Maps

The supplemental connectivity products developed for Greater Sage-Grouse include maps of (1) linkage network centrality (Fig. 3.3), (2) linkage pinch-points (Fig. 3.4), and (3) barriers and restoration opportunities (Figs. 3.5). 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. 3.6– 3.10).

Conservation of Connectivity for Greater Sage-Grouse

- The Mansfield Plateau is key for maintaining connectivity among the Swanson Lakes, Moses Coulee, and Yakima Training Center populations of Greater Sage-Grouse.
- Expansion of occupied habitat within linkage areas adjacent to habitat concentration areas (HCAs) may be the most promising way to "shorten" the movement distance between them.
- Re-establishing occupied habitat for Greater Sage-Grouse along the linkage between Swanson Lakes and Moses Coulee HCAs is key for connectivity.
- The pinch-point near Trinidad created by the infrastructure associated with Rock Island Dam is a key "bottleneck" for north–south movement of Greater Sage-Grouse and is an important area for connectivity conservation.
- The pinch-point in the vicinity of Union Gap is a severe bottleneck for movement between the Yakima Training Center and the Yakama Reservation lands. Ahtanum Ridge is an important area for conservation.
- Powerline corridors create multiple barriers to potential movement by Greater Sage-Grouse.

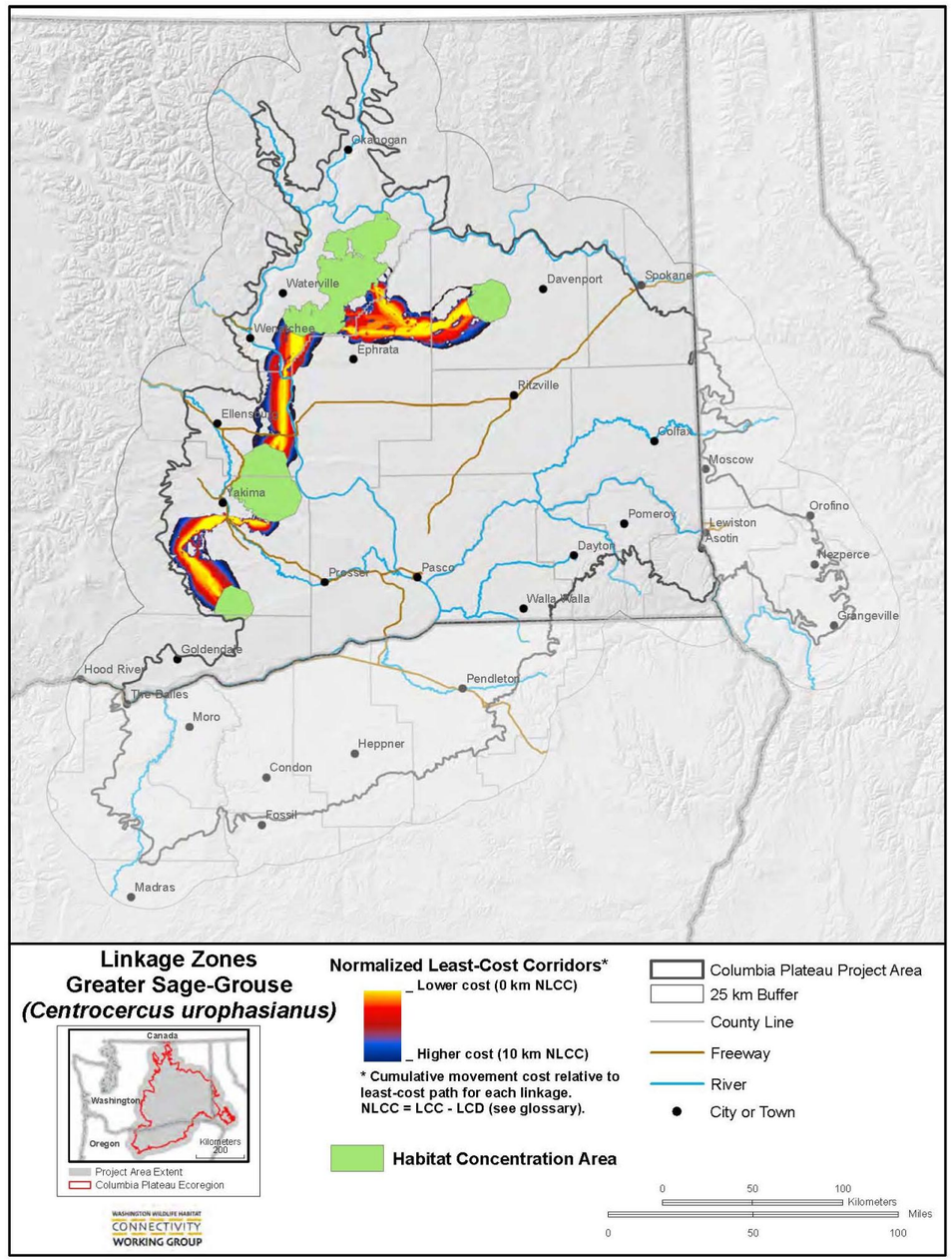

Figure 3.1. Linkage network modeled for Greater Sage-Grouse in the Columbia Plateau Ecoregion (Appendix A.2, WHCWG 2012). Green polygons represent habitat concentration areas (HCAs) for Greater Sage-Grouse. Linkages between HCAs are shown in bright colors; the least-cost pathways are highlighted yellow.

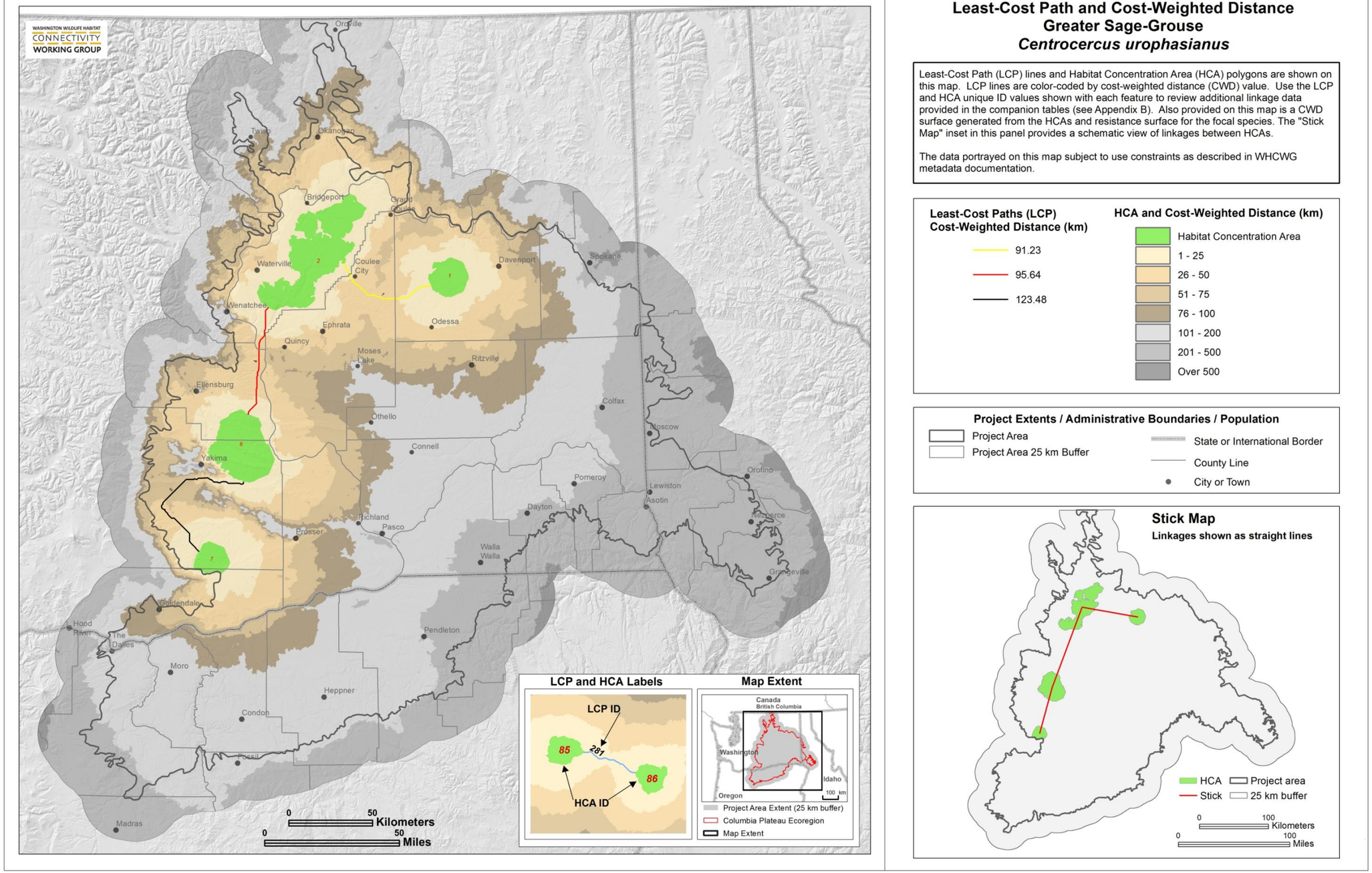

Figure 3.2. The cost-weighted distance map with numbered habitat concentration areas (HCAs) and least-cost paths for Greater Sage-Grouse in the Columbia Plateau Ecoregion (Appendix A.2, WHCWG 2012).

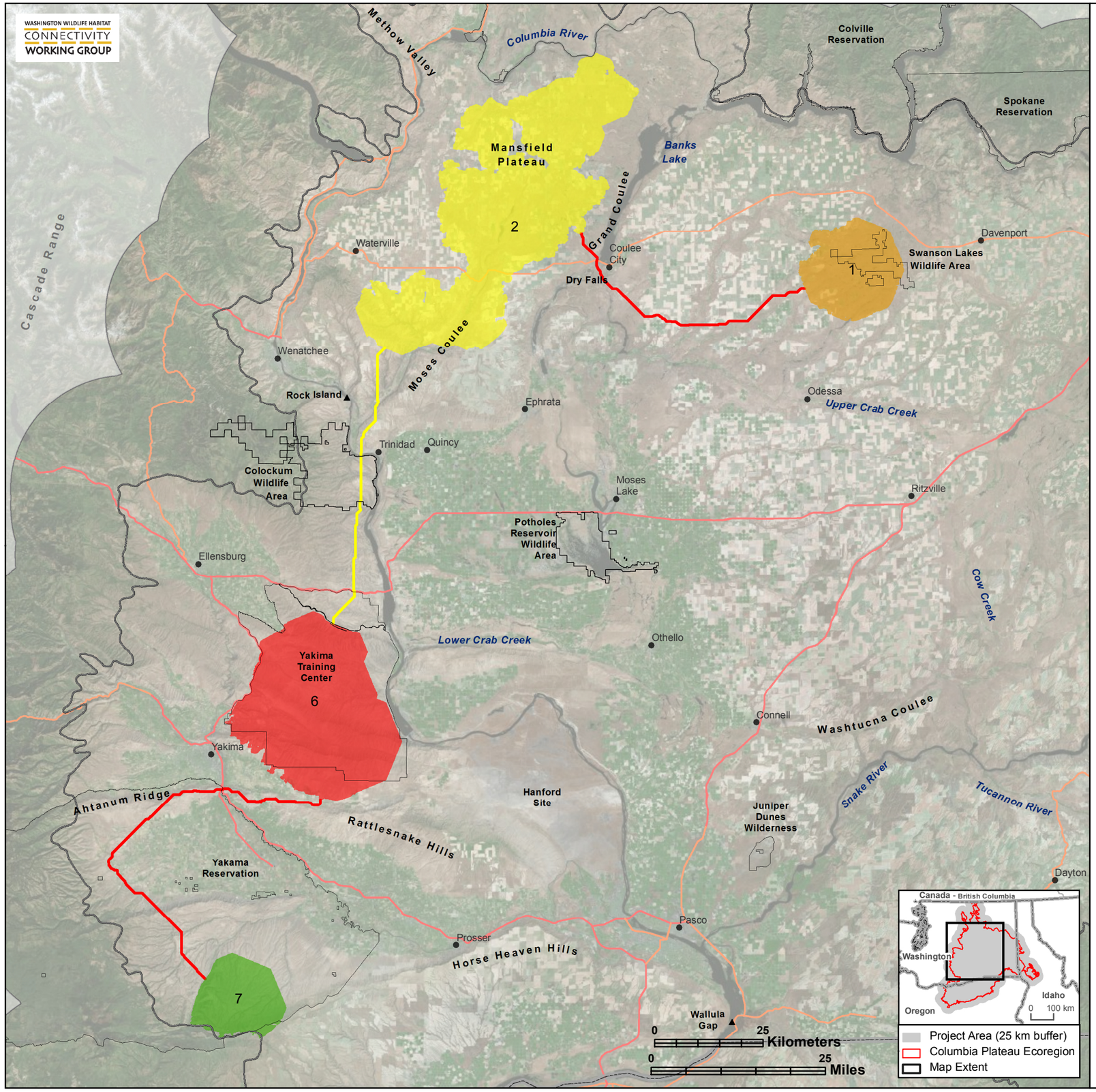

Figure 3.3. Linkage Network Centrality for Greater Sage-Grouse (*Centrocercus urophasianus*).

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

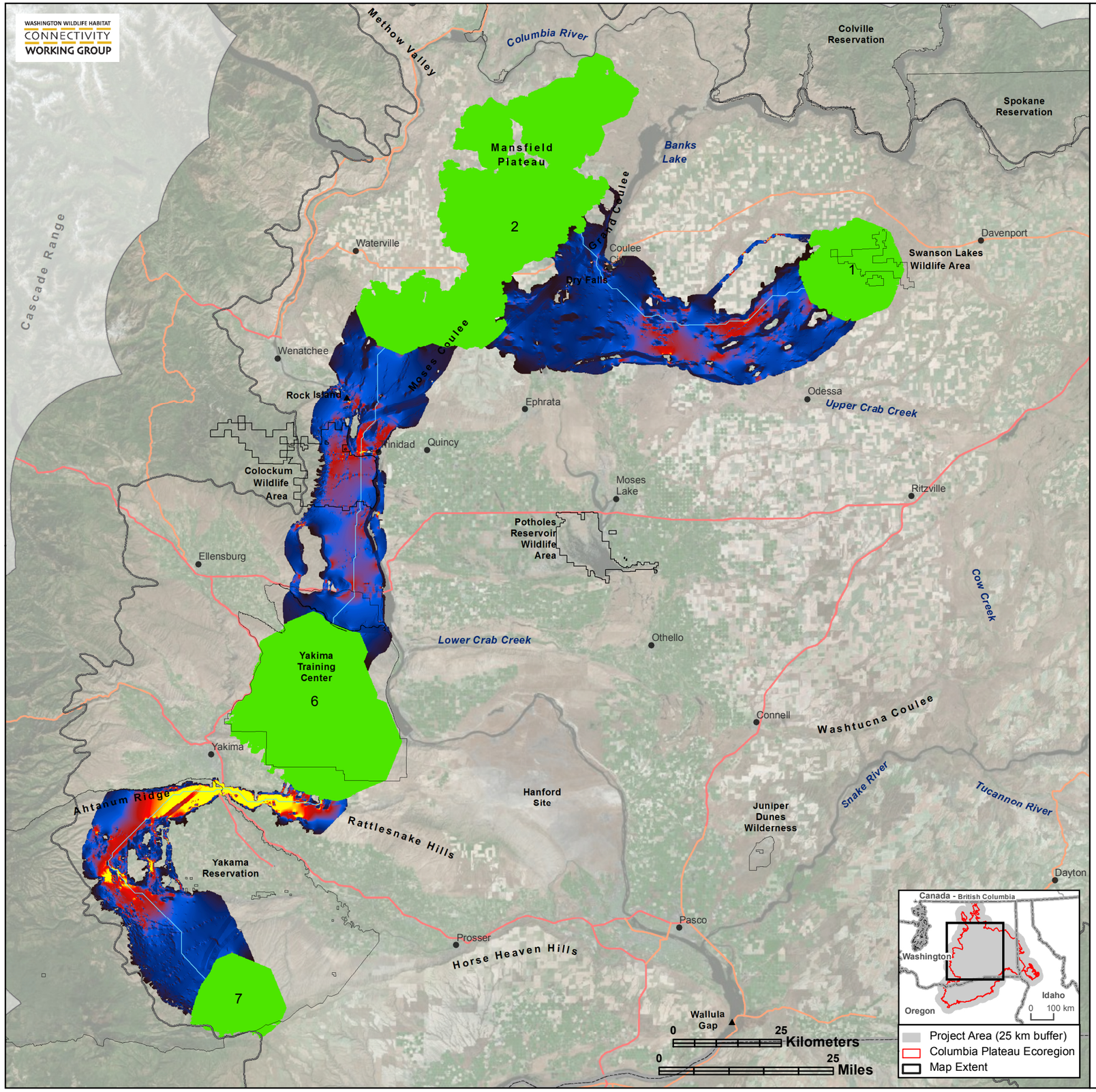

Figure 3.4. Linkage Pinch-Points for Greater Sage-Grouse (*Centrocercus urophasianus*).

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.

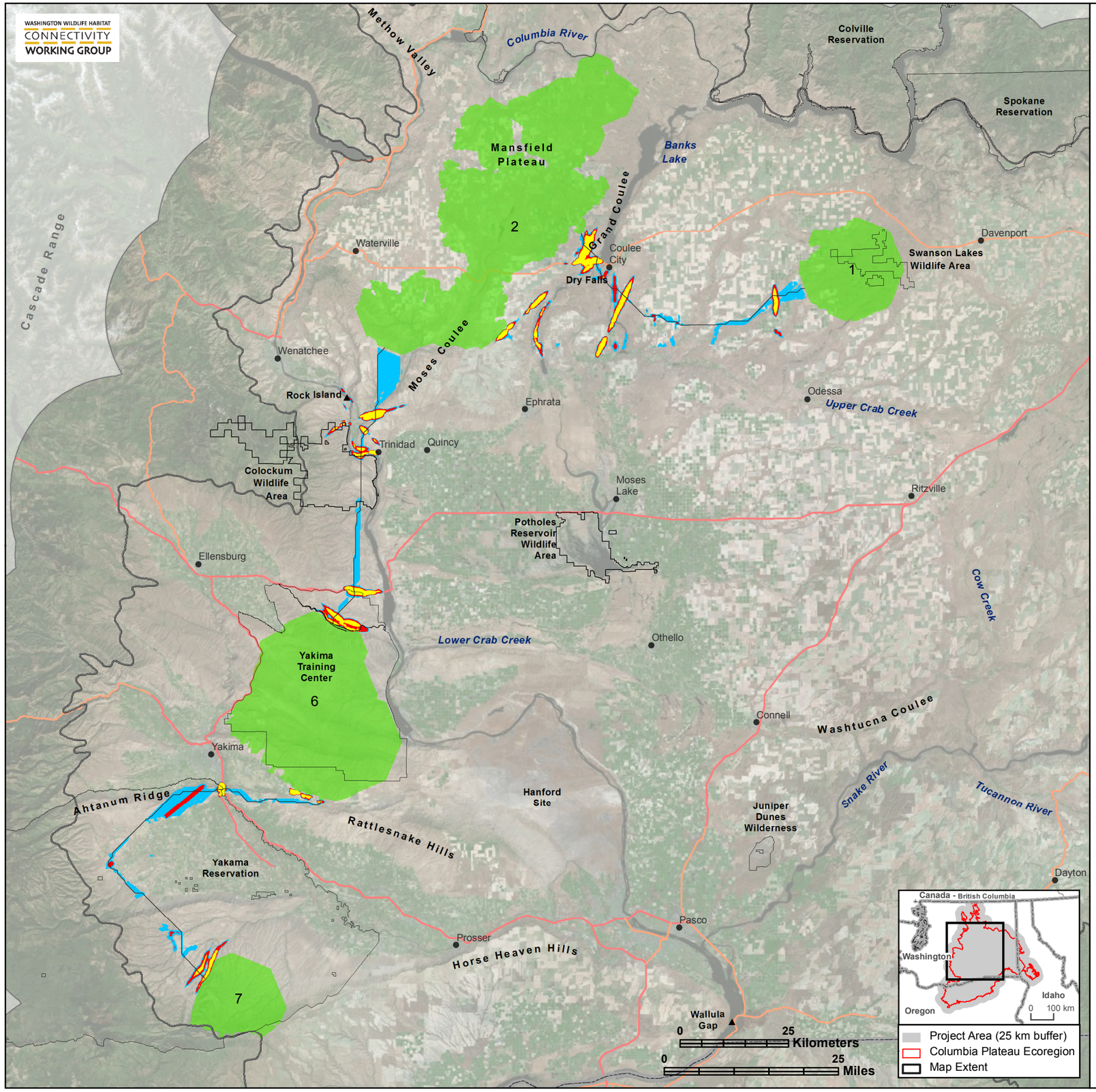

Figure 3.5. Barriers and Restoration Opportunities for Greater Sage-Grouse (*Centrocercus urophasianus*).

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 Mansfield Plateau is the key area for maintaining connectivity among the Swanson Lakes, Moses Coulee, and Yakima Training Center populations of Greater Sage-Grouse (Fig. 3.3).
- The Yakima Training Center is key for maintaining connectivity among Moses Coulee, the Yakima Training Center, and Yakama Reservation lands (Fig. 3.3).

Linkage Pinch-Points

- Expansion of occupied habitat for the Moses Coulee and Yakima Training Center areas may be the most promising way to "shorten" the movement distance between them (Fig. 3.6).
- The pinch-point near Trinidad created by the infrastructure associated with Rock Island Dam is a key "bottleneck" for north–south movement of Greater Sage-Grouse (Fig. 3.6). This pinch-point is an important area for connectivity conservation.
- The pinch-point in the vicinity of Union Gap is a severe "bottleneck" for movement between the Yakima Training Center and the Yakama Reservation lands (Fig. 3.7).
- The linkage pathway between Swanson Lakes (HCA 1) and Moses Coulee (HCA 2) is wide, relatively unconstrained, and far in Euclidean distance (Euclidean length of least-cost path is approximately 68 km). Greater Sage-Grouse historically occupied the linkage pathway. Re-establishing occupied habitat for Greater Sage-Grouse along this linkage is key for connectivity between Swanson Lakes and Moses Coulee (Fig. 3.8).

Barriers and Restoration Opportunities

- Powerline corridors cross the linkage pathway between the Swanson Lakes HCA and the Moses Coulee HCA creating multiple linear barriers to potential movement by Greater Sage-Grouse (Fig. 3.9).
- Barriers to movement between the Moses Coulee HCA and the Yakima Training Center HCA are primarily created by energy infrastructure and I-90 (Fig. 3.10).

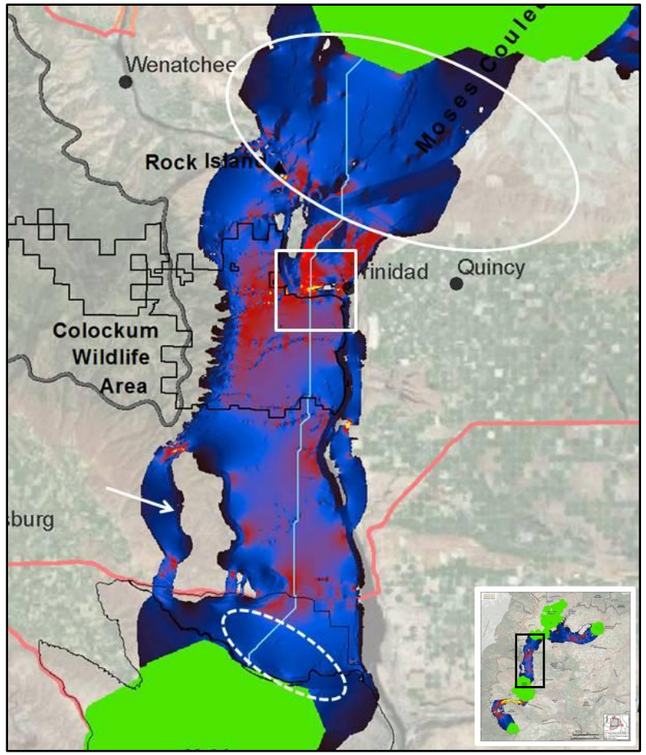

Figure 3.6. Linkage between the Moses Coulee (north) and Yakima Training Center (south) HCAs. Solid circle indicates area of potential habitat for Greater Sage-Grouse. Dashed circle indicates pinch-point near Rock Island Dam and arrow indicates "hole" in linkage pathway created by active wind energy facilities.

- The linkage between the Moses Coulee and Yakima Training Center HCAs is far in Euclidean distance. Habitat in the central portion of the linkage is too rugged for occupancy and consequently there is little opportunity to establish a "stepping stone" population. Expansion of occupied habitat for the Moses Coulee and Yakima Training Center HCAs may be the most promising way to shorten the movement distance between them. This would require expanding the population of Greater Sage-Grouse to the south of the Moses Coulee HCA. The area within the linkage area adjacent to the HCA, as well as the area east of the linkage (solid oval), were historically occupied. The area of occupancy would need to increase north of the Yakima Training Center (dashed oval).
- The pinch-point near Trinidad (square) is created by agricultural lands and the infrastructure associated with Rock Island Dam and is a "bottleneck" for north–south movement of Greater Sage-Grouse. This pinch-point is an important area for connectivity conservation.
- The linkage pathway moves around active wind energy facilities (arrow) with the widest part to the east. Greater Sage-Grouse must cross powerline corridors and I-90 to move between the Moses Coulee and Yakima Training Center. Genetic information for Greater Sage-Grouse from the two areas indicates limited gene flow; the two populations are genetically distinct. Additional resistance to movement in this area may sever north–south movement.

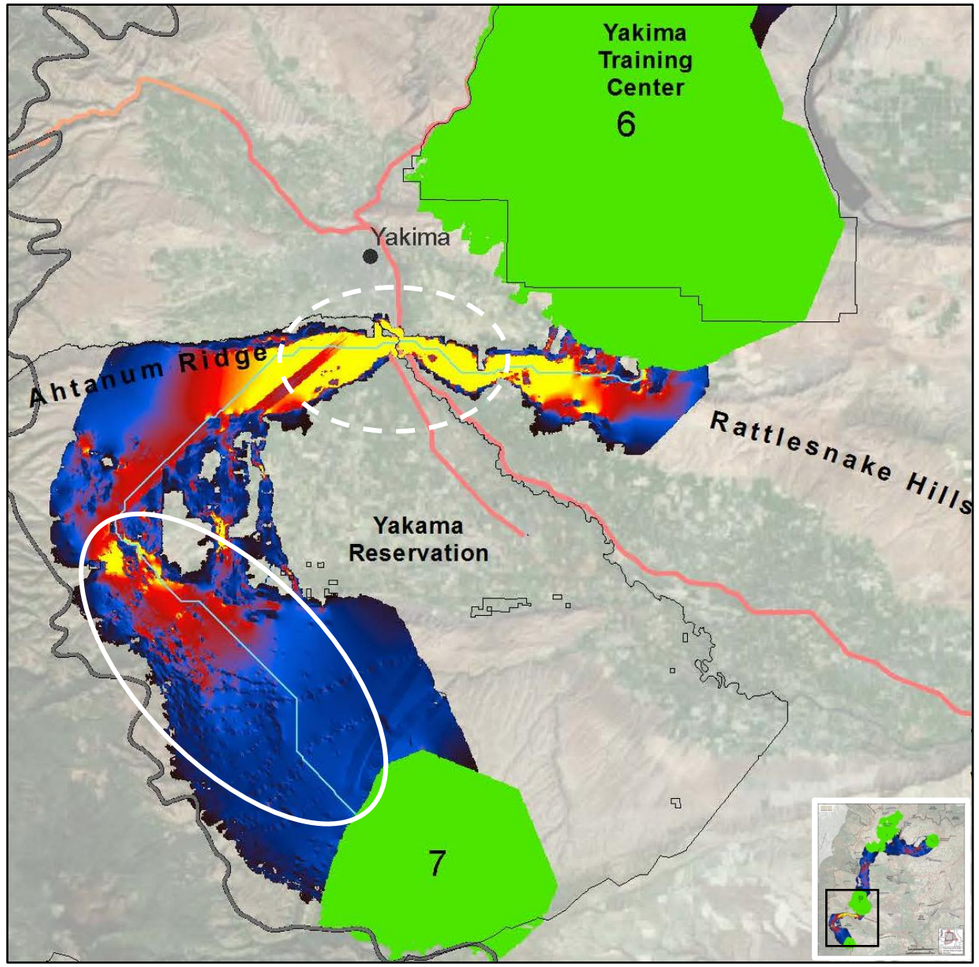

Figure 3.7. Close-up of pinch-points (bright yellow and red areas in ovals) for potential movement of Greater Sage-Grouse between the Yakima Training Center (HCA 6) and Yakama Reservation lands (HCA 7).

- The pinch-point in the vicinity of Union Gap, south of Yakima (dashed oval) is a severe bottleneck for movement between the Yakima Training Center (north) and the Yakama Reservation lands (HCA 7). Increasing occupancy within the unconstrained (blue) area adjacent to HCA 7 (solid oval) would shorten the Euclidean distance of the linkage pathway. The length of the least-cost path (light blue line) between the HCAs is about 98 km Euclidean distance, and about 123 km cost-weighted distance. Greater Sage-Grouse have occasionally been observed on Ahtanum Ridge and although it is possible that birds may move through the pinch-point the Union Gap location is also identified as a significant barrier (Fig. 3.5).

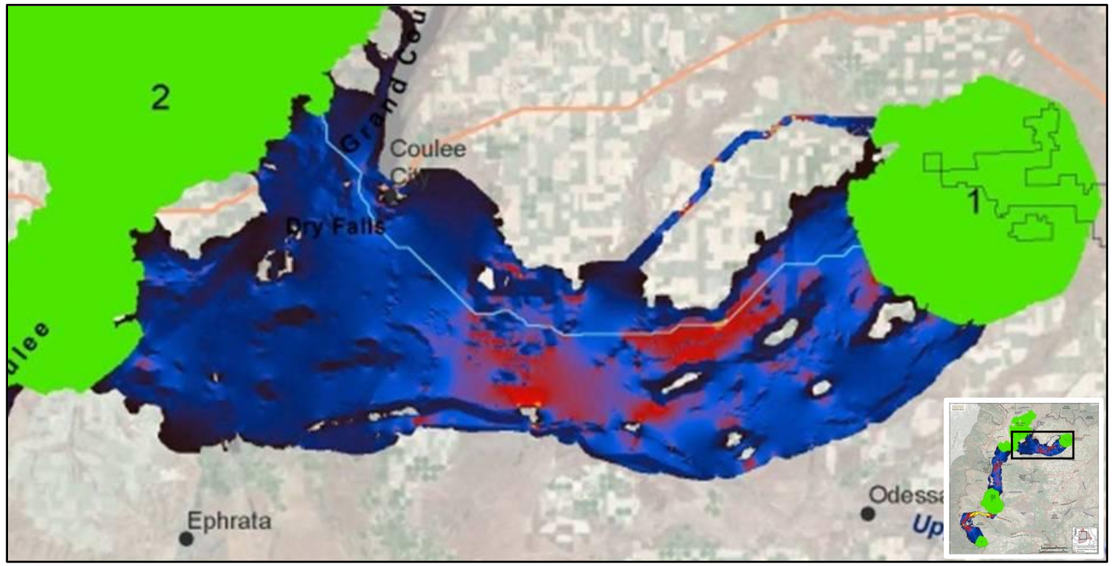

Figure 3.8. Linkage pathway between the Swanson Lakes (HCA 1) and Moses Coulee (HCA 2) areas.

- The linkage pathway between Swanson Lakes (HCA 1) and Moses Coulee (HCA 2) is wide, relatively unconstrained, and far in Euclidean distance (Euclidean length of least-cost path is approximately 68 km). Greater Sage-Grouse historically occupied the linkage pathway and one female Greater Sage-Grouse translocated to Swanson Lakes has been observed in the Moses Coulee HCA.
- Re-establishing occupied habitat for Greater Sage-Grouse along this linkage is key for connectivity between Swanson Lakes and Moses Coulee.

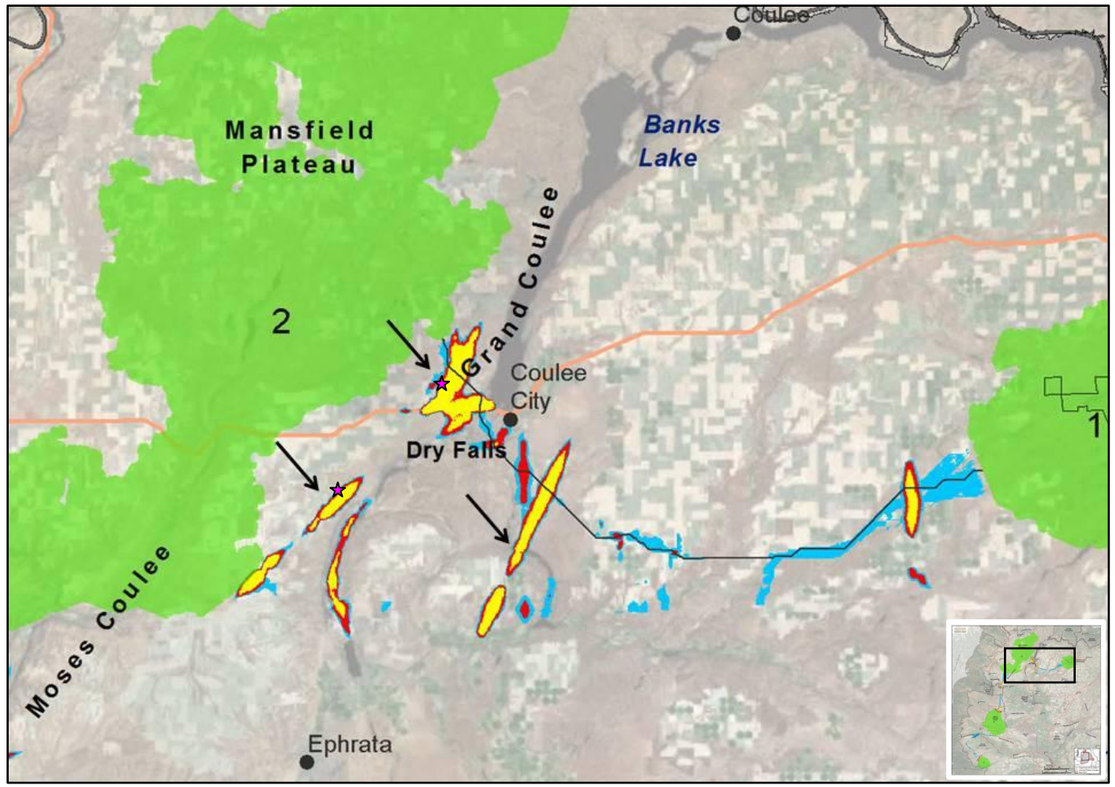

Figure 3.9. Barriers to potential movement created by powerline corridors (arrows) in the linkage pathway between the Swanson Lakes (HCA 1) and Moses Coulee (HCA 2) areas.

- Powerline corridors crossing the linkage pathway between the Swanson Lakes HCA and the Moses Coulee HCA create multiple linear barriers to potential movement by Greater Sage-Grouse.
- Radio-marked Greater Sage-Grouse translocated to the Swanson Lakes area have been detected in or on the edge of the Moses Coulee HCA. Three females are known to have moved from Swanson Lakes to Moses Coulee; 1 established in Douglas County and 2 died near powerline corridors (pink stars indicate approximate mortality locations) on the eastern edge of Douglas County.

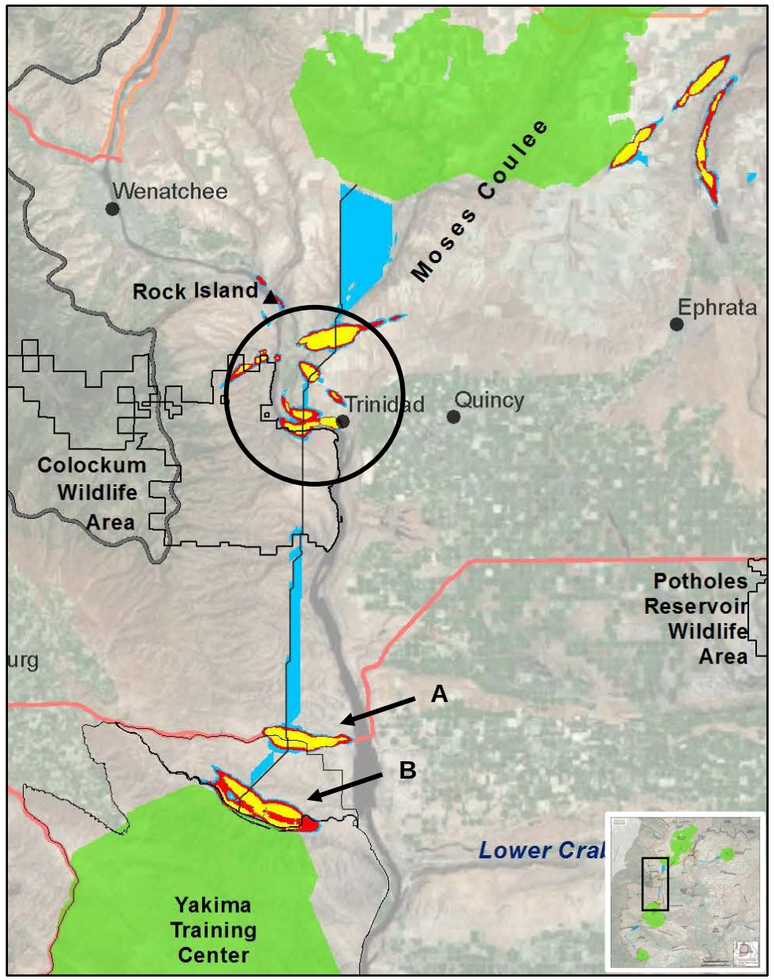

Figure 3.10. Barriers to potential movement (arrows) in the linkage pathway between the Moses Coulee (north) and Yakima training Center (south) HCAs.

- Barriers to movement between the Moses Coulee HCA (north) and the Yakima Training Center HCA (south) are primarily created by energy infrastructure associated with Rock Island Dam (circle), I-90 (arrow labeled “A”), and powerline corridors (arrow labeled “B”).

Acknowledgements

Special thanks to the following persons who provided model review and input: Mike Atamian (WDFW), Brian Hall (WDFW), Jason Lowe (BLM), Brad McRae (TNC), Joanne Schuett-Hames (WDFW), and Derek Stinson (WDFW).