Chapter 2. Network Centrality, Pinch-Points, and Barriers and Restoration Opportunities for Sharp-tailed Grouse (*Tympanuchus phasianellus*)

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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 Sharp-tailed Grouse (*Tympanuchus phasianellus*) that can be used to help prioritize and implement conservation actions. We have also included the linkage network (Fig. 2.1) and cost-weighted distance surface (Fig. 2.2) previously modeled for Sharp-tailed Grouse (See Appendix A.1 WHCWG 2012, available from http://waconnected.org).

Sharp-tailed Grouse, photo by Gregg Thompson

Addendum Connectivity Maps

The supplemental connectivity products developed for Sharp-tailed Grouse include maps of (1) linkage network centrality (Fig. 2.3), (2) linkage pinch-points (Fig. 2.4), and (3) barriers and restoration opportunities (Figs. 2.5). 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. 2.6–2.11).

Conservation of Connectivity for Sharp-tailed Grouse

- The area of high centrality and fewest pinch-points for potential movement of Sharp-tailed Grouse occurs in the north area of the Mansfield Plateau and south part of Okanogan County. This area is important for connectivity conservation and perhaps range expansion. Low centrality areas are also important for conserving connectivity as these areas often have public lands managed for the benefit of Sharp-tailed Grouse.
- East–west movement across the Okanogan Valley is limited to the area north of the city of Okanogan. Conservation of this area is needed to prevent isolation of Sharp-tailed Grouse populations on the western side of the valley.
- Translocations of "healthy" birds into isolated and declining subpopulations may also be a useful tool for restoring the health of sub-populations and their capacity to use movement corridors and/or to expand into suitable habitat. In either case, translocations may improve connectivity.
- It is important to consider a connectivity conservation approach that (1) increases the size of habitat concentration areas (HCAs), i.e., area of occupancy, (2) establishes areas of potential occupancy along linkages, and (3) restores identified barriers to help establish "stepping stone" HCAs.

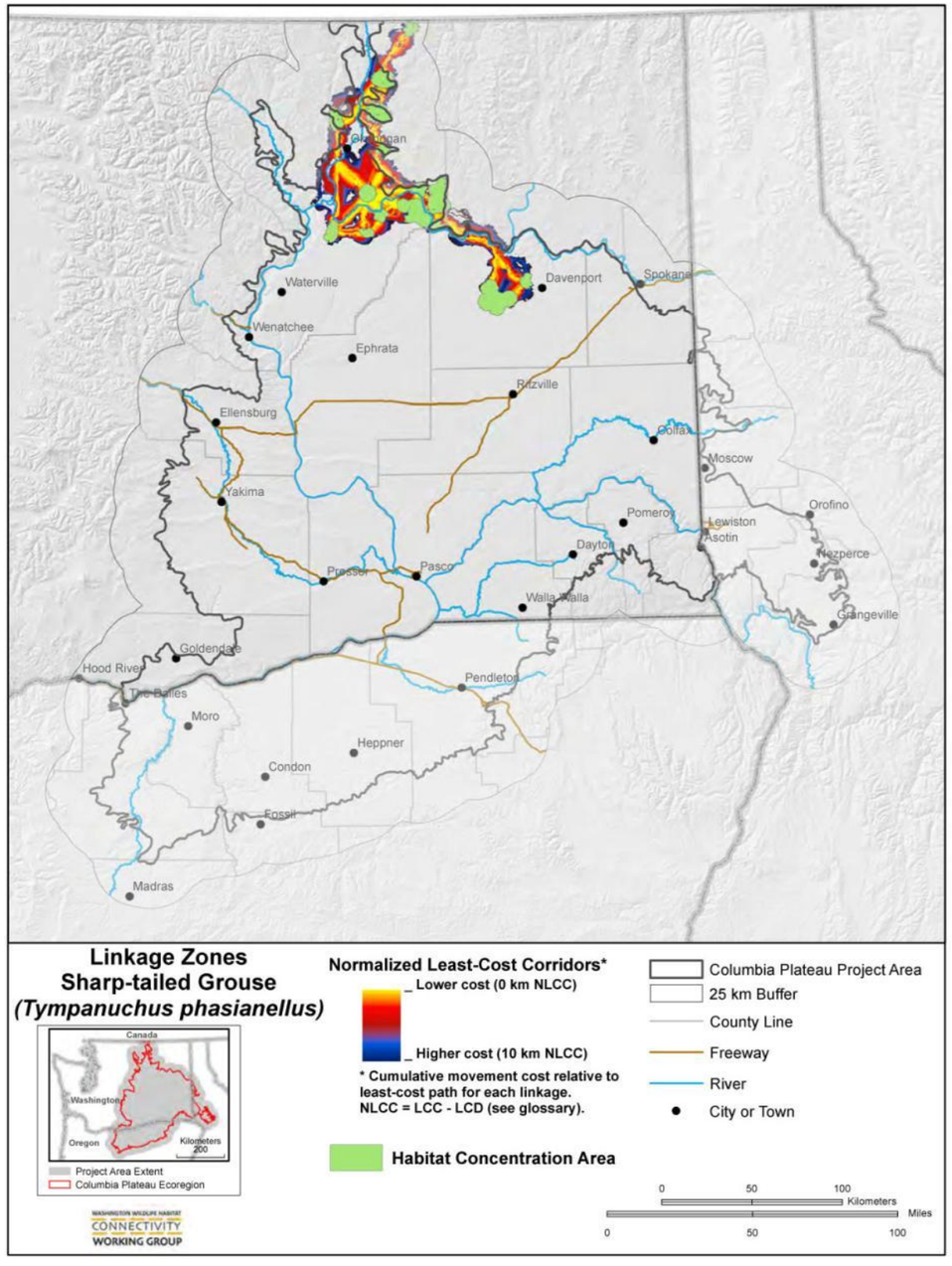

Figure 2.1. Linkage network modeled for Sharp-tailed Grouse in the Columbia Plateau Ecoregion (Appendix A.1, WHCWG 2012). Green polygons represent habitat concentration areas (HCAs) for Sharp-tailed Grouse. Linkages between HCAs are shown in bright colors; the least-cost pathways are highlighted yellow.

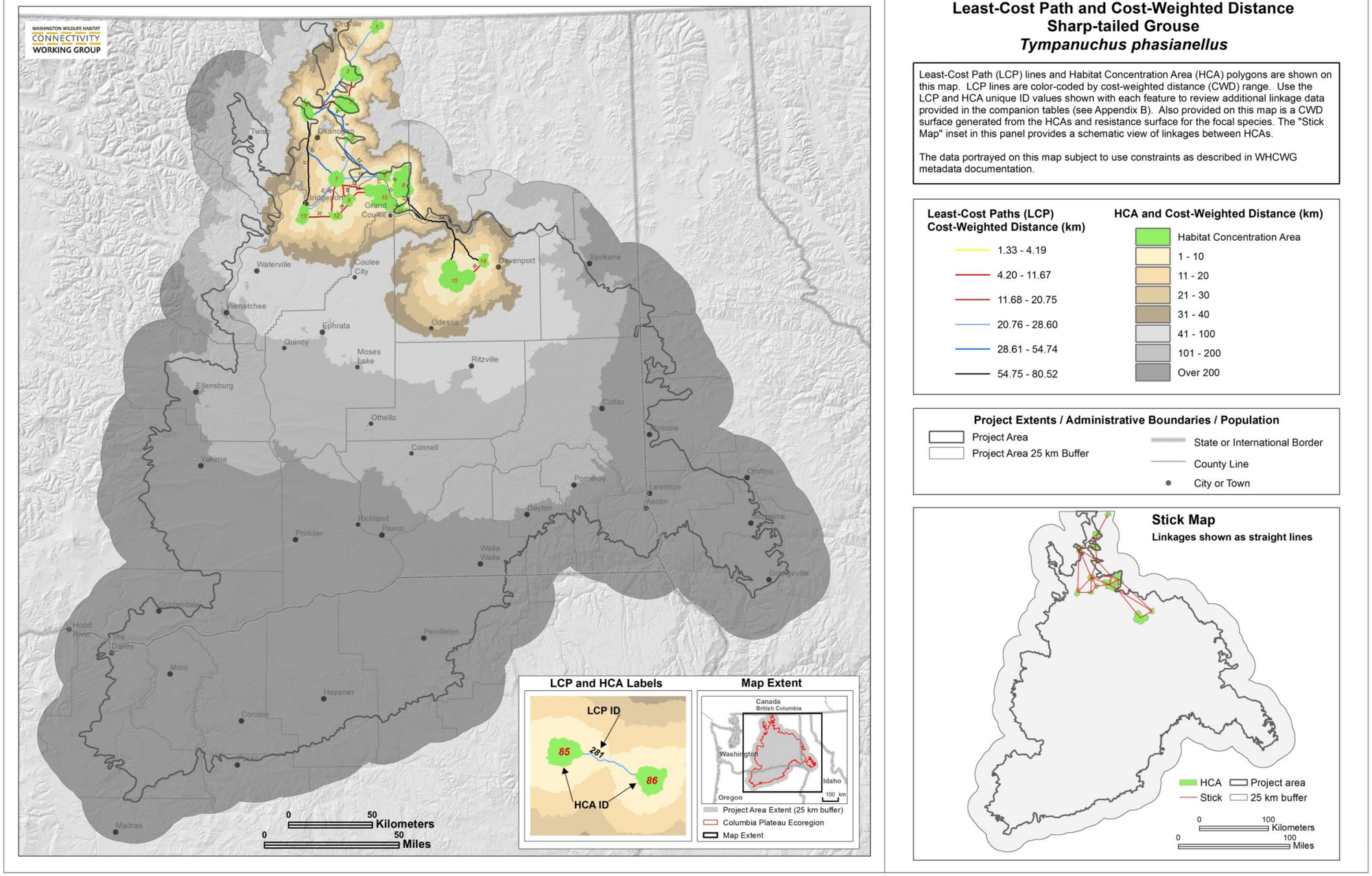

Figure 2.2. The cost-weighted distance map with numbered habitat concentration areas (HCAs) and least-cost paths for Sharp-tailed Grouse in the Columbia Plateau Ecoregion (Appendix A.1, WHCWG 2012).

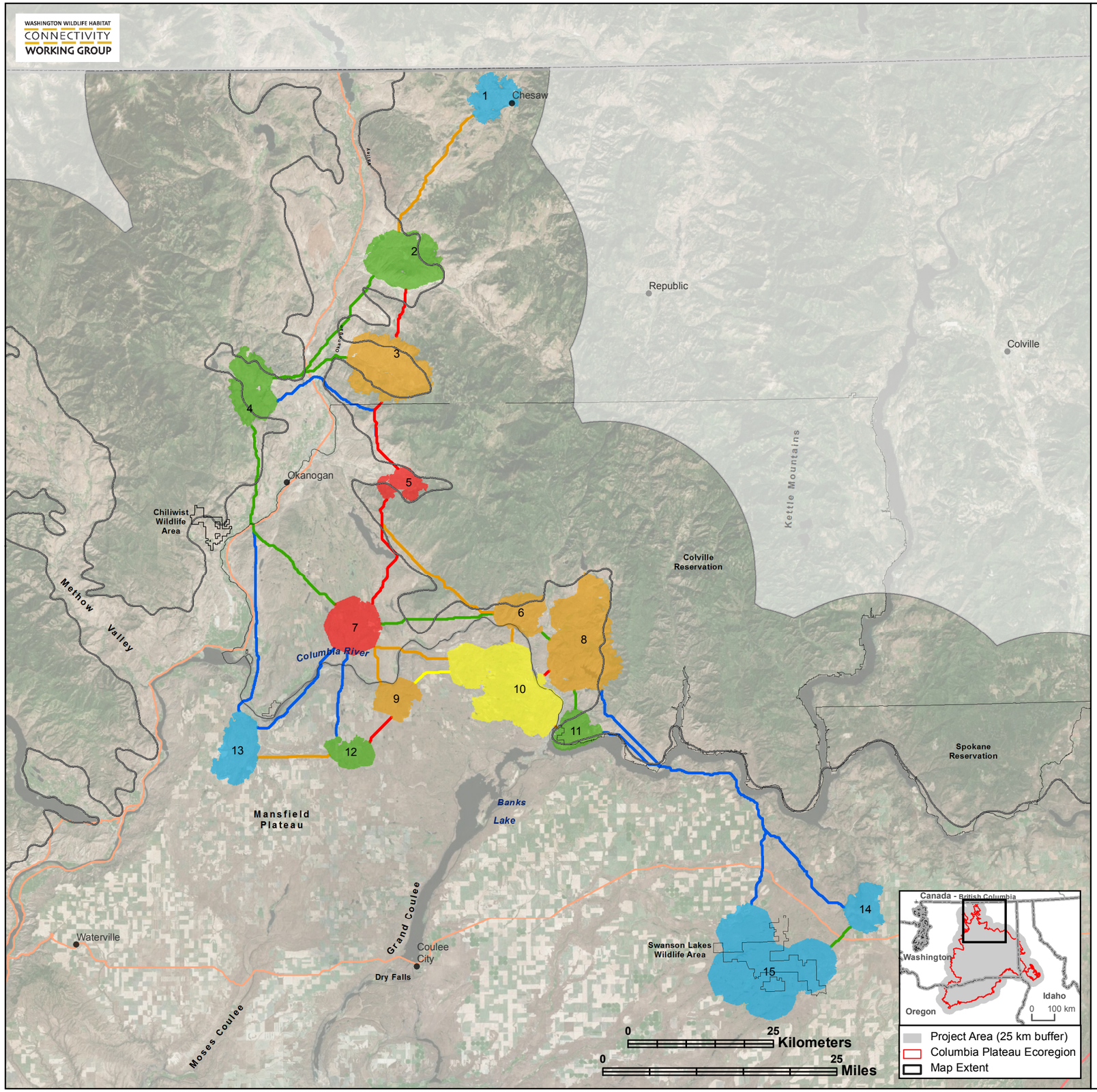

Figure 2.3. Linkage Network Centrality for Sharp-tailed Grouse (*Tympanuchus phasianellus*).

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 2.4. Linkage Pinch-Points for Sharp-tailed Grouse (*Tympanuchus phasianellus*).

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.

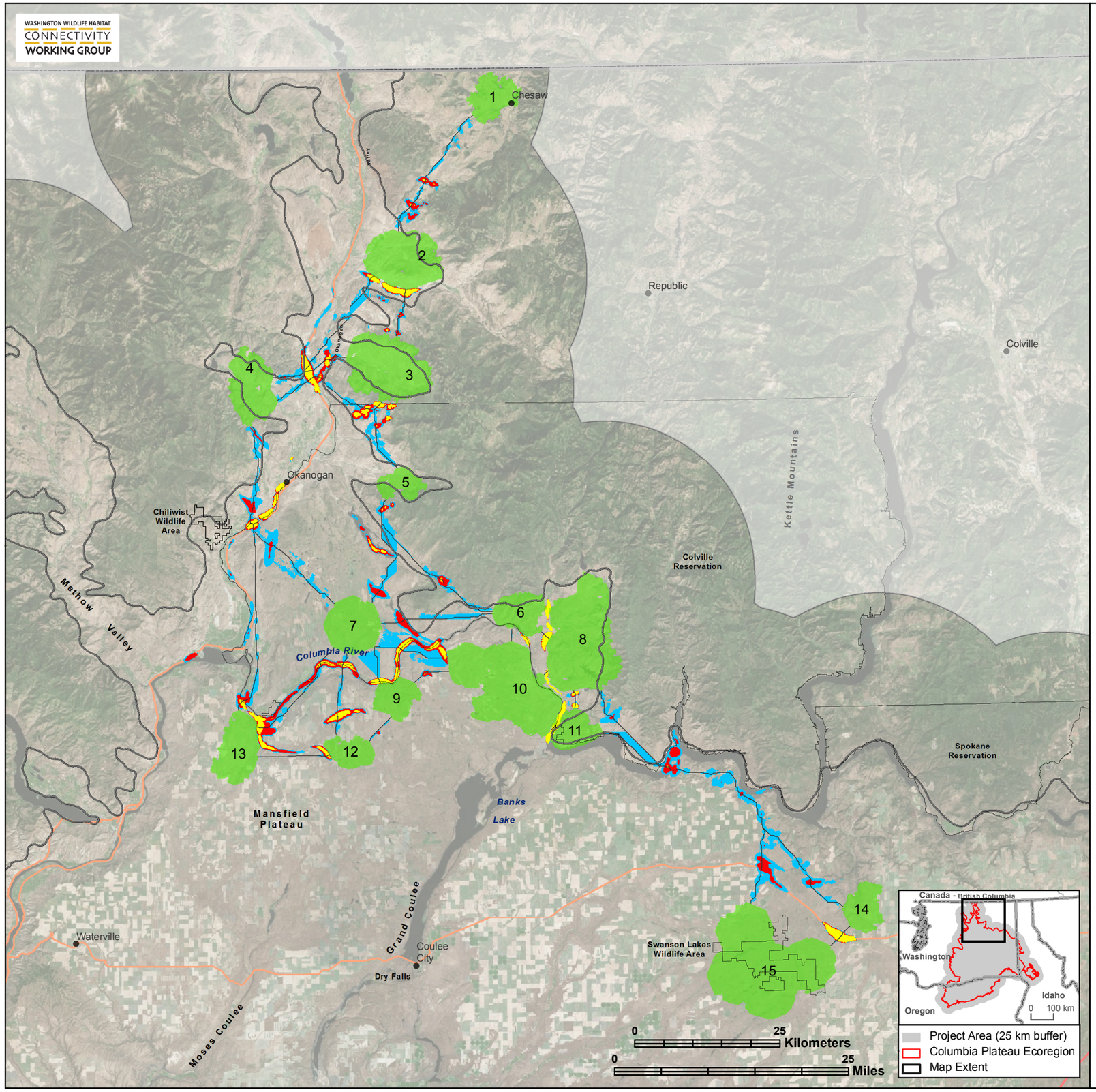

Figure 2.5. Barriers and Restoration Opportunities for Sharp-tailed Grouse (*Tympanuchus phasianellus*).

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 area most central in the Sharp-tailed Grouse linkage network occurs in the north area of the Mansfield Plateau and south part of Okanogan County (Fig. 2.6).
- The linkage between HCAs 7 and 5 (Fig. 2.6) is critical for maintaining connectivity between the Mansfield Plateau and the Okanogan.
- Low centrality areas are also important for conserving connectivity as these areas often have public lands managed for the benefit of Sharp-tailed Grouse (Fig. 2.6).

Linkage Pinch-Points

- Fewest pinch-points for potential movement of Sharp-tailed Grouse occur in the north area of the Mansfield Plateau and the south part of Okanogan County (Fig. 2.7). This area also is important for keeping the linkage network intact.
- Pinch-points between HCAs 7 and 5 (Fig. 2.8) on the east side of the Okanogan Valley are important for conservation of connectivity between the Mansfield Plateau and the Okanogan. The only other linkage potentially connecting these areas is highly constrained.
- East–west movement across the Okanogan Valley is primarily constrained to one area north of the city of Okanogan. Conservation of this area is needed to help prevent further isolation of Sharp-tailed Grouse that occupy habitat on the western side of the valley (Fig. 2.8).

Barriers and Restoration Opportunities

- Restoration of barriers identified in the area north of the city of Okanogan is important for east–west movement of Sharp-tailed Grouse across the Okanogan Valley (Fig. 2.9).
- Barriers identified among HCAs 7, 5, and 3 on the eastern side of the Okanogan Valley are key places for potential conservation action for enhancing/maintaining connectivity between Sharp-tailed Grouse in the Mansfield Plateau and the Okanogan (Fig. 2.9).
- Barriers where restoration is not feasible may be places to avoid incurring additional resistance to movement (Fig. 2.10).
- For Sharp-tailed Grouse it is important to consider a connectivity conservation approach that (1) increases the size of HCAs, i.e., the area of occupancy, (2) establishes areas of potential occupancy along linkages, and (3) restores identified barriers to help establish "stepping stone" HCAs (Fig 2.11).

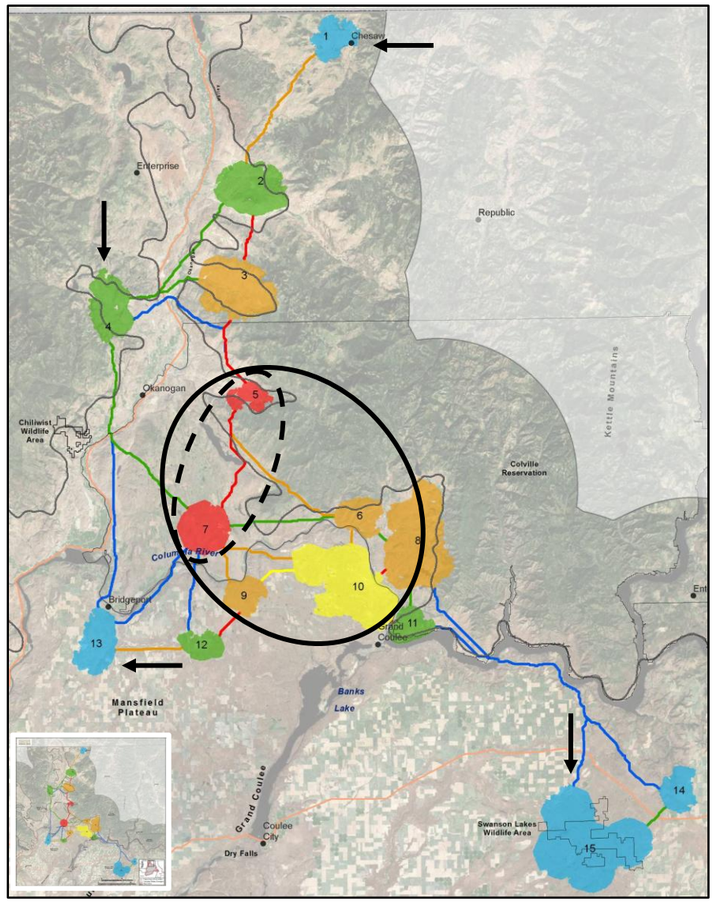

Figure 2.6. Sharp-tailed Grouse areas of High to Highest network centrality (ovals) and peripheral HCAs (arrows).

- The most central area of the linkage network occurs in the north part of the Mansfield Plateau and south part of Okanogan County (in the solid oval).
- The linkage between HCAs 7 and 5 (in the dashed oval) is critical for maintaining connectivity between the Mansfield Plateau and the Okanogan.
- Disturbance in connectivity for HCAs 5, 7, and 10 might sever the range of Sharp-tailed Grouse.
- Low centrality areas (arrows) are also important for conserving connectivity as they often have public lands managed for the benefit of Sharp-tailed Grouse. For example, HCA 15 is dominated by the Swanson Lakes Wildlife Area, HCA 13 is dominated by the West Foster Creek Wildlife Area, HCA 4 is dominated by the Scotch Creek Wildlife Area, and HCA 1 is dominated by the Chesaw Wildlife Area.
- The linear pattern of the linkage network is illustrated by the progressive decrease in centrality from HCA 5 to HCA 1.

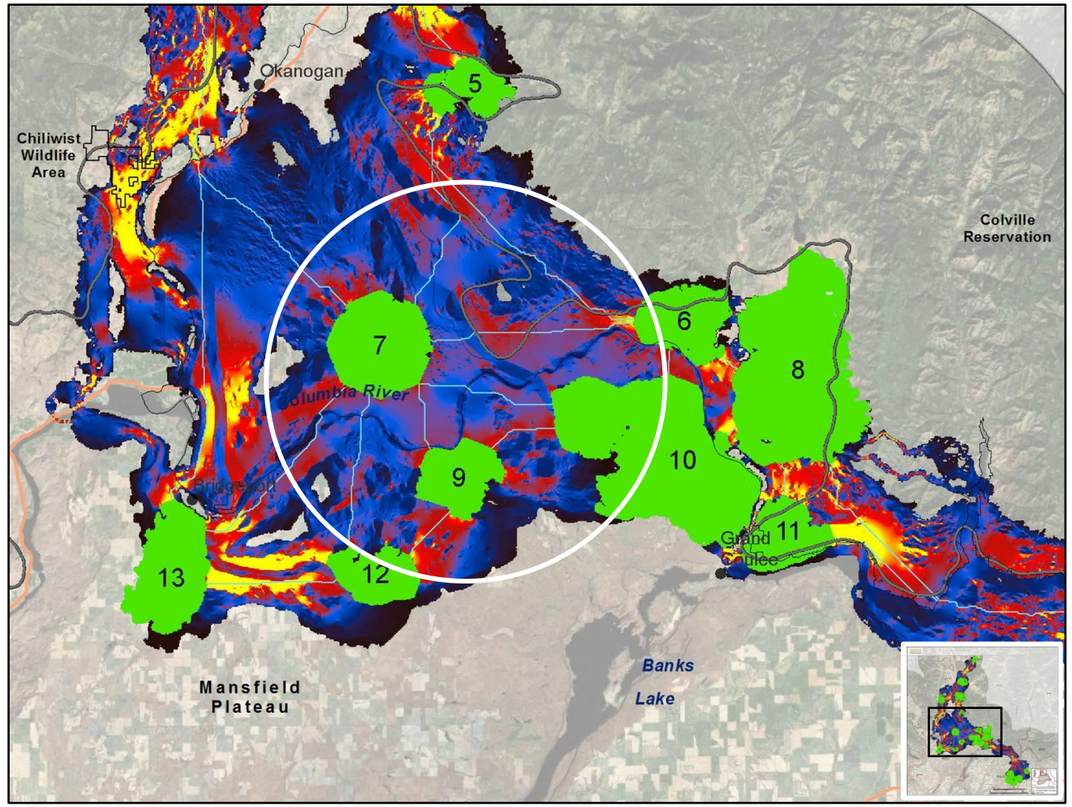

Figure 2.7. Area of the Sharp-tailed Grouse linkage network where there are the fewest pinch-points (circle).

- The north area of the Mansfield Plateau and part of Okanogan County has few pinch-points (circle). This area also is important for keeping the Sharp-tailed Grouse linkage network intact (see Fig. 2.6).

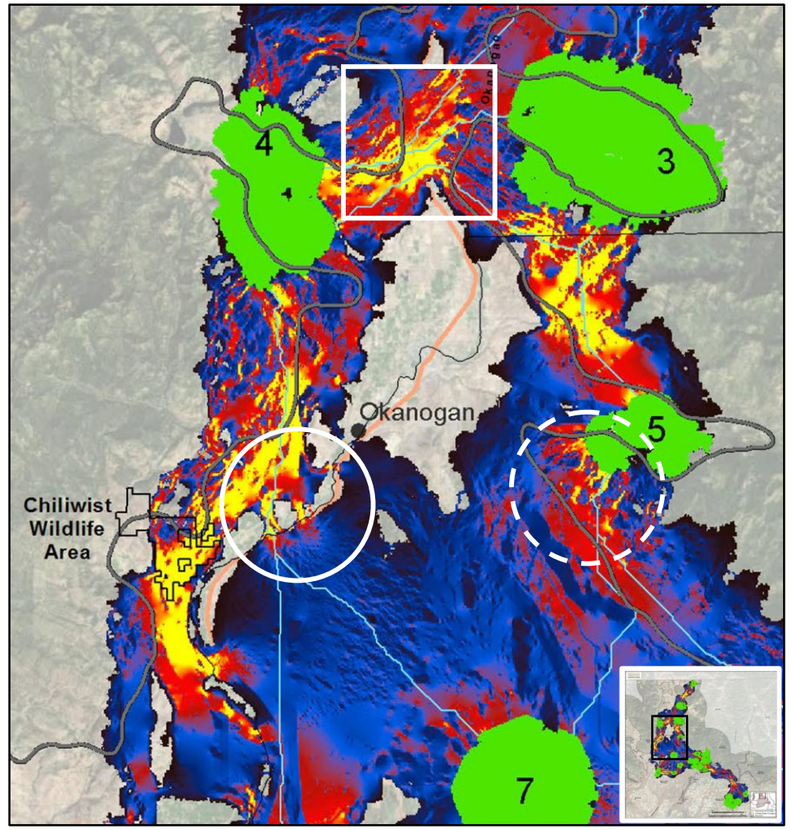

Figure 2.8. Areas of the linkage network for Sharp-tailed Grouse where connectivity is at risk because of narrow pinch-points (circles) and a single constrained linkage (square).

- The narrow pinch-points (solid circle) in the vicinity of the Chiliwist Wildlife Area and the city of Okanogan are highly constrained by U.S. Highway 97, orchards, and housing development along the Okanogan River. These pinch-points are extremely narrow and opportunities for conservation action in the surrounding landscape may be limited.
- The pinch-points between HCAs 7 and 5 (dashed circle) are important to consider for conservation efforts. These pinch-points funnel potential north–south movement of Sharp-tailed Grouse between the Mansfield Plateau and the Okanogan.
- The pinch-point identified north of the city of Okanogan (square) funnels three least-cost pathways that run among HCAs. This pinch-point is located in the vicinity of Riverside in the Okanogan Valley and crosses the Okanogan River and U.S. Highway 97. It is the only modeled route for east–west movement across the Okanogan Valley. Further narrowing of the pinch-point may compromise connectivity and potentially isolate Sharp-tailed Grouse that occupy habitat on the western side of the valley, e.g., on and near the Scotch Creek Wildlife Area (HCA 4). Thus this is a priority area for considering possible connectivity conservation efforts.

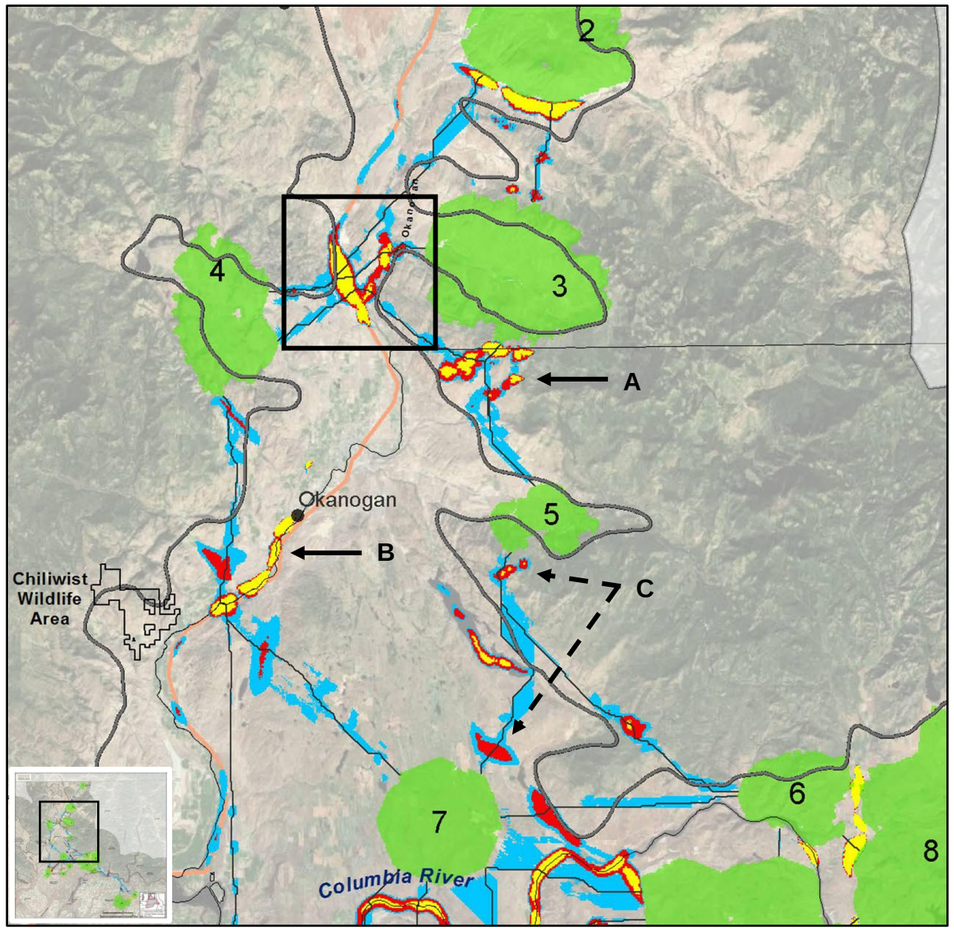

Figure 2.9. Potential restoration opportunities (solid and dashed arrows) for Sharp-tailed Grouse.

- Enhancing connectivity in the area north of the city of Okanogan (square) is important for east–west movement of Sharp-tailed Grouse across the Okanogan Valley.
- Barriers indicated by solid arrows labeled "A" and "B," if possible to restore, may create alternative linkage pathways for Sharp-tailed Grouse. However, the barrier identified by arrow "B" is predominately orchard, housing development, and U.S. Highway 97 along the Okanogan River. This area is not likely to be restored. The barriers/restoration opportunities identified by arrow "A" may be a more feasible target for conservation action to enhance/maintain connectivity for Sharp-tailed Grouse.
- Potential restoration opportunities identified by the dashed arrows labeled "C" may be important for enhancing and maintaining connectivity between the Mansfield Plateau and the Okanogan.

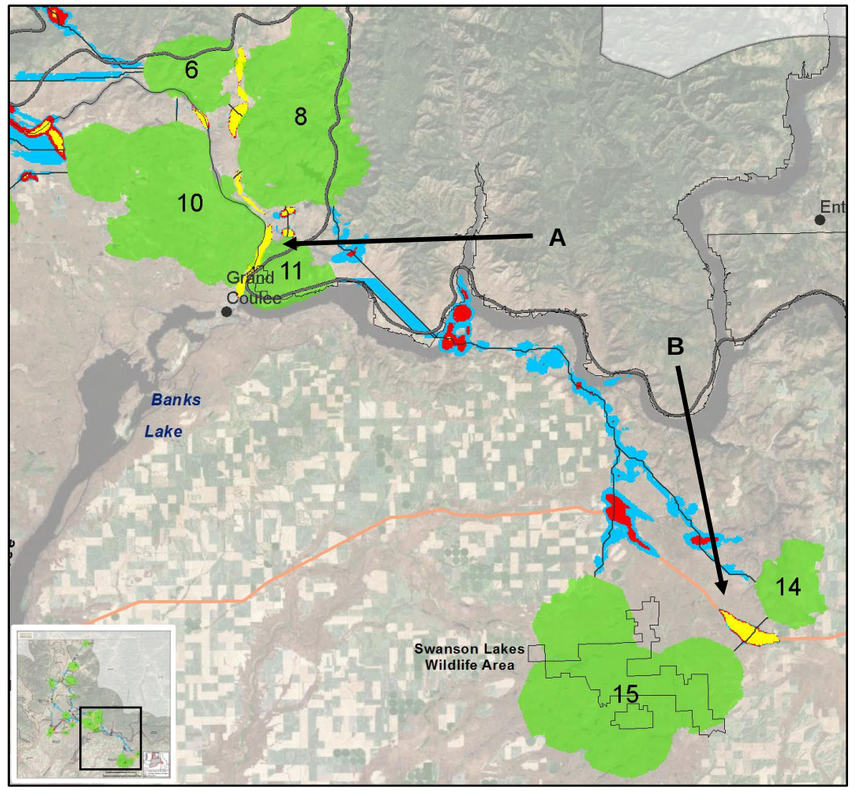

Figure 2.10. Examples of natural and man-made barriers for Sharp-tailed Grouse that are difficult to restore.

- Arrows indicate barriers that if restored would greatly improve connectivity. However, the barrier identified by arrow "A" is the Columbia River and the barrier identified by arrow "B" is primarily U.S. Highway 2. A natural barrier, like the river, is not likely to be altered and wildlife crossing structures typically constructed for roads are currently not designed for birds. However, these types of barriers are important to consider for connectivity as they may be places to avoid incurring additional resistance to movement.

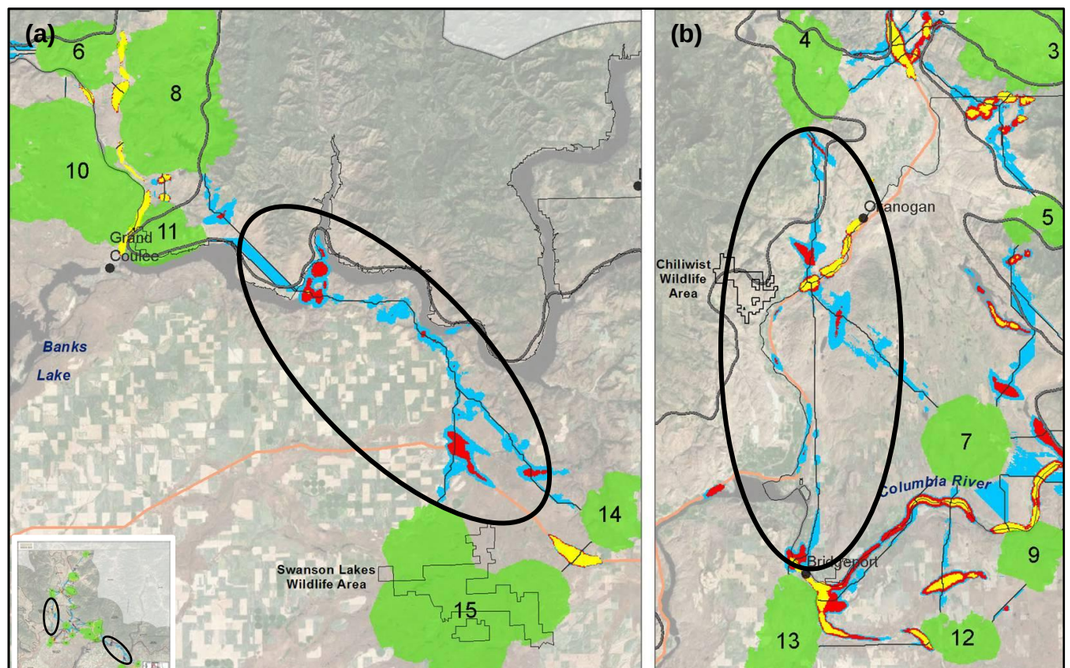

Figure 2.11. Barriers to movement identified for Sharp-tailed Grouse. Panel "a" shows the linkage between HCAs 15 and 14 (vicinity of the Swanson Lakes Wildlife Area) and HCAs north and west of Grand Coulee. Panel "b" shows the linkage betweeen HCA 4 (Scotch Creek Wildlife Area) and the area south of Bridgeport (HCA 13).

- For Sharp-tailed Grouse it is important to consider a connectivity conservation approach that (1) increases the "size" of HCAs, i.e., the area of occupancy, (2) establishes areas of potential occupancy along linkages, and (3) restores identified barriers to help establish "stepping stone" HCAs.
- Restoration of identified barriers for the linkages identified in panels "a" and "b" may yield relatively little improvement in connectivity. Even if all barriers were restored they would still be far in Euclidean distance (approximately 37–50 km).
- For the linkage identified in panel "a" it may be most effective to improve connectivity by increasing the "size" of HCAs 15 and 14, i.e., increasing the area occupied by Sharp-tailed Grouse.
- For the linkage identified in panel "b" land-use practices and the Euclidean length of the linkage pathway limit the effectiveness of conservation actions to improve connectivity. This particular linkage may simply be too challenging to restore. Conservation action may be more effective for north–south linkages on the eastern side of the Okanogan Valley.

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