Appendix A. Modeling Background

Analysis Area

The ecoregional boundaries were slightly modified to correspond to broad-scale patterns identified in the Washington Wildlife Habitat Connectivity Working Group regional analysis. Fracture zone boundaries were delineated by an altitudinal threshold of less than or equal to 1000 m to capture lower side slopes/valley bottoms where agriculture and other land conversion practices predominate and montane forest is not the predominant vegetation cover type. The landscape along the Hwy 3 East Fracture Zone is not well bounded by altitude and, therefore significantly overrepresented human pressures. We applied a 5000 m distance buffer from Hwy 3 to delineate this fracture zone. Between the Hwy 97 Central and Hwy 97 South fracture zones the boundary was defined by the international border where significant differences exist between spatial data and intensity of human development.

Throughout the study area, fracture zone boundaries were regularized by removing long, narrow valleys peripheral to the core zone area. These features were an outcome of applying a 1000 m altitude threshold and did not contribute to our understanding of focal species permeability patterns.

Shrub-steppe Connectivity Models

Focal Species Selection

We used a suite of five shrub-steppe species modeled in the WHCWG statewide analysis (WHCWG 2010) that also occur within or near the Okanagan-Kettle subregion to represent the movement ecology of shrub-steppe species in the study area. These include the American badger (*Taxidea taxus*), Sharp-tailed Grouse (*Tympanuchus phasianellus),* Greater Sage-Grouse (*Centrocercus urophasianus*), black-tailed jackrabbit (*Lepus californicus*), and white-tailed jackrabbit (*L. townsendii*).

The WHCWG focal species selection process followed a series of carefully reviewed steps. This process is outlined in detail in the *Washington Connected Landscapes Project: Statewide Analysis* (WHCWG 2010), available from http://www.waconnected.org.

Resistance model

The shrub-steppe resistance model was based on spatial data layers from the WHCWG statewide analysis (2010). We used the Resistance and Habitat Calculator toolbox in ArcGIS toolbox (McRae et al. 2013) to reclassify and combine (by summing and adding 1) the spatial data layers according to resistance parameters reflecting the movement ecology of shrub-steppe species. These parameters were derived from the mean resistance values assigned to the five focal species listed above in the WHCWG statewide analysis. The mean resistance values used for this composite model are presented in Table A.1. The resulting shrub-steppe resistance model values varied from 1 to 1313.

Habitat Model

We defined shrub-steppe habitat suitability as the reciprocal of the resistance model. The resulting habitat raster was scaled from 0 (non-habitat) to 1 (ideal habitat).

Habitat Concentration Area (HCA) model

HCA polygons for shrub-steppe models were produced using the Core Mapper ArcGIS toolbox (Shirk & McRae 2013). A 500 m moving window was used to identify areas containing an average habitat suitability of at least 0.85. These areas were expanded 1000 m in cost-weighted distance given the resistance model to link nearby patches into larger aggregates. Patches smaller than 500 ha were then removed. The shrub-steppe HCA model was comprised of the remaining patches larger than 500 ha.

Cost-weighted Distance Model

We calculated the cost-weighted distance to the nearest shrub-steppe HCA given the shrub-steppe resistance model. Then, for each of the five fracture zones, we reclassified the CWD models into ten equal area slices with raster values ranked from 1 (lowest CWD) to 10 (highest CWD). The CWD maps in this report reflect the equal area ranking of cost-weighted distance.

Linkage Model

We used the Linkage Mapper ArcGIS toolbox (McRae & Kavanagh 2011) to model the lowest cost corridors between shrub-steppe HCAs, given the shrub-steppe resistance model. For each of the five fracture zones, we reclassified the linkage models into ten equal area slices with raster values ranked from 1 (lowest linkage cost) to 10 (highest linkage cost).

Connectivity Value Model

We calculated connectivity value as the average of the cost-weighted distance models and the linkage models, resulting in a synthesis of the two scaled from 1 to 10, with smaller values being areas that are closer to HCAs and/or closer to the center of the best linkages.

Development Risk Model

We produced a spatial model to identify areas on the landscape that are most at risk of projected future development. This model excluded areas that were already developed (cities, towns, industrial areas, etc.) or not developable (lakes and rivers, wetlands, and steep slopes). Areas farther than 1 km from a major road were also excluded because they were less likely to be developed. What remained were developable lands near major roads.

Connectivity Focus Areas Model

To delineate connectivity focus areas, we masked out portions of the connectivity value model that were not determined to be at risk according to the development risk model. We then calculated the mean connectivity value within a 1 km circular moving window. Finally, we created a binary connectivity focus area model by removing areas where the average smoothed connectivity value was greater than three.

Montane Connectivity Models

Focal Species Selection

We used a suite of ten montane species connectivity models from the WHCWG statewide analysis (WHCWG 2010) that also occur within or near the Okanagan-Kettle subregion to represent the movement ecology of montane species in the study area. These include the Western toad (*Anaxyrus boreas*), Northern flying squirrel (*Glaucomys sabrinus*), wolverine (*Gulo gulo*), Canada lynx (*Lynx canadensis*), American marten (*Martes americana*), mountain goat (*Oreamnos americanus*), American black bear (*Ursus americanus*), elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*), and bighorn sheep (*Ovis canadensis*).

The WHCWG focal species selection process followed a series of carefully reviewed steps. This process is outlined in detail in the *Washington Connected Landscapes Project: Statewide Analysis*, available from http://www.waconnected.org.

Resistance Model

Resistance models for the montane species listed above were produced previously, as described in the WHCWG statewide analysis (WHCWG 2010; available from http://www.waconnected.org).

Habitat Model

Habitat models for the montane species listed above were produced previously, as described in the WHCWG statewide analysis (WHCWG 2010). These models were scaled from 0 (non-habitat) to 1 (ideal habitat), and were based on the reciprocal of the montane species resistance models.

Habitat Concentration Area (HCA) Model

HCA models for the montane species listed above were produced previously, as described in the WHCWG statewide analysis (WHCWG 2010).

Cost-weighted Distance Model

Cost-weighted distance (CWD) models for the montane species listed above were produced previously, as described in the WHCWG statewide analysis (WHCWG 2010). Within each fracture zone, for each of the ten montane species, we reclassified the CWD model into ten equal area slices with raster values ranked from 1 (lowest CWD) to 10 (highest CWD). We then averaged the ten montane focal species CWD models to produce a composite montane CWD rank model scaled from 1 to 10.

Linkage Model

Linkage models for the montane species listed above were all produced previously, as described in the WHCWG statewide analysis (WHCWG 2010). Within each fracture zone, for each of the ten montane species, we reclassified the linkage model into ten equal area slices with raster values ranked from 1 (lowest linkage cost) to 10 (highest linkage cost). We then averaged the ten montane focal species linkage models to produce a composite montane linkage rank model scaled from 1 to 10.

Connectivity Value Model

We calculated connectivity value as the average of the cost-weighted distance models and the linkage models, resulting in a synthesis of the two scaled from 1 to 10, with smaller values being areas that are closer to HCAs and/or closer to the center of the best linkages.

Development Risk Model

We produced a spatial model to identify areas on the landscape that are most at risk of projected future development. This model excluded areas that were already developed (cities, towns, industrial areas, etc.) or not developable (lakes and rivers, wetlands, and steep slopes). Areas farther than 1 km from a major road were also excluded because they were less likely to be developed. What remained were developable lands near major roads.

Connectivity Focus Areas Model

To delineate connectivity focus areas, we masked out portions of the connectivity value model that were not determined to be at risk according to the development risk model. We then calculated the mean connectivity value within a 1 km circular moving window. Finally, we created a binary connectivity focus area model by removing areas where the average smoothed connectivity value was greater than three.

Landscape Integrity Connectivity Models

Resistance Model

The landscape integrity resistance model was based on spatial data layers from the WHCWG statewide analysis (2010), with one exception. The land cover layer was updated within the British Columbia portion of the study area using newly available Okanagan Agricultural Land Use Inventory data (2007–2013) created by the BC Ministry of Agriculture and recent satellite true color imagery. The purpose of the update was twofold: to delineate agricultural uses at a finer scale to capture more subtle differences, e.g., vineyards vs. open fields; and to capture areas of permanent land conversion (i.e., residential development) not reflected in the WHCWG statewide analysis data. We visually interpreted satellite imagery to identify and digitize missing areas of permanent land conversion. We also created a new land cover class for vineyards, which are an important feature in this landscape with resistance that differs from other types of agriculture. Due to time limitations the northern portion of the study area was not reviewed for updates. As the majority of development and agricultural land use changes occur in the southern half of the study area it is likely most of the changes to land use were captured.

We assigned resistance values to the WHCWG statewide analysis spatial data layers (with the above revisions to the landcover layer included), according to the degree to which human landscape modifications reduce movement through landscape features described by these layers. Resistance parameters were based on expert knowledge of the study area and are presented in Table A.2.

We used the Resistance and Habitat Calculator toolbox in ArcGIS (McRae et al. 2013) toolbox to reclassify and combine (by summing and adding 1) the spatial data layers according to the LI resistance parameters. The resulting LI resistance model values varied from 1 to 500.

Habitat Concentration Area (HCA) Model

HCA polygons for the LI model were produced using the Core Mapper ArcGIS toolbox (Shirk & McRae 2013). A 500 m moving window was used to identify areas containing an average habitat suitability of at least 0.85. These areas were expanded 2000 m in cost-weighted distance given the resistance model to link nearby patches into larger aggregates. Patches smaller than 100 ha were then removed. The LI HCA model was comprised of the remaining patches larger than 100 ha.

Cost-weighted Distance Model

We calculated the cost-weighted distance to the nearest LI HCA given the LI resistance model. Then, for each of the five fracture zones, we reclassified the CWD models into ten equal area slices with raster values ranked from 1 (lowest CWD) to 10 (highest CWD). The CWD maps in this report reflect the equal area ranking of cost-weighted distance.

Linkage Model

We used the Linkage Mapper ArcGIS toolbox (McRae & Kavanagh 2011) to model the lowest cost corridors between LI HCAs, given the LI resistance model. For each of the five fracture zones, were reclassified the linkage models into ten equal area slices with raster values ranked from 1 (lowest linkage cost) to 10 (highest linkage cost).

Connectivity Value Model

We calculated connectivity value as the average of the cost-weighted distance models and the linkage models, resulting in a synthesis of the two scaled from 1 to 10, with smaller values being areas that are closer to HCAs and/or closer to the center of the best linkages.

Development Risk Model

We produced a spatial model to identify areas on the landscape that are most at risk of projected future development. This model excluded areas that were already developed (cities, towns, industrial areas, etc.) or not developable (lakes and rivers, wetlands, and steep slopes). Areas farther than 1 km from a major road were also excluded because they were less likely to be developed. What remained were developable lands near major roads.

Connectivity Focus Areas Model

To delineate connectivity focus areas, we masked out portions of the connectivity value model that were not determined to be at risk according to the development risk model. We then calculated the mean connectivity value within a 1 km circular moving window. Finally, we created a binary connectivity focus area model by removing areas where the average smoothed connectivity value was greater than three.

Table A.1. Landscape features and resistance values used to model habitat connectivity for shrub-steppe species.

Spatial data layers and included factors	*Resistance value*
Landcover/Land use	
Agriculture	4
Urban/Developed	1000
Water	20
Sparsely vegetated	2
Alpine	20
Riparian	4
Wetland	4
Grass-dominated	0
Shrub-dominated	0
Dry Forest	0
Wet Forest	0
Slope	
0–20 degrees	0
>20–40 degrees	0
>40 degrees	10
Roads	
Area of no freeways	0
Freeway 500 to 1000 m buffer	0
Freeway 0 to 500 m buffer	4
Freeway centerline	500
Area of no major highways	0
Major highway 500 to 1000 m buffer	0
Major highway 0 to 500 m buffer	2
Major highway centerline	100
Area of no secondary highways	0
Secondary highway 500 to 1000 m buffer	0
Secondary highway 0 to 500 m buffer	1
Secondary highway centerline	20
Area of no local roads	0
Local road 500 to 1000 m buffer	0
Local road 0 to 500 m buffer	0
Local road centerline	0
Forest Structure	
Nonforest	0
Sparse low, forest cover ≤ 40% and height ≤ 25 m	1
Sparse high, forest cover ≤ 40% and height > 25 m	1
Open low, forest cover > 40% and ≤ 70% and height ≤ 25 m	4
Open high, forest cover > 40% and ≤ 70% and height > 25 m	4
Dense low, forest cover > 70% and height ≤ 25 m	20
Dense high, forest cover > 70% and height > 25 m	20

Table A.2. Landscape features and resistance values used to model habitat connectivity for landscape integrity.

Spatial data layers and included factors	*Resistance value*
Landcover/Land use	
Agriculture	25
Urban/Developed	500
Water	2
Sparsely vegetated	0
Alpine	0
Riparian	0
Wetland	0
Grass-dominated	0
Shrub-dominated	0
Dry Forest	0
Wet Forest	0
Forage, pasture, grains, cereals, lawn/grass, other	15
Vines and berries	50
Roads	
Area of no freeways	0
Freeway 500 to 1000 m buffer	8
Freeway 0 to 500 m buffer	25
Freeway centerline	175
Area of no major highways	0
Major highway 500 to 1000 m buffer	3
Major highway 0 to 500 m buffer	25
Major highway centerline	150
Area of no secondary highways	0
Secondary highway 500 to 1000 m buffer	1
Secondary highway 0 to 500 m buffer	3
Secondary highway centerline	25
Area of no local roads	0
Local road 500 to 1000 m buffer	0
Local road 0 to 500 m buffer	1
Local road centerline	3