Appendix C. GIS Data Layer Development and Data Sources

The following sections describe how we developed the six GIS base layers for the connectivity project and list the data compilation sources. Forest structure, acres per dwelling unit, elevation, slope, and road buffer base layer maps are provided in Figures C.1, C.2, C.3, C.4, and C.5, Figure 2.3 (See Chapter 2) shows the land cover/land-use base layer. Following the GIS base layer description below is a listing of specialized GIS data used in Habitat Concentration Area model development. The final section below provides map projection specifications on which the WHCWG GIS data are cast. GIS processing was performed using ArcGIS version 9.2/9.3 software (ESRI 2009).

Land Cover/Land-Use

U.S. — The foundation layer used for constructing the land cover/land-use (LC/LU) raster was obtained from the Northwest Gap Analysis Program (GAP) in April 2009. The GAP layer was recoded into a draft LC/LU layer using the look-up table shown in Table C.1. Several modifications were applied to the GAP ecological systems map to create the final 11-class land cover layer (See Appendix B). The GAP ecosystems map contained over 1 million hectares in the harvested forest-tree regeneration class, a forest disturbance class without an ecosystem designation. In Northwest GAP Mapping Zone 1 (Washington Cascades to Pacific Ocean), the Northwest GAP Ecosystem Modifiers map was used to "tag" forest regeneration areas with an ecosystem classification. In Oregon, Landfire Existing Vegetation (EVT) was used to tag forest regeneration areas in the region from the Cascades to the Pacific coast. In the remaining areas of eastern Washington and Oregon, harvested forest regeneration areas were labeled as dry forest. Recently burned forest areas in eastern Washington and Oregon were recoded to grass. After the modifications, the modified ecosystems raster was recoded into LC/LU classes (See Appendix B). The draft 11-class raster map was projected from U.S. Albers to WHCWG Albers and converted to 100-meter cell using a modified majority block statistics procedure.

The Oregon portion of the GAP ecosystems map had considerable mileage of logging roads embedded in the map (mapped as Developed, Open Space). Additional GIS processing was performed to remove some of the light-duty roads and replace them with land cover adjacent to the roads.

British Columbia — The Provincial Biogeoclimatic Subzones/Variant (BGC) layer provided ecosystem boundaries. The BGC was incorporated with other layers to tie ecosystem type to mapped forest cover. The Vegetation Resource Inventory (VRI) was the primary forest cover source. The Baseline Thematic Mapping (BTM) layer provided forest cover information in areas not mapped by VRI (e.g., tree farm license areas attributed as unreported). The BGC, VRI, and BTM were converted to 25-meter rasters prior to development work. VRI and BTM forested areas were tagged with a BGC ecosystem type and mapped to wet or dry forest. Additional review of VRI forest labels and BGC subzone/variant labels was performed in the south central portion of the project area, refining the wet and dry forest assignments.

VRI provided the initial mapping for the non-forest classes Agriculture, Urban/Developed, Water, Sparsely Vegetated, Alpine, Wetland, Grass-dominated, and Shrub-dominated (See Appendix B). In VRI unreported areas BTM was used for non-forest mapping. BTM non-vegetated areas were also used in VRI reported areas to amend and/or augment VRI mapping.

The VRI and BTM data varied in mapping completeness, attribution, and currency requiring some post processing and/or manual editing of vegetated and non-vegetated areas. Shrub appeared over represented in the south central portion of the British Columbia project area. Selected shrub areas were moved to a forest class based on a query of VRI site index and harvest date. Marsh and swamp polygons from the British Columbia Freshwater Atlas augmented the Wetland class in the draft map. The Riparian class is not represented in the British Columbia portion of the project because the VRI and BTM do not map riparian as a class. Due to source data coding, transmission line corridors in remote areas were assigned to the Urban/Developed class in preliminary maps. These areas were blended with adjacent land cover types in the same manner as the roads in the Oregon area.

Forest Structure

U.S. — The forest structure raster was constructed from the Landsat-based Landfire forest crown cover and forest height layers. When the initial crown cover mosaic was constructed and compared to orthophotographs, many forest areas appeared to have higher crown cover values than expected. Time did not permit full independent analysis of ancillary aerial photography. Landfire crown cover has a documented problem with over estimation of crown cover (Landfire Notification December 2006). To alleviate some of the apparent over estimation, crown cover was adjusted downward across the U.S. portion of the project area. The adjustments were adapted from Landfire documentation (Landfire Notification December 2006). Tree cover greater than or equal to 10% and less than 50% was adjusted downward by 15%. Tree cover greater than or equal to 50% was adjusted downward by 25%. Ideally, adjustments should be done within Landfire mapping zones or ecological units, however, time constraints did not allow more detailed crown cover work.

Comparison of Landfire forest height with orthophotography also revealed mapping inconsistencies. Forest height was used directly however without attempting adjustment. The forest cover and forest height layers were processed into a single raster layer using the forest structure classes listed in Appendix B.

Additional GIS processing was required to amend a Landfire data gap south of the international border. The data gap is a documented Landfire mapping problem (Landfire Notification August 2006). In Washington, this data gap grows increasingly wide, to about 1 kilometer, from the eastern Washington Cascades to the Washington – Idaho border. For the crown cover layer, crown cover from 2001 National Land Cover Data (NLCD) was used to patch the gap. Forest height data were not readily available; therefore, GIS procedures were used to "pull" forest height values across the data gap from the U.S. and British Columbia. The 11-class LC/LU and forest structure layers were post-processed to reconcile differences between forest and nonforest.

British Columbia — Construction of the British Columbia forest structure layer was problematic. No single GIS source was available, data gaps existed, and, unlike the U.S. portion, data were compiled from manual interpretation of aerial photos and Landsat photos and digital image processing of Landsat imagery. The primary source layer was the VRI vector polygons. In VRI data gaps, BTM or Earth Observation Sustainable Development (EOSD) data were used. The EOSD forest cover categories did not match WHCWG cover class breaks, however, no alternative data source was available. In limited portions of the VRI coverage, data gaps existed in which no forest information was available, therefore, crown cover and structure were estimated from the BGC layer.

In areas of VRI coverage, the VRI crown closure attribute was used in constructing the crown cover component of the forest structure layer. Crown closure and crown cover forest inventory procedures can connote different ways of assessing forest cover (Jennings et al. 1999). VRI aerial photo interpretation procedures (Ministry of Forests and Range 2010) appear to describe a crown cover interpretation methodology. The procedures also specify reporting crown closure for each canopy layer and linking the closure value to the polygon with a layer ID value. It was not apparent from the data if the reported crown closure value was for a single forest canopy layer or an aggregate value for each polygon. Comparison of VRI crown closure values and orthophotographs indicated that in many VRI polygons the crown closure attribute was considerably lower than percent forest cover as viewed in orthophotography. Communication with BC Ministry of Forests and Range also indicated a tendency of photo interpreters to underestimate crown closure (Edward Fong, personal communication).

Given the uncertainties in forest cover mapping and limited time available for developing the layer, a coarse adjustment was applied. The VRI crown closure values were adjusted upward by 20% to improve agreement with orthophotographs. The coarse adjustment, while not ideal, provided an expedient means to integrate the VRI with the Landsat-derived U.S. crown cover.

The primary forest height source was VRI and it was used directly without adjustment. Height was roughly estimated using the VRI attribute Proj_Height. In VRI unreported areas where no combination of BTM or EOSD yielded any forest information, BGC was used to estimate forest height.

The 11-class land cover, forest cover, and forest height rasters were combined in an editing procedure to reconcile forest and nonforest areas between the three layers. The forest cover and forest height layers were combined into a single raster layer and coded into seven classes (See Appendix B). The 11-class LC/LU and forest structure rasters were converted from 25 meter cell size to 100 meter using a majority block stats GIS procedure. The layers were mosaicked with the U.S. layers to create the final 11-class land cover and forest structure layers. The base layers were trimmed to U.S. and British Columbia mainland areas, removing islands and marine features.

Land Cover/Land-Use and Forest Structure Data Sources

- ***U.S.***

Theme: **Gap Analysis Program National Land Cover**
Source: Gap Analysis Program
Format: raster
Cell size: 30 meters
Publication date: 2009/2010
Landsat acquisition period: 1999–2001
On line linkages:
http://gap.uidaho.edu/index.php/gap-home/Northwest-GAP/landcover/download-data-by-state
http://www.gap.uidaho.edu/landcoverviewer.html

Theme: **Potential Ecological System Modifiers in Mapping Zone 1 (Modifier Map)**
Source: Gap Analysis Program
Format: raster
Cell size: 30 meters
Publication date: 2007
Landsat acquisition period: 1970s, 1990s, and the year 2000.
On line linkage: unknown. Available from Northwest GAP Office, Moscow, Idaho.

Theme: **Existing Vegetation Type**
Source: Landfire (Landscape Fire and Resource Management Planning Tools Project)
Format: raster
Cell size: 30 meters
Publication date: 2006
Landsat acquisition period: 1999 – 2003
On line linkage: http://www.landfire.gov/NationalProductDescriptions21.php

Theme: **Existing Vegetation Height**
Source: Landfire (Landscape Fire and Resource Management Planning Tools Project)
Format: raster
Cell size: 30 meters
Publication date: 2006
Landsat acquisition period: 1999 – 2003
On line linkage: http://www.landfire.gov/NationalProductDescriptions22.php

Theme: **Existing Vegetation Cover**
Source: Landfire (Landscape Fire and Resource Management Planning Tools Project)
Format: raster
Cell size: 30 meters
Publication date: 2006
Landsat acquisition period: 1999 – 2003
On line linkage: http://www.landfire.gov/NationalProductDescriptions23.php

- ***British Columbia***

Theme: **Biogeoclimatic Subzones/Variant Version 7**
Source: BC Ministry of Forests and Range, Research Branch
Format: vector polygons
Publication date: 2008
Scale of mapping online link:
ftp://ftp.for.gov.bc.ca/HRE/external/!publish/becmaps/PaperMaps/BGC_ScaleOfMapping.pdf
Online linkage:
http://www.for.gov.bc.ca/hre/becweb/resources/maps/gis_products.html

Theme: **Baseline Thematic Mapping Present Land Use**
Source: BC Integrated Land Mgt. Bureau, Crown Registry and Geographic Base Branch
Format: vector polygons
Publication date: Version 1 1995/Limited updates to Version 2 circa 2000
Scale of mapping: 1:250,000
Online linkages:
https://apps.gov.bc.ca/pub/geometadata/metadataDetail.do?recordUID=43171&recordSet=ISO19115
http://archive.ilmb.gov.bc.ca/cis/initiatives/ias/btm/index.html

Theme: **Vegetation Resource Inventory Forest Vegetation Composite Polygons and Rank 1 Layer (VRI)**
Source: BC Ministry of Forests and Range, Forest Analysis and Inventory Branch
Format: vector polygon
Scale of mapping: 1:20,000
Publication date: 2006/ongoing
Online linkages: http://www.for.gov.bc.ca/hts/vri/intro/index.html
https://apps.gov.bc.ca/pub/geometadata/metadataDetail.do?recordUID=47574&recordSet=ISO19115

Theme: **Earth Observation for Sustainable Development of Forests**
Source: Canadian Forest Service
Format: raster
Cell size: 25 meters
Publication date: 2006
Landsat acquisition period: circa 2000
Online linkages:
http://www4.saforah.org/eosdlcp/nts_prov.html
http://cfs.nrcan.gc.ca/subsite/eosd/home

Theme: **Freshwater Atlas Wetlands**
Source: BC Integrated Land Mgt. Bureau, Crown Registry and Geographic Base Branch
Format: vector polygon
Publication date: 2006/2008 revisions
Scale of mapping: 1:20,000

Online linkage:
http://ilmbwww.gov.bc.ca/geobc/FWA
https://apps.gov.bc.ca/pub/geometadata/metadataDetail.do?from=search&edit=true&showall=showall&recordSet=ISO19115&recordUID=50653

Acres per Dwelling Unit

U.S. — The housing density data were compiled from U.S. Census 2000 block and block-group sources using methods described by the U.S. Environmental Protection Agency (EPA; 2009). Dwelling unit projection data (e.g., from year 2000 to year 2010) were not used in the habitat connectivity project. An additional class was added to the raster to contain sparsely populated areas not mapped in the published 11-class map. The modified housing density raster was recoded from 12 classes to five classes for the habitat connectivity project (See Appendix B).

British Columbia — Dwelling counts were derived from 2001 Statistics Canada total private dwellings census subdivision-level summaries. Areas not likely to contain human habitation or development were partitioned from the census subdivision polygons using polygons used by Singleton et al. (2002). Additional refinements incorporated BTM Urban class and lands within publically-protected areas. The number of dwelling units was linked to the partitioned area within each census subdivision polygon. Area units were converted to acres to match the U.S. housing density data. The vector polygons were converted to a 100-meter raster and mosaicked with the U.S. dwelling unit layer. The base layer was trimmed to U.S. and British Columbia mainland areas, removing islands and marine features.

Acres per Dwelling Unit Data Sources

- ***U.S.***

  Theme: **Housing Density 2000**
  Source: Natural Resource Ecology Lab, Colorado State University, Fort Collins, CO
  Format: raster
  Cell size: 100 meters
  Publication date: production circa 2008; U.S. census year 2000.
  Online linkage: www.nrel.colostate.edu

- ***British Columbia***

  Theme: **Census Subdivisions Cartographic Boundary Files**
  Source: Statistics Canada
  Format: vector polygon
  Scale of mapping: 1:50,000–1:250,000
  Publication date: 2002
  Online linkage:
  http://www.statcan.gc.ca/bsolc/olc-cel/olc-cel?lang=eng&catno=92F0162X

Theme: **Population and Dwelling Counts for Canada, Provinces and Territories**
Source: Statistics Canada
Format: table
Publication date: 2002; Canada census year 2001
Online linkage:
http://www12.statcan.ca/English/census01/products/standard/popdwell/Table-CSD-P.cfm?PR=59

Elevation

U.S. — The elevation raster was assembled from the USGS 1 arc second, 30-meter National Elevation Dataset. Data were downloaded in August 2009, mosaicked and projected to WHCWG Albers using bilinear interpolation. Elevation units meters.

British Columbia — The elevation raster was compiled from 25-meter digital elevation grids. Elevation units meters. The elevation grids were reprojected from UTM to WHCWG Albers and resampled to 30 meter cell size using bilinear interpolation. The 30 meter raster was mosaicked with the U.S. elevation layer. The combined U.S. - British Columbia 30-meter elevation raster was resampled to 100 meter cell size using bilinear interpolation. This raster was recoded to 9 elevation classes (See Appendix B). The base layer was trimmed to U.S. and British Columbia mainland areas, removing islands and marine features.

Elevation Data Sources

- ***U.S.***

  Theme: **National Elevation Dataset (NED)**
  Source: US Geological Survey
  Format: raster, elevation unit meters
  Cell size: 30 meters
  Publication date: ongoing
  Online linkage: http://seamless.usgs.gov/products/1arc.php

- ***British Columbia***

  Theme: **Terrain Resource Information Management (TRIM) Digital Elevation Model**
  Source: BC Integrated Land Mgt. Bureau, Crown Registry and Geographic Base Branch
  Format: raster, elevation unit meters
  Cell size: 25 meters
  Publication date: ongoing
  Online linkage:
  http://archive.ilmb.gov.bc.ca/crgb/products/imagery/gridded.htm

Slope

The slope raster was generated from the U.S. - British Columbia 100-meter elevation mosaic. Degree slope was computed from the mosaic and recoded to the project slope categories (See Appendix B). The base layer was trimmed to U.S. and British Columbia mainland areas, removing islands and marine features.

Roads

We evaluated a number of different GIS layers representing the road networks in our study area. GIS data developed for the United States census, a system called TIGER, included roads. We found the TIGER roads layer to be very good wherever people were living. It was not, however, particularly good at capturing roads in remote areas like industrial or state forest lands or National Forest or other federal lands. The Washington Department of Natural Resources (DNR) has built a roads data layer that is considerably more complete outside of urban areas. For Oregon, we considered the TIGER roads layer adequate for our purposes. For British Columbia, we used government data called “British Columbia Roads”.

Because the TIGER roads layer was accurate and complete in urban areas, and included useful road characteristics attributes, we used it to represent roads in all urban areas of Washington but defaulted to DNR’s roads layer outside of urban areas. TIGER roads in Washington urban areas, DNR roads in Washington rural areas, TIGER roads for all of Oregon and Idaho, and B.C. roads for British Columbia, were compiled as a single data layer.

Focal species biologists advised that major interstates, characterized by multiple lanes in each direction, median or concrete barriers between opposing traffic, and high traffic volumes over much of their lengths deserved to be a separate category because of the significant barrier effect they represent to many wildlife species. This category is called “Freeway”. Three other categories of road were established, “Major Highway”, “Secondary Highway”, and “Local Road”. Based on our roads classification, approximately 95% of all roads within the project area boundary are Local Road and the remaining 5% are divided among Freeway, Major Highway, and Secondary Highway categories. We also established a category called “Distance to Roads” to represent any behavioral avoidance, injury or mortality effects of roads to our focal species.

- *Freeway* — TIGER field CFCC2 = “A1”, (and visually matched DNR roads with Road Class = “Primary”) and most British Columbia freeways. This combination of road types includes TIGER Interstate highways distinguished by the presence of interchanges. They have multiple lanes of traffic, and opposing lanes are separated by a median strip (A1 roads). It also includes B.C. Digital Road Atlas roads for which ROAD_CLASS = “freeway”, with the exception of a few roads identified by the Modeling Team as belonging in the Major Highway category. Though traffic volumes at any particular location along these highways can vary considerably, these road types tend to carry the highest traffic volumes and are designed for relatively high speeds. Annual Average Daily Traffic Volumes are almost always above 2000 vehicles and commonly exceed 25,000 vehicles. Examples include Interstate 5 (I-5), I-405, I-82, I-90, and I-182.

- *Major Highway* — TIGER field CFCC2 = “A2”, (and all DNR Road Class = “Primary” roads not matching up with TIGER CRCC2 “A1” roads and a few British Columbia freeways). This combination of road types includes nationally and regionally important highways, mainly U.S. highways, but also some state highways and county highways that connect cities and larger towns (A2 roads). It also includes several roads from the B.C. Digital Road Atlas (ROAD_CLASS = “freeway”) that were downgraded from the Freeway category; these were selected based on their limited length, and the fact that they did not connect adjacent provinces or large cities. Traffic volumes at any particular location along these highways can vary considerably. Annual Average Daily Traffic Volumes usually range between 800 and 20,000 vehicles. Examples include: U.S. 101 (Olympia to Shelton), State Route 8 (SR8) and U.S. 12 (Olympia to Elma), SR 167, SR 512, U.S. 2 (at Marysville), U.S. 395 (Tri-cities to I-90), U.S. 2 (jct. U.S. 97 to Wenatchee), U.S. 101 (Olympic Peninsula and Willapa Hills), U.S. 2 (Snohomish to jct. U.S. 97), U.S. 12 (I-5 to Naches), U.S. 12 (Tri-cities to Idaho border), SR195 (Spokane to Pullman), U.S. 395 (Spokane to Canada), U.S. 2 (Spokane to Idaho border), and U.S. 97 (Wenatchee to Canada).

- *Secondary Highway* — TIGER field CFCC2 = “A3”, DNR Road Class = “Secondary” and B.C. Road_Class = “Arterials” and “Collectors”. These roads are mostly state highways but may include some county highways that connect smaller towns, subdivisions, and neighborhoods. The roads in this category generally are smaller than roads included in the Major Highway category, must be hard-surfaced (concrete or asphalt), and are usually undivided with single-lane characteristics. Traffic volumes are highly variable but Average Annual Daily Traffic often ranges between about 500 and 10,000 vehicles. Examples include: SR530 (Arlington to U.S. 20), U.S. 20 (Anacortes to Okanogan), SR153 (Twisp to Pateros), Redmond-Fall City Rd, Carnation-Duvall Rd, SR243 (I-90 to Mattawa), SR24, SR240, SR260, SR261, SR28 (Soap Lake to Davenport), SR155 (Omak to Coulee Dam), and many more.

- *Local Road* — TIGER field CFCC2 = “A4” or “A6”, DNR Road Class = “Light Duty”, “Unimproved”, or “Unknown”, and all remaining roads in B.C. Roads layer. Roads included in this category have a single lane of traffic in each direction. In an urban area, this is a neighborhood road or street that is not a thoroughfare belonging in one of the above categories. In a rural area, these roads are short-distance roads connecting the smallest towns. These roads may or may not have a state or county route number. Scenic park roads, unimproved or unpaved roads, and industrial roads are included in this category. Most roads in the nation fall in this category.

- *Distance to Road* — Road effects are characterized for each road type within each of four distance bands: Centerline, 0–500 meters, 500–1000 meters, and >1000 meters. Centerline road effects can include both behavioral avoidance and injury or mortality. Other distance bands can cause behavioral avoidance that varies by species. The causes of behavioral avoidance can include noise, odors, the presence of people, and a variety of visual cues. Disturbance effects are expected to diminish with distance, depending on the species and its behavior/vulnerabilities.

The U.S. and British Columbia transportation vector data sets were merged into a single layer. Each road type was extracted and converted to 100-meter cell raster. For each raster road type, a raster buffer was generated using Euclidean distance from the raster line. Euclidean distances 0 to 500 meters, 500 to 1000 meters, and greater than 1000 meters were assigned to classes 3, 2, and 1 respectively (See Appendix B). Class 4 was assigned to the raster road "centerline" from which Euclidean distances were measured. The base layer was trimmed to U.S. and British Columbia mainland areas, removing islands and marine features. Figure C.6 shows the raster road buffer configuration.

The final raster buffers are uniform for straight line segments and form true buffer distances from the center raster line. However as the transportation lines become more sinuous, raster representation of buffer distances become more variable. The Euclidean distance procedure provided an expedient GIS methodology to build zones around the large number of transportation lines.

A single road effect value contributed to each species' resistance cell values. In instances of overlapping road influences, a cell was assigned the highest resistance represented in the competing categories.

Road Data Sources

- ***U.S.***

  Theme: **TIGER/Line Roads Census 2000**
  Source: US Census Bureau
  Format: vector line
  Scale of mapping: 1:100,000
  Publication date: 2001
  Online linkage: http://www.census.gov/geo/www/tiger/

  Theme: **Washington Department of Natural Resources Transportation Data Layer**
  Source: Washington State Department of Natural Resources
  Format: vector line
  Scale of mapping: 1:24,000
  Publication date: 1996 with partial updates to 2008
  Online linkage: http://fortress.wa.gov/dnr/app1/dataweb/dmmatrix.html

- ***British Columbia***

  Theme: **Digital Road Atlas**
  Source: BC Integrated Land Mgt. Bureau, Crown Registry and Geographic Base Branch
  Format: vector line
  Scale of mapping: 1:20,000
  Publication date: on-going
  Online linkages:
  http://archive.ilmb.gov.bc.ca/crgb/products/mapdata/digital_road_atlas_products.htm

https://apps.gov.bc.ca/pub/geometadata/metadataDetail.do?from=search&edit=true&showall=showall&recordSet=ISO19115&recordUID=45674

Habitat Concentration Area (HCA) GIS Model Data Sources

Nine focal species required specialized GIS data for HCA modeling. This section provides information pertaining to GIS data used in focal species HCA model development (See Appendix A).

Sharp-tailed Grouse (*Tympanuchus phasianellus*)

Digital polygonal data not formally published. Seven HCA polygons acquired from internal WDFW GIS source developed from Stinson & Schroeder (2010). One HCA polygon developed from Methow Recovery Unit. Compilation scale for all polygons not published, but may be in the range of 1:24,000 to 1:500,000 scale.

Greater Sage-Grouse (*Centrocercus urophasianus*)

Digital polygonal data not formally published. HCA polygons acquired from internal WDFW GIS source developed from Stinson et al. (2004) and Schroeder et al. (2004). Original polygons based on distribution data and areas of known high conservation potential. Primary compilation scale was 1:10,000 with transfer of polygons to regional mapping at 1:2,000,000-scale.

Mule deer (*Odocoileus hemionus*)

Theme: Mule Deer Habitat of North America
Source: RS/GIS Laboratory, Utah State University
Scale of mapping: 1:250,000
Format: vector polygon
Publication date: 2004
Online linkage: http://www.gis.usu.edu/current_proj/muledeer.html

Bighorn sheep (*Ovis canadensis*)

Digital polygonal data not formally published. Washington herd polygons compiled by Washington Department of Fish and Wildlife at coarse scale from aerial surveys and observation data. Other herd location data sources include Northern Wild Sheep and Goat Council and the British Columbia Ministry of Environment.

Elk (*Cervus elaphus*)

Theme: Winter and summer elk range
Source: Rocky Mountain Elk Foundation M.A.P Elk Habitat Project
Scale of mapping: 1:250,000 in the U.S.; 1:1,000,000 in Canada
Format: vector polygon
Publication date: 1999
Data on CD from Rocky Mountain Elk Foundation, Missoula, MT.

Western toad (*Anaxyrus boreas*)

Theme: National Wetlands Inventory
Source: U.S. Fish and Wildlife Service
Scale of mapping: 1:24,000
Format: vector polygon
Publication date: 1977 to present
On line linkages: http://www.fws.gov/wetlands/data/DataDownload.html

Canada lynx (*Lynx canadensis*)

Theme: Canada lynx core and secondary areas
Source:
USFWS (U.S. Fish and Wildlife Service). 2005. Recovery Outline: Contiguous United States Distinct Population Segment of the Canada Lynx. U.S. Fish and Wildlife Service, Montana Field Office, Helena, Montana.
On line linkage:
http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=A073#recovery

Mountain goat (*Oreamnos americanus*)

Digital polygonal data not formally published. Herd location data sources include Washington Department of Fish and Wildlife, Idaho Department of Fish and Game, Oregon Department of Fish and Wildlife, Montana Department of Fish, Wildlife, and Parks. Data collected by ground surveys, aerial surveys, and expert knowledge.

Wolverine (*Gulo gulo*)

Theme: Snow cover estimation data
Source: Snow Data Assimilation System (SNODAS), National Snow and Ice Data Center, University of Colorado, Boulder, Colorado.
Format: Raster
Cell size: 1 kilometer
Publication dates: 2003–2009
Online linkage: http://nsidc.org/data/g02158.html

Theme: Snow cover estimation data
Source: Data received 7 October 2009 via personal communication from Ross Brown, Environment Canada
Format: Raster
Cell size: 24 kilometer
Publication dates: 1980–1997

WHCWG Map Projection Specifications

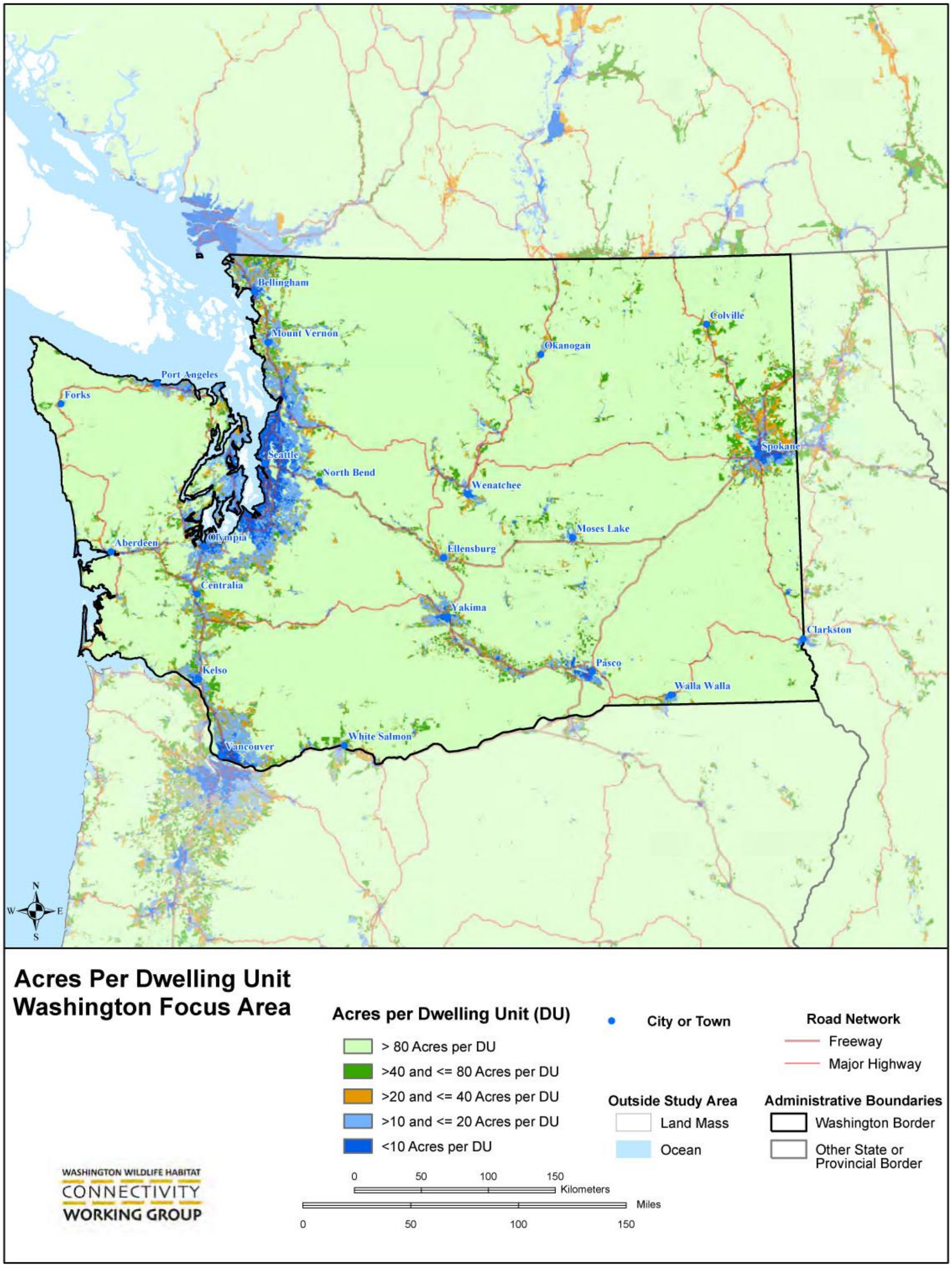
Projected coordinate system name:
HabConnectProjectArea_North_America_Albers_Equal_Area_Conic
Geographic coordinate system name: GCS_North_American_1983

Map_Projection_Name: Albers Conical Equal Area
Albers_Conical_Equal_Area:
Standard_Parallel: 43.000000
Standard_Parallel: 48.000000
Longitude_of_Central_Meridian: -120.000000
Latitude_of_Projection_Origin: 41.000000
False_Easting: 700000.000000
False_Northing: 0.000000

Planar_Coordinate_Information:
Planar_Coordinate_Encoding_Method: coordinate pair
Coordinate_Representation:
Abscissa_Resolution: 0.000100
Ordinate_Resolution: 0.000100
Planar_Distance_Units: meters

Geodetic_Model:
Horizontal_Datum_Name: North American Datum of 1983
Ellipsoid_Name: Geodetic Reference System 80
Semi-major_Axis: 6378137.000000
Denominator_of_Flattening_Ratio: 298.257222

Appendix C. Figure C.1. Forest structure base layer.



Appendix C. Figure C.2. Acres per dwelling unit base layer.

Appendix C. Figure C.3. Elevation base layer.

Appendix C. Figure C.4. Slope base layer.

Appendix C. Figure C.5. Road buffers base layer.

Appendix C Table C.1. GAP raster to WHCWG land cover/land-use reclassification table.

WHCWG Classname	*GAP Raster Class Name*
Agriculture	CRP
Agriculture	Orchards/Vineyards
Agriculture	Pasture/Hay
Agriculture	Cultivated Cropland
Agriculture	High Structure Agriculture
Alpine	North Pacific Alpine and Subalpine Bedrock and Scree
Alpine	North American Alpine Ice Field
Alpine	Rocky Mountain Alpine Bedrock and Scree
Alpine	North Pacific Dry and Mesic Alpine Dwarf-Shrubland, Fell-field and Meadow
Alpine	Rocky Mountain Alpine Dwarf-Shrubland
Alpine	Rocky Mountain Alpine Fell-Field
Alpine	Rocky Mountain Alpine Turf
Alpine	North Pacific Alpine and Subalpine Dry Grassland
Alpine	Rocky Mountain Alpine Tundra/Fell-field/Dwarf-shrub Map Unit
Dry Forest	North Pacific Oak Woodland
Dry Forest	Northern Rocky Mountain Western Larch Savanna
Dry Forest	Rocky Mountain Aspen Forest and Woodland
Dry Forest	Mediterranean California Mixed Oak Woodland
Dry Forest	Mediterranean California Lower Montane Balck Oak-Conifer Forest and Woodland
Dry Forest	Mediterranean California Red Fir Forest
Dry Forest	North Pacific Dry Douglas-fir (Madrone) Forest
Dry Forest	Mediterranean California Mixed Evergreen Forest
Dry Forest	Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest
Dry Forest	Northern Rocky Mountain Subalpine Woodland and Parkland
Dry Forest	Rocky Mountain Lodgepole Pine Forest
Dry Forest	Northern Rocky Mountain Ponderosa Pine Woodland and Savanna
Dry Forest	Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland
Dry Forest	Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland
Dry Forest	Middle Rocky Mountain Montane Douglas-fir Forest and Woodland
Dry Forest	Rocky Mountain Poor Site Lodgepole Pine Forest and Woodland
Dry Forest	East Cascades Oak-Ponderosa Pine Forest and Woodland
Dry Forest	Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland
Dry Forest	North Pacific Wooded Volcanic Flowage
Dry Forest	Introduced Upland Vegetation - Treed
Grass-dominated	Willamette Valley Upland Prairie and Savanna
Grass-dominated	Columbia Plateau Steppe and Grassland
Grass-dominated	Columbia Basin Foothill and Canyon Dry Grassland
Grass-dominated	Inter-Mountain Basins Semi-Desert Grassland
Grass-dominated	North Pacific Montane Grassland
Grass-dominated	Northern Rocky Mountain Lower Montane, Foothill and Valley Grassland
Grass-dominated	Northern Rocky Mountain Subalpine-Upper Montane Grassland
Grass-dominated	Columbia Basin Palouse Prairie

Appendix C Table C.1. Continued.

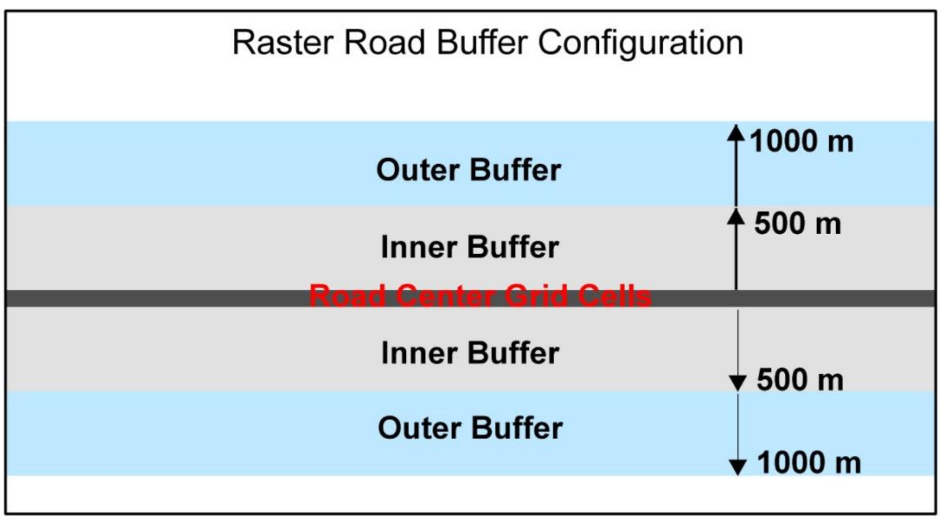
WHCWG Classname	*GAP Raster Class Name*
Grass-dominated	Rocky Mountain Subalpine-Montane Mesic Meadow
Grass-dominated	North Pacific Herbaceous Bald and Bluff
Grass-dominated	Introduced Upland Vegetation - Annual Grassland
Grass-dominated	Introduced Upland Vegetation - Perennial Grassland
Grass-dominated	Recently burned forest
Grass-dominated	Recently burned grassland
Grass-dominated	Harvested forest-grass regeneration
Grass-dominated	Willamette Valley Wet Prairie
Landfire EVT or Regap Modifier	Harvested forest-tree regeneration
Riparian	Introduced Riparian and Wetland Vegetation
Riparian	North Pacific Lowland Riparian Forest and Shrubland
Riparian	North Pacific Montane Riparian Woodland and Shrubland
Riparian	Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland
Riparian	Rocky Mountain Lower Montane Riparian Woodland and Shrubland
Riparian	Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland
Riparian	Columbia Basin Foothill Riparian Woodland and Shrubland
Riparian	Rocky Mountain Subalpine-Montane Riparian Shrubland
Riparian	Rocky Mountain Subalpine-Montane Riparian Woodland
Riparian	Mediterranean California Foothill and Lower Montane Riparian Woodland
Shrub-dominated	Columbia Plateau Western Juniper Woodland and Savanna
Shrub-dominated	Inter-Mountain Basins Mountain Mahogany Woodland and Shrubland
Shrub-dominated	Columbia Plateau Scabland Shrubland
Shrub-dominated	Great Basin Xeric Mixed Sagebrush Shrubland
Shrub-dominated	Inter-Mountain Basins Big Sagebrush Shrubland
Shrub-dominated	Inter-Mountain Basins Mixed Salt Desert Scrub
Shrub-dominated	North Pacific Avalanche Chute Shrubland
Shrub-dominated	North Pacific Montane Shrubland
Shrub-dominated	Rocky Mountain Lower Montane-Foothill Shrubland
Shrub-dominated	California Montane Woodland and Chaparral
Shrub-dominated	Northern and Central California Dry-Mesic Chaparral
Shrub-dominated	Northern Rocky Mountain Montane-Foothill Deciduous Shrubland
Shrub-dominated	Northern Rocky Mountain Subalpine Deciduous Shrubland
Shrub-dominated	Northern Rock Mountain Avalanche Chute Shrubland
Shrub-dominated	Columbia Plateau Low Sagebrush Steppe
Shrub-dominated	Inter-Mountain Basins Big Sasgebrush Steppe
Shrub-dominated	Inter-Mountain Basins Montane Sagebrush Steppe
Shrub-dominated	Inter-Mountain Basins Semi-Desert Shrub Steppe
Shrub-dominated	North Pacific Hypermaritime Shrub and Herbaceous Headland
Shrub-dominated	Introduced Upland Vegetation - Shrub
Shrub-dominated	Introduced Upland Vegetation - Forbland
Shrub-dominated	Recently burned shrubland
Shrub-dominated	Harvested forest-shrub regeneration

Appendix C Table C.1. Continued.

WHCWG Classname	*GAP Raster Class Name*
Shrub-dominated	Harvested forest-herbaceous regeneration
Shrub-dominated	Inter-Mountain Basins Greasewood Flat
Shrub-dominated	Columbia Plateau Silver Sagebrush Seasonally Flooded Shrub-Steppe
Sparsely Vegetated	Inter-Mountain Basins Volcanic Rock and Cinder Land
Sparsely Vegetated	Rocky Mountain Cliff, Canyon and Massive Bedrock
Sparsely Vegetated	North Pacific Volcanic Rock and Cinder Land
Sparsely Vegetated	North Pacific Montane Massive Bedrock, Cliff and Talus
Sparsely Vegetated	North Pacific Coastal Cliff and Bluff
Sparsely Vegetated	North Pacific Serpentine Barren
Sparsely Vegetated	Inter-Mountain Basins Active and Stabilized Dune
Sparsely Vegetated	Inter-Mountain Basins Cliff and Canyon
Sparsely Vegetated	Columbia Plateau Ash and Tuff Badland
Sparsely Vegetated	North Pacific Maritime Coastal Sand Dune and Strand
Sparsely Vegetated	Inter-Mountain Basins Playa
Sparsely Vegetated	Inter-Mountain Basins Alkaline Closed Depression
Sparsely Vegetated	Non-specific Disturbed
Sparsely Vegetated	Columbia Plateau Vernal Pool
Urban/Developed	Developed, Open Space
Urban/Developed	Developed, Low Intensity
Urban/Developed	Developed, Medium Intensity
Urban/Developed	Developed, High Intensity
Urban/Developed	Quarries, Mines and Gravel Pits
Water	Open Water
Water	Unconsolidated Shore
Water	North Pacific Maritime Eelgrass Bed
Wet Forest	East Cascades Mesic Montane Mixed-Conifer Forest and Woodland
Wet Forest	Mediterranean California Dry-Mesic Mixed Conifer Forest and Woodland
Wet Forest	Mediterranean California Mesic Mixed Conifer Forest and Woodland
Wet Forest	North Pacific Hypermaritime Sitka Spruce Forest
Wet Forest	North Pacific Maritime Dry-Mesic Douglas-fir-Western Hemlock Forest
Wet Forest	North Pacific Maritime Mesic Subalpine Parkland
Wet Forest	North Pacific Maritime Mesic-Wet Douglas-fir-Western Hemlock Forest
Wet Forest	North Pacific Mountain Hemlock Forest
Wet Forest	North Pacific Mesic Western Hemlock-Silver Fir Forest
Wet Forest	Northern California Mesic Subalpine Woodland
Wet Forest	Northern Rocky Mountain Mesic Montane Mixed Conifer Forest
Wet Forest	Rocky Mountain Subalpine Mesic-Wet Spruce-Fir Forest and Woodland
Wet Forest	California Coastal Closed-Cone Conifer Forest and Woodland
Wet Forest	North Pacific Hypermaritime Western Red-cedar-Western Hemlock Forest
Wet Forest	North Pacific Dry-Mesic Silver Fir-Western Hemlock-Douglas-fir Forest
Wet Forest	North Pacific Broadleaf Landslide Forest and Shrubland
Wet Forest	North Pacific Lowland Mixed Hardwood-Conifer Forest and Woodland

Appendix C Table C.1. Continued.

WHCWG Classname	*GAP Raster Class Name*
Wetland	Temperate Pacific Intertidal Mudflat
Wetland	Northern Rocky Mountain Conifer Swamp
Wetland	North Pacific Bog and Fen
Wetland	North Pacific Shrub Swamp
Wetland	North Pacific Hardwood-Conifer Swamp
Wetland	Rocky Mountain Alpine-Montane Wet Meadow
Wetland	Temperate Pacific Freshwater Aquatic Bed
Wetland	North Pacific Intertidal Freshwater Wetland
Wetland	North American Arid West Emergent Marsh
Wetland	Rocky Mountain Supalpine-Montane Fen
Wetland	Western Great Plains Saline Depression Wetland
Wetland	Temperate Pacific Freshwater Emergent Marsh
Wetland	Temperate Pacific Subalpine-Montane Wet Meadow
Wetland	Temperate Pacific Tidal Salt and Brackish Marsh
Wetland	Temperate Pacific Freshwater Mudflat



Appendix C. Figure C.6. Road buffer configuration.

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