Travel management screens for the Okanogan-Wenatchee National Forest

Report to the Travel Management and Forest Plan Revision Team

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Executive Summary

This report describes the creation of a set of maps and procedures that can be used to identify problematic roads and motorized trails for Travel Management Planning and Forest Plan Revision. The Forest Planning process for the Okanogan and Wenatchee National Forests has been underway since 2006, while Travel Management Planning for this forest is due to begin official scoping this year. Both of these plans will address and make decisions relevant to the travel management on this forest. The use and overuse of travel routes can create problems when they interfere with wildlife habitat function and ecosystem processes (Heflick and others 2002; Huntington 1998). This report describes the creation and use of a set of travel management screens that can identify potential problem areas in travel management. These screens provide a scientifically defensible justification for prioritizing travel management planning.

The ArcGIS 9 and Arcview 3.2 (ESRI 1992+) geographic information systems (GIS) were used for this developing the screens. Data sets were assembled for the Okanogan and Wenatchee National Forests. Some data sets extend beyond these administrative boundaries but the scope of this analysis is specific to these two Forests.

The development of a set of travel management screens is based on the principle of finding the intersection of areas where impacts and habitats interact most strongly (USDA-FS 2008, Singleton and others 2002). The USDA reference cited is specific to management in riparian management areas (RMAs), the principles apply to upland areas as well. Conservation priorities for the travel management screens were determined by mapping key elements of habitat and ecosystem function. The habitat map layers produced encompass a range of ecological values including riparian systems, indicator species, species of seclusion, inverse distance to wide-ranging carnivore habitats, and late successional reserves. Late successional forest reserves were used as a surrogate for old growth, maps of which were not available for this area.

The travel management screens were added together to produce a single screen by summing all of the overlapping habitat values. This screen is also referred to as the habitat sum layer. The determination of problem roads, problem snowmobile routes and problem trails was done by intersecting the habitat sum layer with the travel management screen.

A second set of screens was produced by analyzing line density of open roads, level 1 roads, highways, railroads snowmobile routes and trails.

Methods

See Appendix 1 for detailed descriptions of these procedures.

Travel routes are contained in map layers representing roads, trails, ORV routes, and snowmobile routes. These layers are shown in Figures 1, 2 and 3.
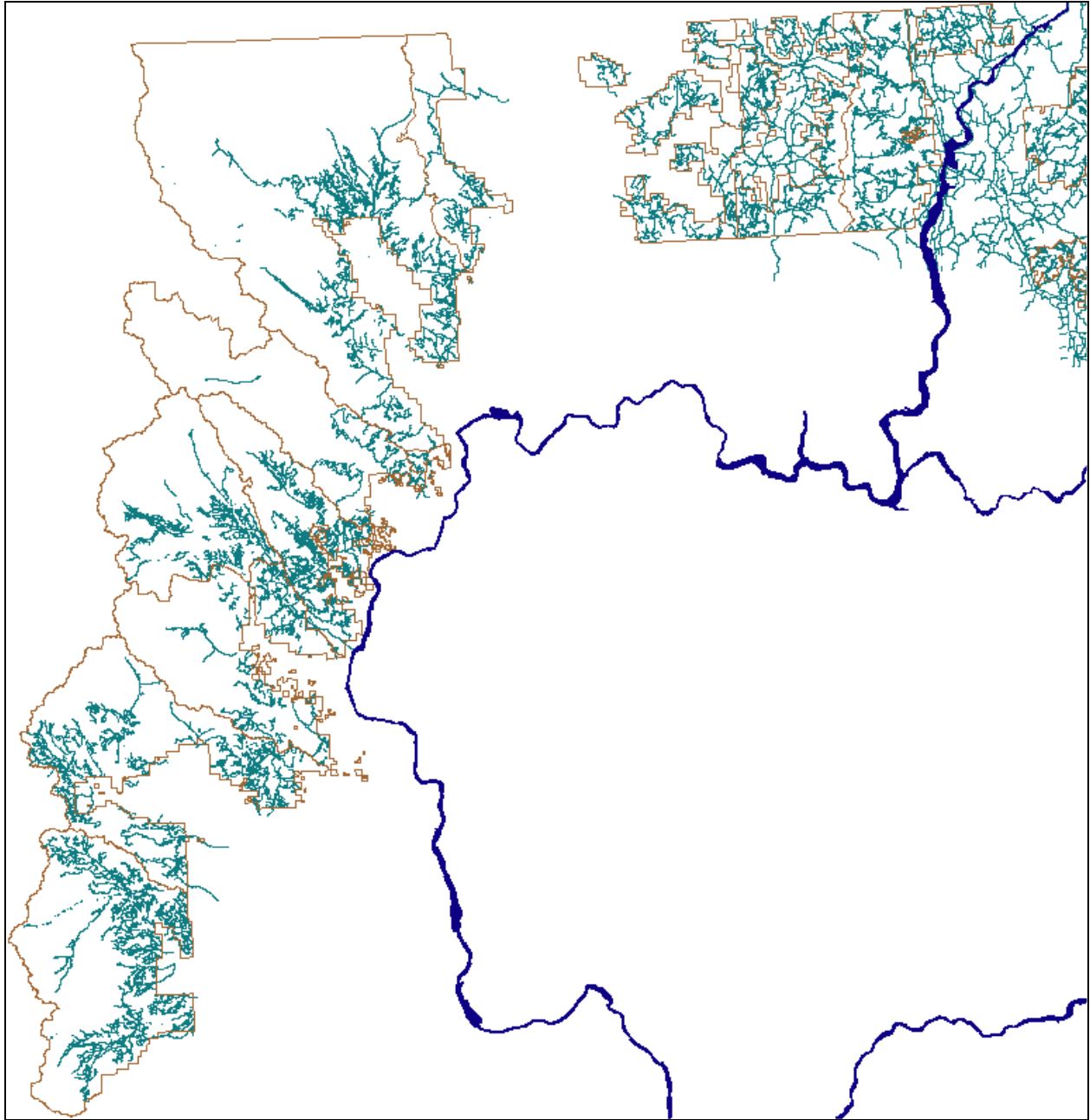

Figure 1. Open roads, levels 2-5 (teal) with National Forest District Boundaries (brown) and the Columbia River (dark blue).
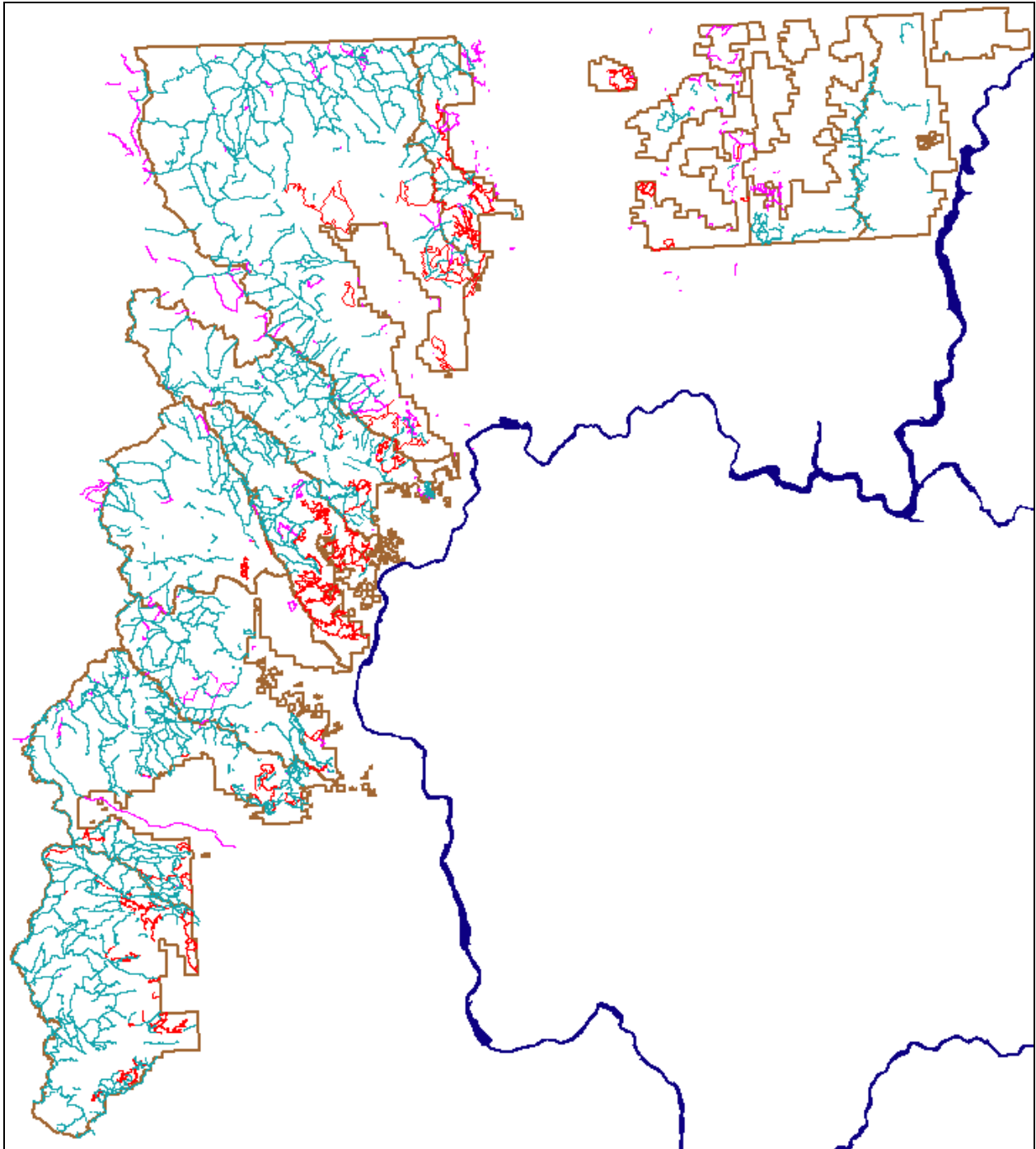
Figure 2. System trails shown on the 2006 Forest Plan revision layer (teal), additional system trails shown on the 2007 Travel Plan layer (magenta) and additional proposed new trails from the 2007 Travel Plan layer (red). This figure does not distinguish whether trails are motorized or not. The National Forest District Boundaries are brown; the Columbia River is deep blue.
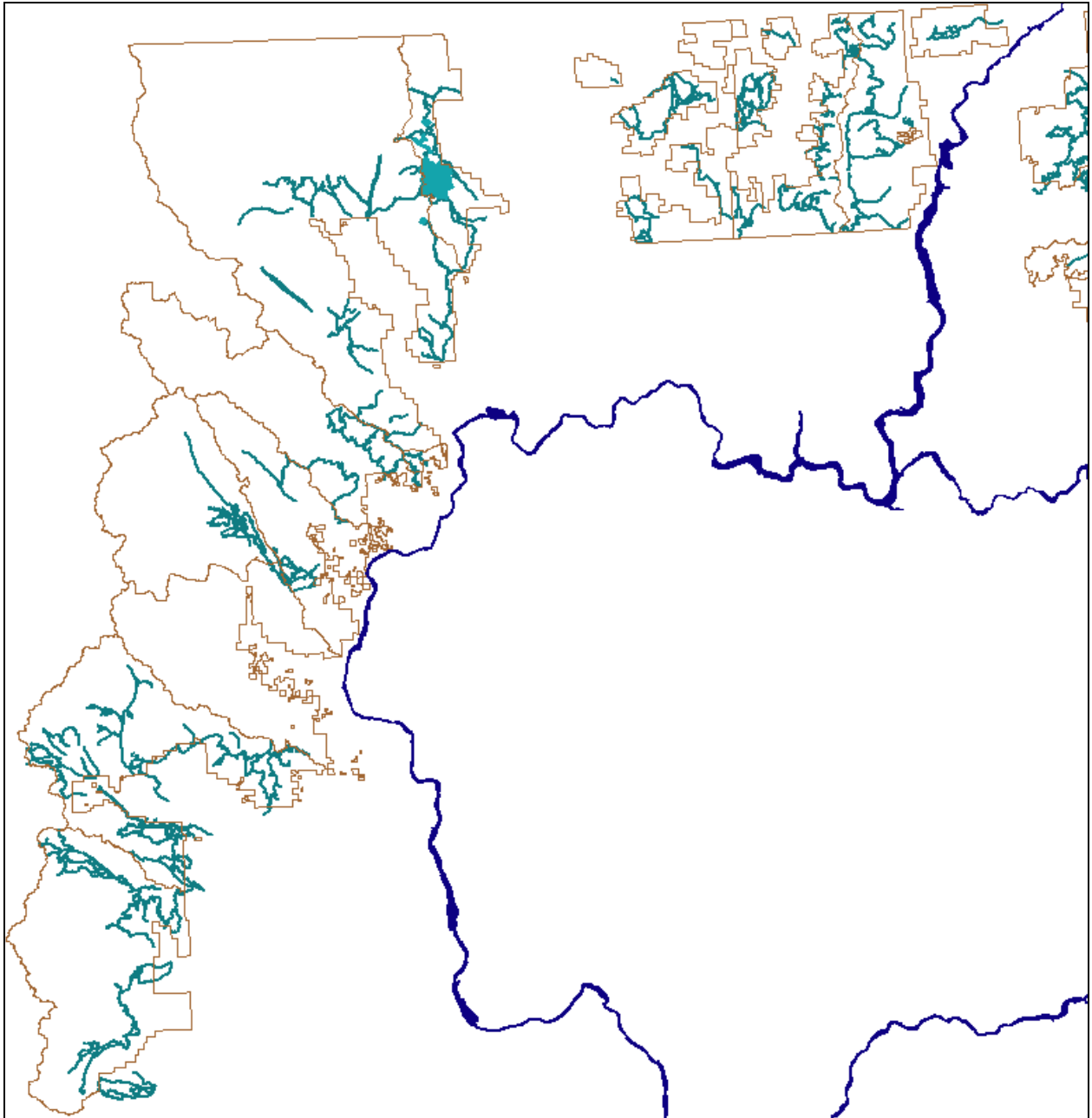
Figure 3. Snowmobile routes (teal), ONF snowmobile play areas & National Forest District Boundaries (brown).

Development of the habitat screens

The travel management screens are comprised of a set of GIS map layers within the GIS (Appendix 1). Travel management screens are attributed with habitat values ranging from 0 to 20 that were then overlaid and summed to determine an overall habitat value ranging from 0 to 80, contained in the summed habitat layer.

One set of screens contains the habitat values for core habitats of four wide-ranging carnivores ("focal species"). These habitats are grizzly bear early core habitat, Canada lynx habitat, wolf habitat and wolverine habitat. Habitat values for wide-ranging carnivores were assigned a value of 10. A related data set used for analyzing travel impacts was an inverse weighted distance layer made from the composite habitats for all four focal species (Singleton 2002).

Lynx, wolf and wolverine core habitat layers were developed primarily from data sets of Singleton and others (2002). The lynx core habitat was modified to include all areas mapped as revised proposed critical habitat by the USFWS in 2008. The wolf core habitat was modified to include several thousand acres of winter habitat used in 2008-9 by the Lookout Wolf Pack in the Methow Valley. This area was added as a single additional polygon prior to creating the grid. Lynx and wolf habitats are shown in Figure 4; wolverine habitat is shown in Figure 5.

The grizzly bear early core habitat layer was developed from data provided by the Wenatchee National Forest Supervisor's Office in 2007. These layers were processed into separate files representing core and non-core early- and middle-season habitats. The non-core habitats were not used for these screens. The grizzly bear screen used only the early core grizzly bear habitat layer, which was assigned a habitat value of 10. Grizzly bear early core habitat is shown in Figure 5.
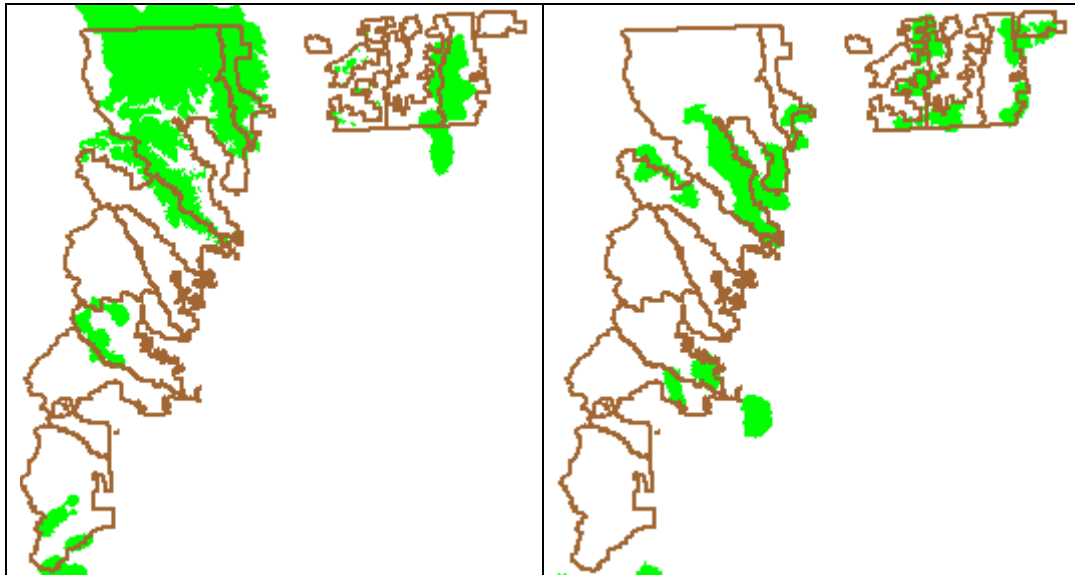
Figure 4. Lynx (left) and wolf core habitat (right). The National Forest District Boundaries are brown.
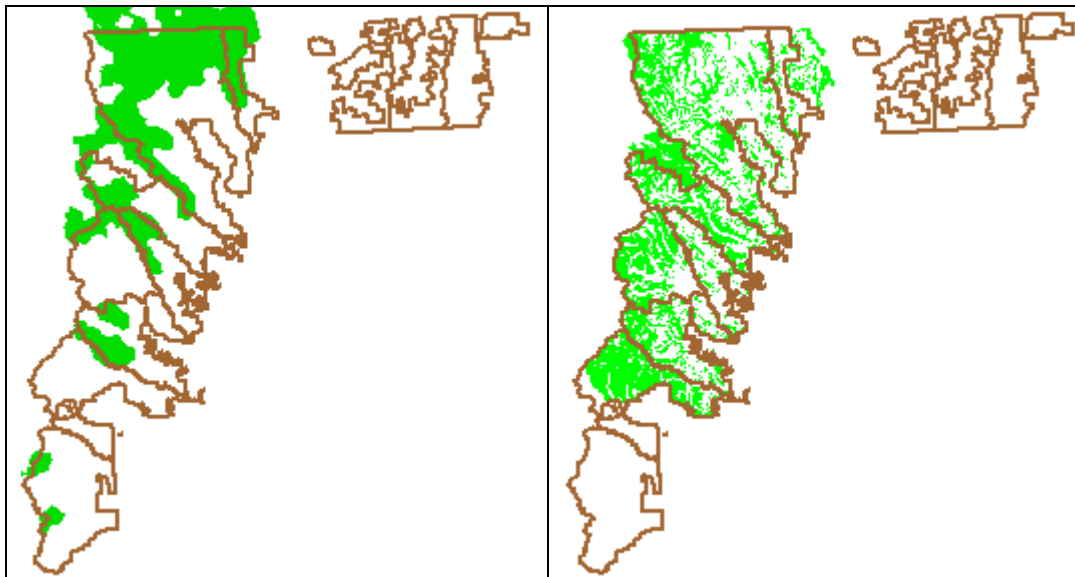

Figure 5. Wolverine (left) and grizzly bear early core habitat (right). The National Forest District Boundaries are brown.

The screens included a layer containing values of the inverse weighted distances from core generalized focal species habitat. This layer was based on Singleton and others (2002), followed by conversion to an approximation of the inverse. The assigned habitat values of the inverse weighted distance screen ranged from 1 to 10, with low values being further from generalized core habitats. The inverse weighted distance screen is shown in Figure 6.

The screens also included a layer of late successional forest reserves (LSRs) used as a surrogate for old growth habitats which were not available for this area. This layer also includes the Snoqualmie Pass AMA. Habitat values for the LSRs were assigned a value of 10. A map of the LSRs and AMA are shown in Figure 6.
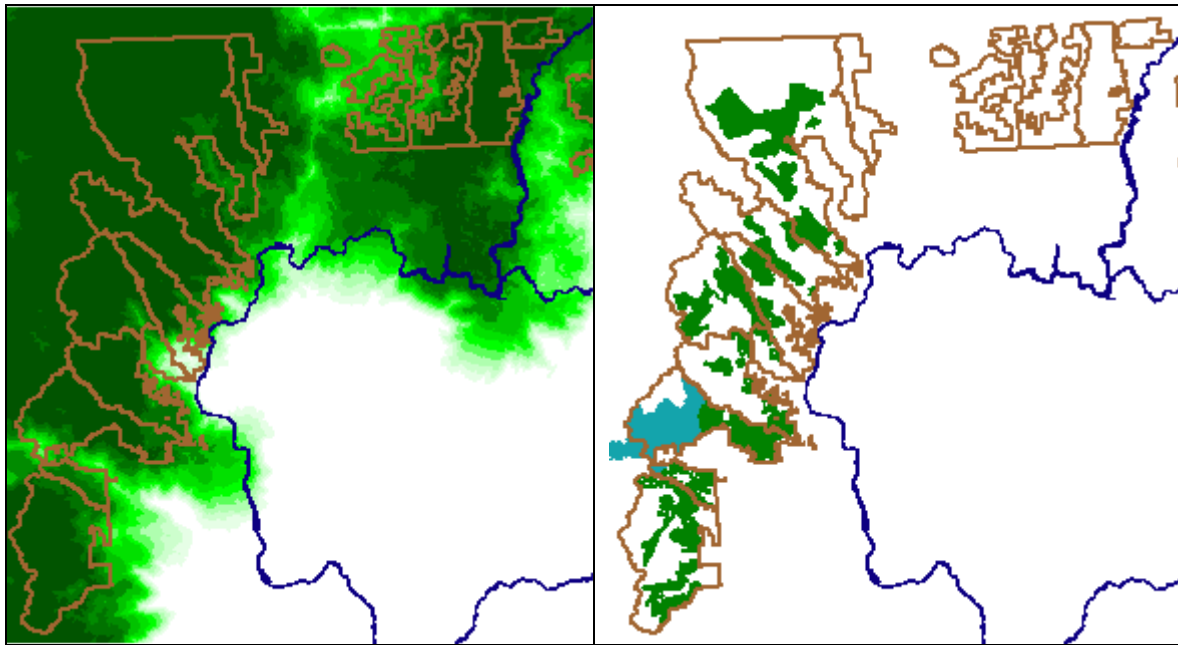

Figure 6. Inverse weighted distance to generalized focal species (left; dark shading has higher values). LSRs and the AMA (right). The National Forest District Boundaries are brown.

The travel management screens also included habitat values for T & E fisheries, riparian areas, lakes and wetlands. These habitats were combined into a single composite screen to simplify data analysis.

Streams and rivers were classified into the following categories, with habitat scores assigned based on USDA Forest Service (2008) and reference to the Forest Service Riparian Direction layer (Appendix 1):
- T & E fisheries (stream class 1). These features were assigned a habitat value of 20 and a buffer width of 300 ft.
- Class 2-3 streams; these are other fish-bearing streams (stream class 2) and perennial non-fish-bearing streams (stream class 3); stream classes 2 and 3 are not separated. These features were assigned a habitat value of 15 and a buffer width of 150 feet
- Class 4 streams (and some smaller class 3 streams. These features were assigned a habitat value of 10 and a buffer width of 100 feet.

Streams classes are defined here as follows.
- Class 1 streams are perennial streams used by large numbers of fish for spawning, rearing, and/or migration;
- Class II streams are perennial streams used by moderate through significant numbers of fish for spawning, rearing, and/or migration;
- Class 3 streams are all other perennial streams or segments thereof not meeting higher class criteria; Class 4 Streams are intermittent streams not meeting higher class criteria.

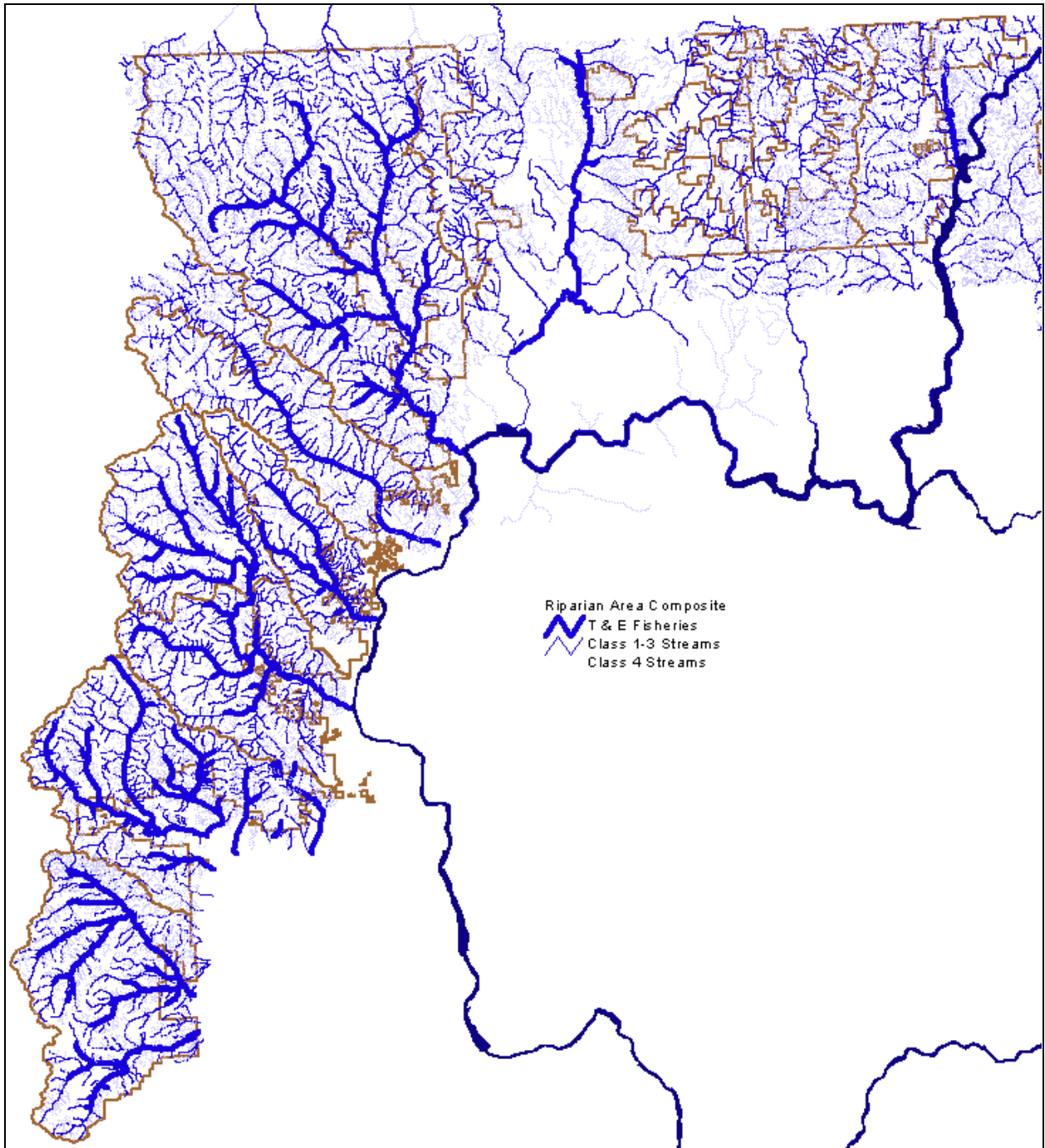A map of the riparian buffer screens is shown in Figure 7.

Figure 7. Riparian Area Composite Screen (lakes and wetlands not shown), shown with the National Forest District Boundaries (brown) and the Columbia River (deep blue).

The screen for lakes was assigned a habitat value of 15 and a buffer width of 300 feet, based on the Riparian Direction layer (Appendix 1). The screen for wetlands was assigned a habitat value of 10 and a buffer width of 150 feet.

The final layer containing the travel screens was a composite of all the other screens. This layer was produced by first merging the streams, lakes and wetlands into a single grid to preserve habitat values in the priority streams > lakes > wetlands. Next all of the cell values of the screens were summed into a single grid layer using Map Calculator.

The determination of problem roads was done by intersecting the screens with the road polygons. Problem roads were identified by imputing the grid values of the screens into the overlaying road buffer polygons.

Line Density of roads, trails and snowmobile routes
Road and trail density was determined from layers containing roads, highways, railroads, snowmobile routes and trails (Appendix 1).

Road density calculations and other linear density analyses were processed using the ArcGIS 9 line density function to produce raster (grid) outputs with a cell size of 30 m. Linear density was calculated in miles / square mile for the following line grids: FS Open Roads (levels 2-5); Forest Service level 1 roads; snowmobile routes; motorized trails; and non-motorized trails.

Line density was calculated separately for the aggregate of DNR roads, highways, railroads and motorized trails by unioning all of these into a single layer.

The line density grids were converted to polygon shapefiles with values of 1 or 3 mi/sq mi. and then clipped to the extent of the National Forest for in further analyses.

Results and Discussion

Screen development
The use of focal species for developing screens is based on a number of important conservation principles. The four species chosen encompass range of habitats Singleton and others (2002). The four focal species habitats are grizzly bear early core, Canada lynx, wolf, and wolverine

The habitat values of these for species' habitats integrate a large number of ecosystem values. All of the species receive some protection under the Endangered Species Act and/or state species of concern. The species are generally seclusion-dependent species, and thus directly indicate when road or trail density exceeds thresholds for their survival (Wydeven 2006). All of these species are wide-ranging carnivores that are important habitat quality indicators as well as ecosystem elements in their own right (Singleton and others 2002).

The habitats used by these species require a degree of seclusion from human disturbance. Traditionally, a surrogate procedure for protecting these habitats has been to assign a threshold road density. A related data set used for this analysis was an inverse weighted distance from the composite habitats for all four focal species. Habitat values for wide-ranging carnivores were assigned a value of 10 out of 80 possible for each cell in the travel screen.

The Forest Service grizzly bear early core habitat model is not the same as the core range maps produced by Singleton and others (2002). The latter maps primarily depicted high elevation habitats, which are suitable for mapping wildlife corridors. However the early core habitat map is better for representing limiting factors for grizzly bears such as fish habitat and early season vegetation. The Forest Service map of early core habitat included many small, isolated polygons, that are not technically "core habitat". The effect of including these small polygons

may have a small bias in favor of warm, wet biophysical environments, however it was beyond the scope of this project to evaluate the maps provided..

The screens also included a layer of late successional forest reserves (LSRs, including Snoqualmie Pass AMA) used as a surrogate for old growth habitats which were not available for this area. The use of LSRs is a realistic surrogate for old growth, since there are stricter environmental protections within LSRs. Additionally, LSRs and the AMA have designated management requirements that depend on assessing habitat values and potential road and trail impacts. According to our current analysis, there are 30 LSRs or AMAs containing over 762 square miles of areas with high density roads. Analyses still underway indicate that areas exceeding high density of level 1 roads would more than double this area.

The habitat values for T & E fisheries were assigned to higher values (of 20) than those for wide-ranging carnivores because T & E fisheries are doubly valuable as both T & E fisheries habitat as well as habitats for many other species. Likewise the habitat attribute values for class 2-3 streams were assigned a moderately higher habitat value of 15. The buffer width of the riparian layers were based on the Riparian Direction layer. The habitat value of lakes is moderate based on the use of lakes by a large number of species, as well as the magnification of impacts by the lack of cover. The buffer width of wetlands corresponds to INFISH (1995) recommendations rather than the Riparian Direction layer.

Problem roads and motorized trails
Within the administrative boundary of the Okanogan and Wenatchee National Forests, there are 10,828 miles of level 2-5 system roads, 2,806 miles of snowmobile routes, 2,844 miles of non-motorized trails, and 1,081 miles of motorized "trails".

Travel screens were able to identify problem travel routes that can be addressed in the Travel Management Plan and Forest Plan Revisions. Problem travel routes can be addressed in several important ways: (1) prioritizing road closures; (2) prioritizing road maintenance and restoration activities; (3) developing guidance for users of travel routes.

An attached spreadsheet identifies specific problem segments and routes that are reflected in the maps within this report.

The travel screens identified 1571.9 miles of problematic open roads (levels 2-5) on the Okanogan and Wenatchee National Forests. These were identified as the 90th percentile of mean summed habitat values of the underlying travel screen. These roads are shown in Figure 8.

The screens identify problematic snowmobile routes as the 80th percentile of mean summed habitat values of the underlying travel screen. The 80th percentile was chosen because there are fewer snowmobile trails, making analysis of a larger data set possible. Problem snowmobile routes are shown in Figure 9. The ONF-WNF had 537 miles of problem snowmobile routes (19.1% of the total mileage on those Forests). These snowmobile routes are listed in the attached spreadsheet.

The screens were also used to identify problematic motorized trails as the 90th percentile of mean summed habitat values of the underlying travel screen. Our analysis identified 97.4 miles of problematic motorized trails on the forest that are shown in Figure 10.

Road and trail line density determination
Road and trail line density was determined for the following sets of linear features: Forest Service open road (level 2-5) density; motorized trails; and snowmobile route density. Used

here, high line density is considered to be areas with > 1mi/sq mi of linear features. Very high line density is considered to be areas with > 3 mi/sq mi of linear features.

The linear density data was filtered to determine areas where road or trail density exceeded recognized standards of environmental quality (Wydeven and others 2006).

The open road density is shown in Figure 11. Land allocations with stated goals of road density guidelines such as Late Successional Reserves and Adaptive Management Areas were analyzed with the road density of only Level 2 to 5 roads (Figure 12). This analysis does not account for unauthorized or otherwise open road systems, but does highlight areas of high density overlaying with these land allocations in districts across the forest.

Snowmobile route density is shown in Figure 13. Figure 14 shows areas where the snowmobile route density exceeds 1 mile per square mile or 3 miles per square mile.

Recommendations

One area of interest are the numerous problem roads within the Snoqualmie Pass AMA in the southern part of the Forest. This area was included with LSRs as part of the screens. Since LSRs are being used as a surrogate for old growth, this analysis should be repeated with the AMA excluded from the screens to prevent circular logic.

The use of travel screens can be improved by the use of more accurate maps and habitat ratings. Two habitat maps that could be improved most are grizzly bear early core habitat and wolf core habitat. Additional layers of great importance include those of habitat connectivity for focal species as are being developed in the forest plan revision, and layers showing important water bodies and watersheds in light of climate change.

Key ungulate range maps could be incorporated in the screens.

Additional analysis should be run on the full existing system on the ground incorporating all open and unauthorized road systems.

The National Forest layer of trails is largely incomplete. Many of the fields that should indicate whether a trail is motorized, proposed, system or not are left blank. This layer should be completed so that one doesn't have to guess what the intended management is.
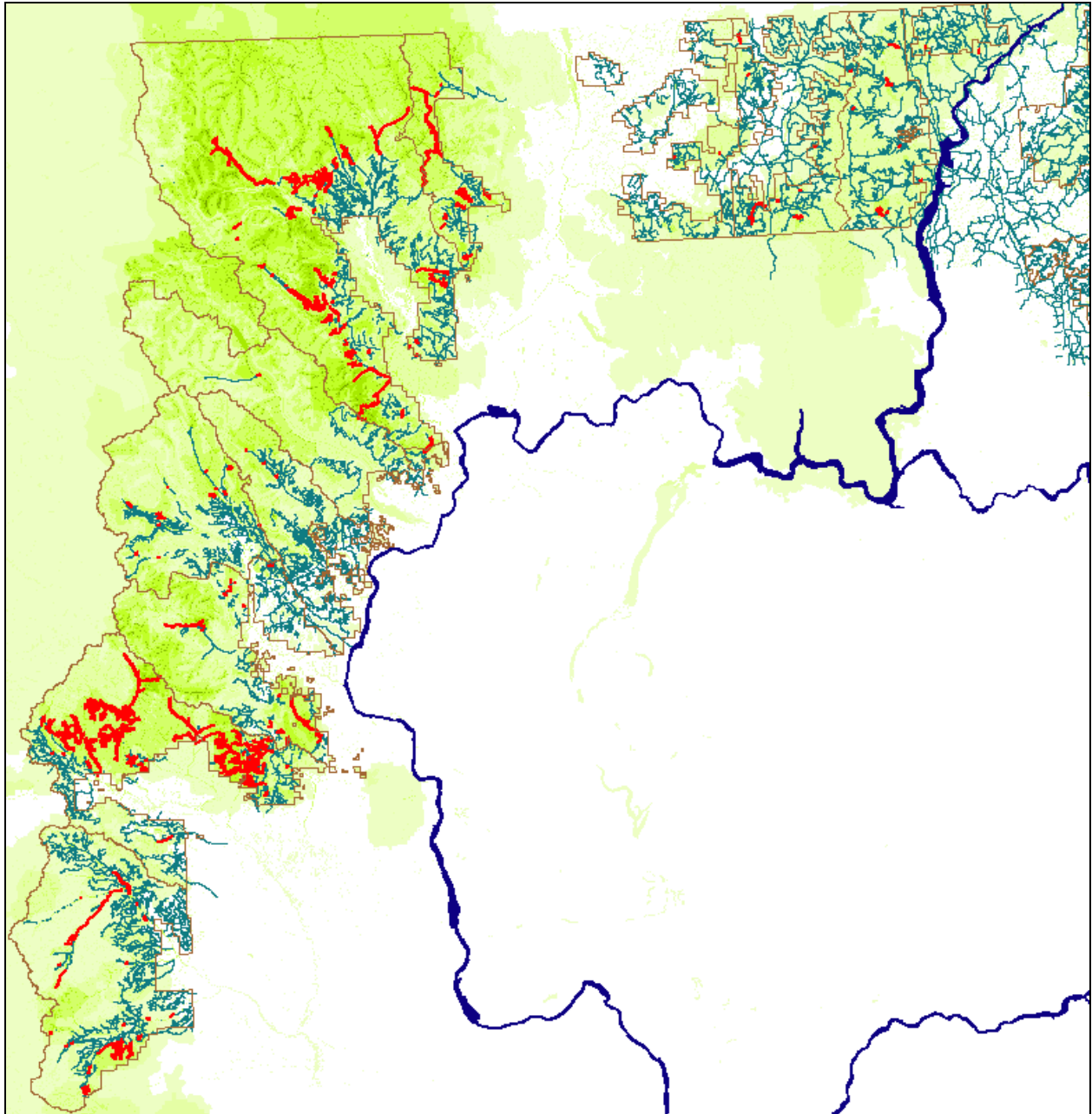
Figure 8. Problem open roads (red) identified by the travel management screen. Other open roads are teal. The intensity of the chartreuse background represents the summed values of the habitat scores of the travel screen. The National Forest District Boundaries are brown.
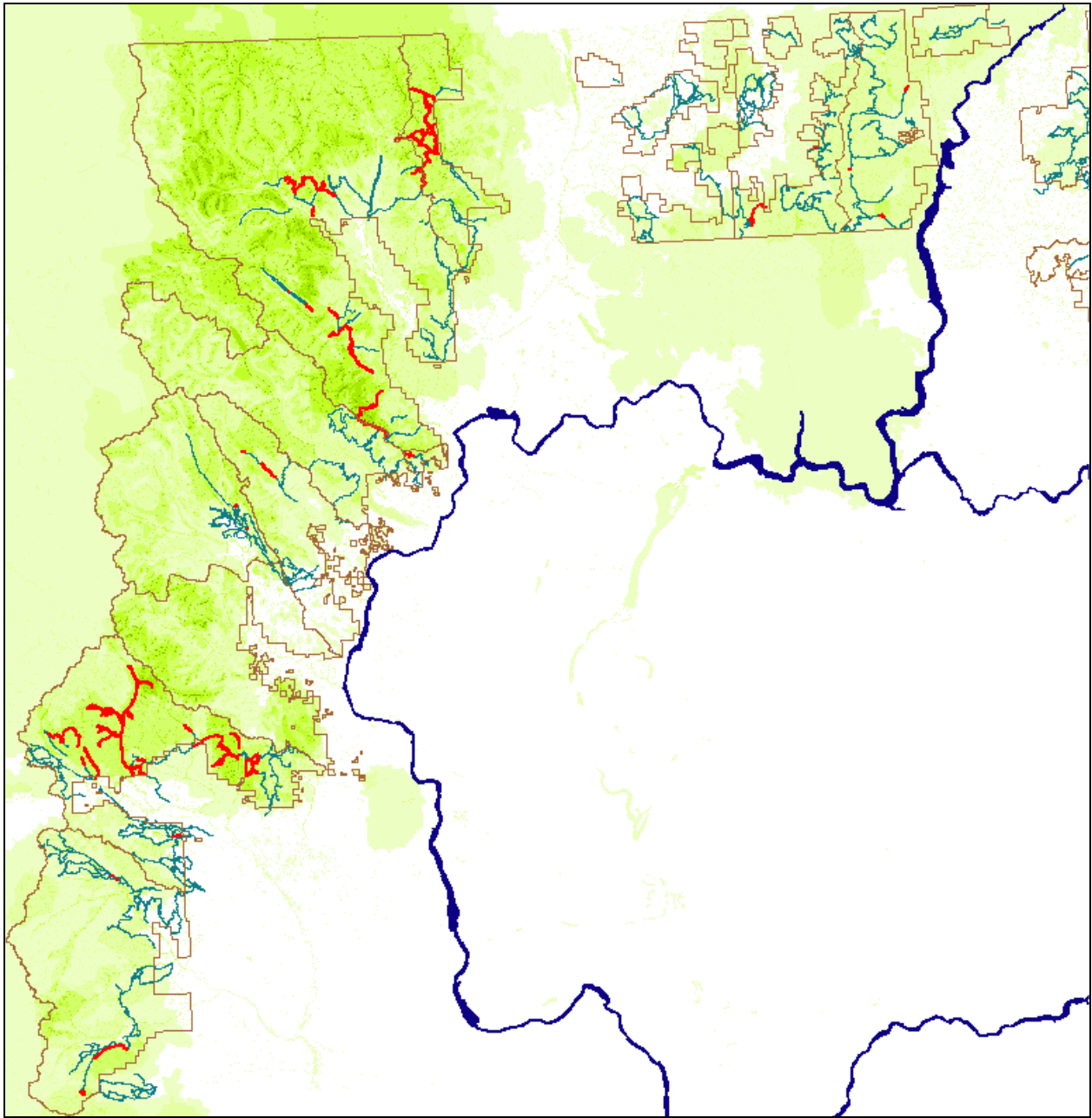
Figure 9. Problem snowmobile routes (red) identified by the underlying chartreuse travel management screen. Other snowmobile routes are teal. The National Forest District Boundaries are brown.
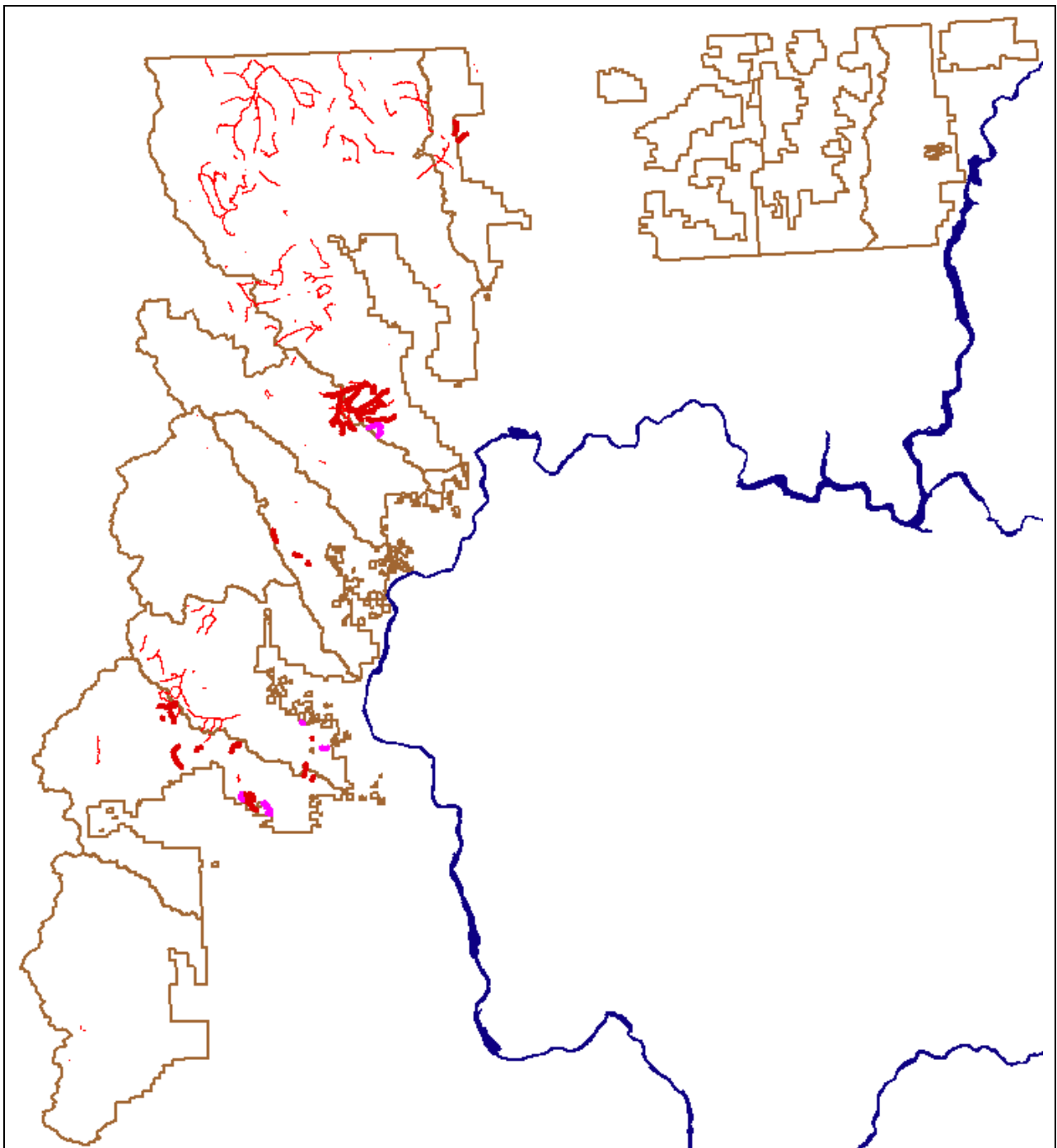
Figure 10. Problem trails. Motorized trails (heavy red lines), proposed new trails (heavy magenta lines) and other problem trails (light red lines). The National Forest District Boundaries are brown.
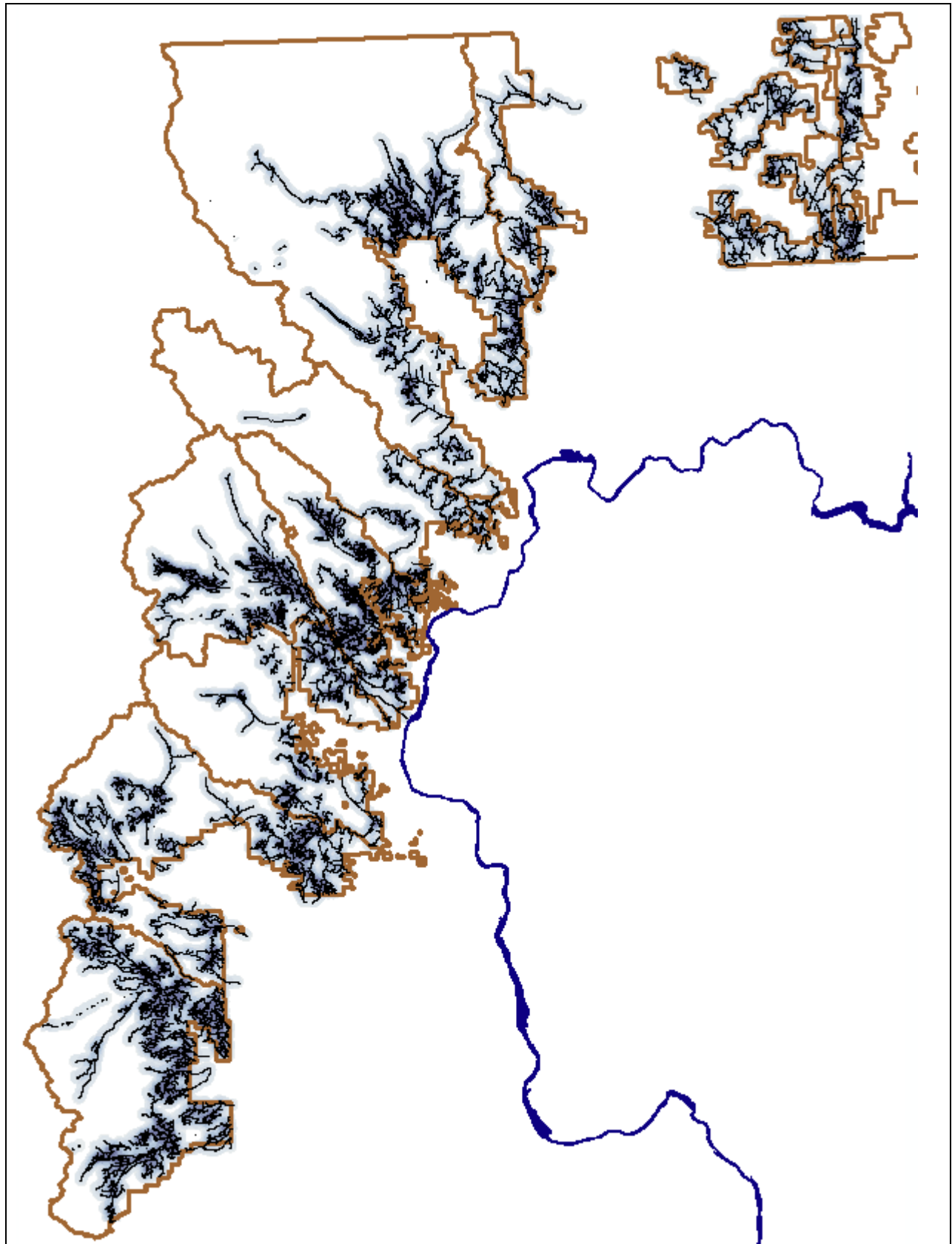
Figure 11. Forest Service open road (level 2-5) density grid (blue shading) with overlaid roads in black lines. The National Forest District Boundaries are brown.
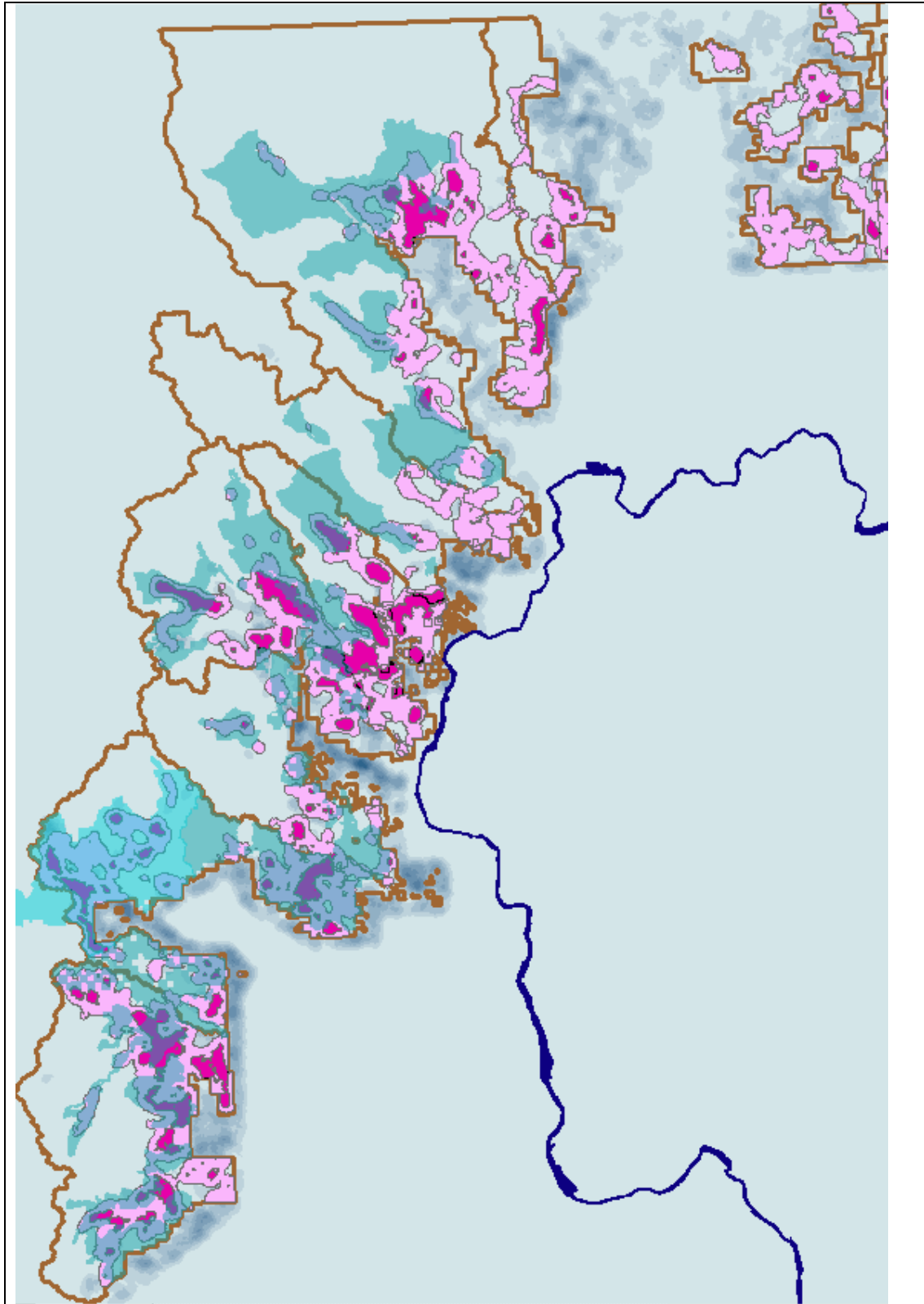
Figure 12. Overlap of LSRs and AMA with road densities of Level 2-5. Map colors are lavender (>1 mi / sq mi) and fuschia (>3 mi / sq mi). National Forest District Boundaries are brown, LSR and AMA areas are in blue overlay.

Figure 13. Snowmobile route density grid (blue shading) with overlaid snowmobile routes in black lines. The National Forest District Boundaries are brown.

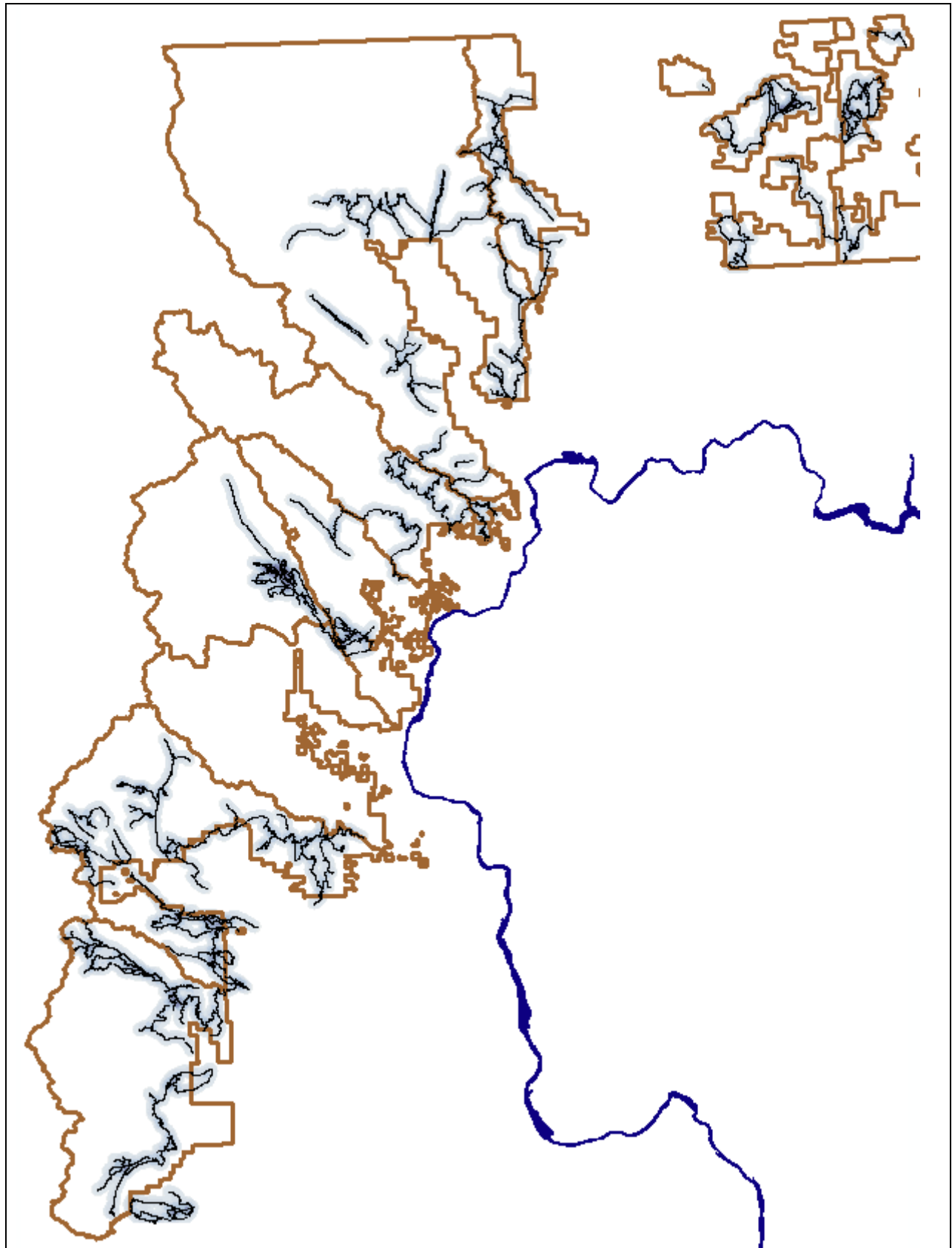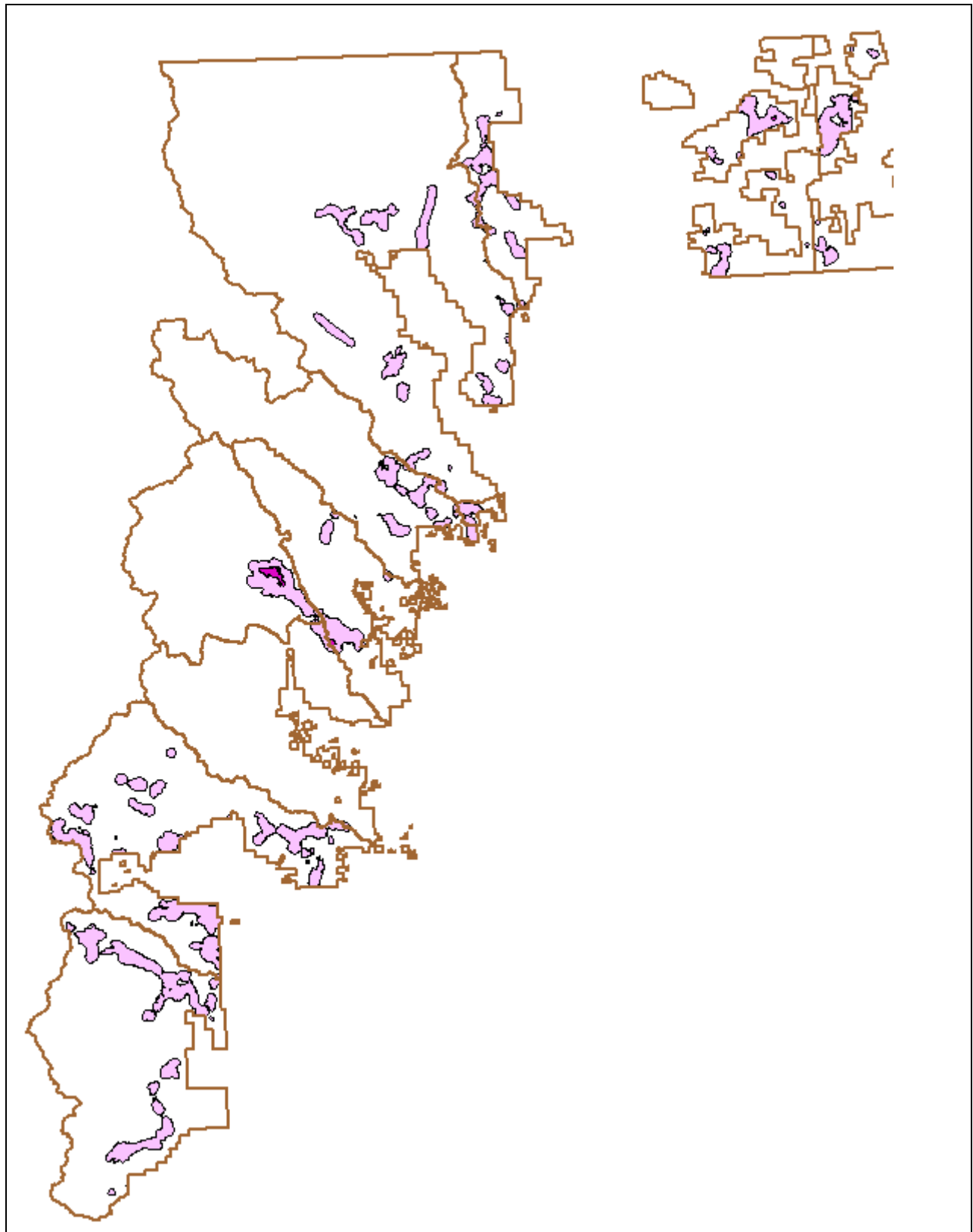**Figure 14**. Snowmobile route density exceeding 1 mi/sq mi. Map colors are lavender (>1 mi / sq mi) and fuschia (>3 mi / sq mi). The National Forest District Boundaries are brown.

References

ESRI (Environmental Systems Research Institute). 1992+. Arcview GIS 3.2 Geographic Information System software.

Heflick, David compiler. 2002. Out of Bounds! ORV recreation: Colville and Okanogan National Forest. Kettle Range Conservation Group.

Huntington, C. W. 1998. Fish habitat and salmonid abundance within roaded and unroaded landscapes in the Clearwater River Sub-basin, Idaho. Pages 413-428 in M.K. Brewin and D.M.A Monita, Tech. Coords. Forest-fish conference: land management practices affecting aquatic ecosystems. Proc. Forest-Fish Conf., May 1-4, 1996, Calgary, Alberta.

"INFISH". 1995. Decision Notice and Finding Of No Significant Impact for the Inland Native Fish Strategy, USDA Forest Service, July 28, 1995.

"PACFISH". 1995. Implementation of Interim Strategies for Managing Anadromous Fish-producing Watersheds in Eastern Oregon and Washington, Idaho, and Portions of California. Adopted by the USDA Forest Service, February 24, 1995.

Singleton, P.; W. Gaines; J. Lehmkuhl. 2002. Landscape permeability for large carnivores in Washington: a geographic information system weighted-distance and least-cost corridor assessment. USDA-FS Research Paper PNW-RP-549.

USDA Forest Service, Pacific Northwest Region. 2008. Aquatic and Riparian Conservation Strategy (ARCS). USDA Forest Service, Pacific Northwest Region. Available online at http://www.reo.gov/library/acs/

Wydeven, Adrian, David Mladenoff, Theodore Sickley and Robert Haight. 2006. Appendix C: GIS Evaluation of Wolf Habitat and Potential Populations in the Great Lakes States. Wisconsin Department of Natural Resources, Madison, Wisconsin (dnr.wi.gov).

Appendix 1: GIS procedures and map layers used for creating travel management screens

I.A. General Analysis Procedures

GIS Layers were assembled in a UTM zone 10 NAD1983 projection. Vector data was stored in Arcview shapefiles; raster data was stored in Arcview grid files.

Raster data was used in the form of ESRI "grid" themes that were converted from polygon shapefiles within Arcview. Grid files were created from the shapefiles. The base grids had their corners located on integer UTM coordinates. The base layer was an L-shaped grid encompassing all of the Colville, Okanogan and Wenatchee National Forests, and extending several dozen miles beyond in all directions. Grid files were aligned to one of two base grid layers, either "base" for 30 m grids or "base15" for 15 m grids). Only road layers used 15 meter grid cells, the other grids were 30 meter grids.

I.B. Line Density

Road density and other linear density analyses were processed in ArcGIS 9. Linear density in units of meters /sq meter was calculated using a radius of 1609.344 m (1 mi) and a 30 m grid cell size. Calculation of line density are as follows. Line density was created as output from ArcGIS in meters per square meter and converted to miles/square by multiplying the result in meters per square by the factor 1609.344. For Example:

meters / meters^2 (1609.344^2 meters / miles^2) (1 mile/1609.344 meters) = miles / miles^2

The above is equivalent to:

1609.344 · meters/meters^2 = miles/square mile

The results of the calculation of density in meters per square meter on the files above were converted to tenth miles /square mile by multiplying the above result by 10, and truncating the result to the next lower integer. The calculation was solved in one step with this expression:

INT(16094 · grid cell value).

This is equivalent to the following Map Algebra (Single Output Map Algebra) expression in ArcGIS (for the following example of the grid file dentrmo):

INT(16094 * F:\apr\cnw\apr\projects\travel\grid1083\density\dentrmo)

I.C. Travel Management Screens

Screens were processed as 30 m grid files. The values of the grid cells were taken from the field [habitat] in the source polygon files. Cells with null values were set to a value of zero for subsequent map algebra.

The final screen was made by summing the values in each cell of all of the overlapping screens. The method for summing all of the screens into a single grid layer used Map Calculator to input the following expression into Arcview:

([No NULLs General Inverse Distance Grid] + [No NULLs Wolverine Grid] + [No NULLs Wolf Grid] + [No NULLs Lynx Grid] + [No NULLs Griz Early Grid] + [No NULLs LSR and AMA Grid] + [No NULLs Rip-lk-wet])

Problem roads were identified by imputing the grid values of the habitat sum screen into the overlaying buffered road, snowmobile, trail or recreational site polygons. The method used for imputing grid values into a polygon theme is as follows:

(1) Open the polygon theme, and select the records to calculate grid overlap for (or select none to calculate overlap for all polygons).
(2) Make the polygon theme active.
(3) Use the Memo Tools command RecNo to Table to number all of the fields.

(4) Use the MILA Grid Utilities command to calculate a new table containing the zonal statistics for the polygon table, by clicking the "Z" button on the toolbar, and then choosing the RecNo as the field to relate to.
(5) Next select the grid file and statistic to impute into the polygon file.
(6) Arrange the Arcview workspace so that the Answer table and the road polygon table are both visible.
(7) Open Tables from the Project Window, and join the RecNo field in the Answer table with the RecNo field in the polygon table using the Join command
(8) Make the join permanent with the Fixjoin button ("J" button). Test that the join worked by sorting the table by the joined field.

II. Layers used in the development of National Forest Travel Management Screens

Layer set 1. National Forest boundary. The National Forest boundary layer was made from the National Forest planning process maps distributed by the Forest Service in 2006. This layer has the Forest and District boundaries for the Okanogan, Wenatchee and Colville Forests. The National Forest layer includes inholdings and traded lands. Although inholdings need to be subtracted from the final analysis, they should to be included during map algebra calculations (e.g., fish habitat). This layer was unioned with another version of this map modified by Conservation Northwest during roadless mapping that has corrected boundaries between adjacent forests, private lands and the Idaho-Panhandle NF. Polygons from the original version remained unchanged, however the map was enlarged to include the full extent of both layers, as well as private inholdings.

Layer set 2. Late Successional Reserves (LSR). The LSR map layer was provided by the Forest Service during the 2006 National Forest planning process. There are two feature attributes: Managed Late Successional Area (MLSA) and Late Successional Area (LSR). It is possible to separate private land inholdings within this layer using attributes within the data set.

Layer set 3. AMA (Adaptive Management Area). The AMA map layer contains the Snoqualmie Pass AMA downloaded from the Forest Plan revision website.

Layer set 4. Forest Planning layers. Forest Plan map layers include the following files. These files were not used for analysis, but were used for reference information.
4.a. Forest Plan Management Areas (2006). This layer covers the Colville, Okanogan and Wenatchee National Forests. It includes Wenatchee NF revisions from 10/27/2005.
4.b. Okanogan Forest Plan Management Areas (1989, 2002).
4.c. Proposed special management areas (2006). This is the Forest Service draft Forest Plan revision map showing wilderness areas, experimental forest, proposed and established research natural areas, proposed and established special interest areas, adaptive management area, wild and scenic rivers (buffered to 1/4 mile), and scenic byways and highways (buffered to 1/2 mile).

Layer set 5. Roads
5.a. FS Roads level 2-5. The road map layer is based on the GIS map of Forest service system roads (maintenance levels 2-5) for the Colville, Okanogan and Wenatchee National Forests. The latest 2007 version of the road layer was downloaded from the Forest Plan revision website. Roads on this layer were attributed in [Trans_type] with the value 25 and in [Trans_rte] withe the value "FS-level 2-5".
5.b. FS Roads Level 2-5 roads 100 ft buffer polygons. The level 2-5 roads were converted to polygons by buffering them to a distance of 100 feet (file rd-buffer-stats.shp). This polygon file was imputed with the mean value of the summed habitat scores of the underlying cells of the travel screen. The 90th percentile mean habitat scores, representing problematic roads, were colored with a red outline to identify them on a map.

5.c. FS Roads Level 2-5 Line Density grid. This layer was created from the FS Roads Level 2-5 line shapefile using ArcGis 9 Spatial Tools Line Density function. Run parameters were 30 m grid size and 1609.344 m sample radius (1 mi). Output units are in m/sq m.

5.d. Major Highways and Railroads. This layer was created by adding the DNR railroads to the Washington Department of Transportation layer of major state and federal highways. This file was named maj_hwy&rails.shp. Highways were attributed with 40 in [Trans_rte] and "Highways" in [Trans_type]. Railroads were attributed with 30 in [Trans_rte] and "Railroads" in [Trans_type].

5.e. Major Highways and Railroads Line Density grid. This layer was created from the Major Highways and Railroads line shapefile using ArcGis 9 Spatial Tools Line Density function. Run parameters were 30 m grid size and 1609.344 m sample radius (1 mi). Output units are in m/sq m.

5.f. DNR Roads. This layer shows all roads on all ownerships including Forest Service level 1 roads. The counties covering this analysis area were Chelan, Okanogan, Kittitas and Yakama. These data were all merged (file roads-dnr.shp). The original DNR data set includes railroads (file railroad-dnr.shp). Roads were attributed in [Trans_rte] with the value 10, and in [Trans_type] with the value "Level 1 DNR". Railroads were attributed in [Trans_rte] with the value 30 and in [Trans_type] with the value "Railroads". The records representing railroads were subtracted and added to the Highways and rails layer.

5.g. DNR Roads not Intersecting FS Level 2-5 Roads. This layer was created by selecting features of the DNR roads layer that did not intersect the Forest Service Level 2-5 roads layer. This file was named Roads-dnr-non-fs.shp. This layer was attributed in [Trans_rte] with the value 10 and in [Trans_type] with the value "Level 1 DNR". Most of these roads are not on the National Forest. The ones that are on the National Forest are fewer in number than the actual number of level 2 roads, because this layer did not include roads that just barely intersected the level 2 roads. Therefore analyses using this layer will result in slightly underestimating the degree of impacts.

5.h. DNR Roads not Intersecting FS Level 2-5 Roads Line Density grid. This layer was created from the Major Highways and Railroads line shapefile using ArcGis 9 Spatial Tools Line Density function. Run parameters were 30 m grid size and 1609.344 m sample radius (1 mi). Output units are in m/sq m.

5.h. DNR Roads not Intersecting FS Level 2-5 Roads Line Density grid. This layer was created from the line files listed above using ArcGis 9 Spatial Tools Line Density function. Run parameters were 30 m grid size and 1609.344 m sample radius (1 mi). Output units are in m/sq m. See below under line density for details.

5.i. FS Level 2-5 Problem Roads. All open roads that were completely overlapped by the 90th percentile of problem road buffers were selected to create a list of problem roads. The shapefile containing all of these roads within the ONF and WNF is called problem-roads-sent.shp

Layer set 6. Trails. The trails map theme has several different layers described below.

6.a. System Trails (2006). This map layer was supplied by the Forest Service in 2006 as part of the Forest Planning process.

6.b. Proposed New Trails (2007). This GIS map layer was supplied by the Forest Service in November, 2007 in response to a FOIA by Conservation Northwest. It is a set of 6 files that cover both forests. The files were reprojected from 2 different projections, Albers and UTM. The Methow Valley proposed trails layer was a polylineM file that was scanned and redigitized. These trails were all merged into a single file, prop-trail-all.shp.

6.c. System Trails (2007). This GIS map layer was supplied by the Forest Service in November, 2007 in response to a FOIA by Conservation Northwest. It claims to contain existing trails, however a number of new trails were added that weren't on the 2006 Forest Plan revision map layer. On the other hand, there were no trails subtracted from the 2006 layer.

6.d. System Trails edited and merged. The 2007 system trail layer was edited as follows. Trail no. 372 on South Twentymile Peak was connected to Trail no. 512, where it erroneously did

not connect. A field [new_trail] was created and edited to indicate the year a trail segment was added to the map after the 2006 version of the trail map. Trail segments that did not exist or were added since 2006 were attributed in [new_trail] with "2007". New trail segments that had been added to this map from the proposed new trail layer were attributed in field [new_trail] by appending "proposed" to indicate the source of the record. The remaining records were attributed in [new_trail] with a value of "2006". Administrative ownership was added by intersecting with the National Forest layer and road mileage was added as a new field. When completed, the 2007 trail layer contained all of the trails in shapefile trails-by-own-all&2007&proposed1083.shp. The other trail layers were no longer used in this analysis.

6.e. System trail 100 ft buffer polygons. The merged and edited system trails layer was converted to polygons by buffering all trails to a distance of 100 feet (file trails-buffer100.shp). This polygon file was imputed with the mean value of the summed habitat scores of the underlying cells of the travel screen. The 90th percentile mean habitat scores, representing problematic trails, were identified by coloring them with a red outline.

6.f. Problem trails. This is a separate layer of system trails and proposed trails that have their center inside the problem trail polygons (Problem-proposed-trails.shp). This layer was used to separately categorize the type of problem trails as motorized trails (problem-trails-motorized.shp) or proposed trails (problem-trails-proposed).

Layer set 7. Snowmobile routes.

7.a. Snowmobile routes. The snowmobile map layer was downloaded from the Wenachee Forest Planning GIS website in 2009. Another GIS map layer depicts snowmobile play areas shown on the ONF Travel Plan. The snowmobile play layer was created by digitizing the Travel Plan map. This was only done on the ONF and was not used in this analysis. A clipped version of this map containing only route segments within the ONF and WNF, with an added field for calculated mileage was called snomo-clip&calc.shp.

7.b. Snowmobile route 100 ft buffer polygons. The snowmobile routes were converted to polygons by buffering them to a distance of 100 feet (file snomo&buffer100.shp). This polygon file was imputed with the mean value of the summed habitat scores of the underlying cells of the travel screen. The 80th percentile of the mean habitat scores, representing problematic snowmobile routes, were colored with a red outline to highlight them.

Layer set 8. Recreation sites.

8.a. Recreation sites. A point layer containing the locations of recreation sites was created by the Forest Service during the 2006 Forest Planning process.

8.b. Recreation site 100 ft buffer polygons. The recreation sites were converted to polygons by buffering them to a distance of 100 feet (file recsites-100buffer.shp). This polygon file was imputed with the mean value of the summed habitat scores of the underlying cells of the habitat travel screen. The 90th percentile of the mean habitat scores, representing problematic recreation sites, were saved as a separate shapefile colored red to highlight them (file problem-rec-90th.shp).

Layer set 9. Riparian areas, fisheries, lakes and wetlands. Fisheries, riparian areas and hydrographic map layers were developed in association with other riparian, aquatic and wetland layers described below.

9.a. NF Streams (National Forest). This layer was produced by the Wenatchee National Forest during the 2006 Forest Planning process. The streams cover the Okanogan, Wenatchee, Colville, and Kaniksu National Forests. The layer was originally called LLID.

9.b. T&E fisheries. This layer is a line map of streams with T & E species bull trout, spring chinook or summer steelhead. This was created by merging the two layers below.

T & E fish (Methow Watershed). This layer was created by digitizing segments of the NF streams layer that overlapped fish-bearing waters. This was done in consultation with

Jennie Molesworth and David Hopkins, USFS Fisheries Biologists. This layer was refined by comparison with the maps from the Upper Columbia Salmon Recovery Board (2006), Proposed Upper Columbia Spring Chinook Salmon, Steelhead, and Bull Trout Recovery Plan. Where the maps differed, the biologists' information was preferred.

T&E fish (outside the Methow). This layer was created by manually digitizing segments of the NF streams layer that overlapped WDFW fish inventories on the Department of Ecology online maps of Water Resource Inventory Areas (WRIA).

9.c. Riparian Direction. This layer was developed by the Forest Service. It is a polygon map of streams that shows intended Forest Service planning direction for designating stream buffers for riparian areas. There were two versions of the Riparian Direction layer, one for the Okanogan National Forest and one for the Wenatchee National Forest. These differed in data quality.

Unfortunately, the Riparian Direction layers could not be used directly, as the polygons were not separated at stream confluences, and the data standards were different inside or outside of Wilderness or depending on whether the data was from the Okanogan or the Wenatchee. However the Riparian Direction layer was useful for determining Forest Service intended direction on intended buffer widths.

The Riparian Direction layer assigned wetlands with either a 300 foot buffer or no buffer at all. This discrepancy appears to be due to misidentification of wetland areas in the Riparian Direction layer. It appears that only wetlands that were associated with streams or lakes were buffered in the riparian direction layer.

9.d. Streams and rivers. Streams and rivers were classified into the following categories: (1) T & E fisheries; (2) other fish-bearing streams; (3) perennial non-fish-bearing streams; (4) intermittent streams that were smaller class 4 streams with some misclassified class 3 streams (the Forest Service stream data did not identify stream classes). Streams classes were defined as follows, based on the definitions in INFISH (1995) and PACFISH (1995). Class 1 streams are perennial streams used by large numbers of fish for spawning, rearing, and/or migration; Class II streams are perennial streams used by moderate through significant numbers of fish for spawning, rearing, and/or migration; Class 3 streams are all other perennial streams or segments thereof not meeting higher class criteria; Class 4 Streams are intermittent streams not meeting higher class criteria.

9.e. Riparian buffer polygons. This layer contains polygons representing stream buffers of appropriate widths for riparian areas, lakes and wetlands. The riparian buffer layers were created from the NF stream layer, attributed with the presence of T & E fisheries or with stream classes. The buffer widths for this layer were based on the Riparian Direction layer.

Riparian areas, lakeshores and wetlands were maintained as separate layers, however they were merged into a composite grid file prior to analysis of the screens. In order to assign a single value when cell values overlapped, the grids were merged in the order riparian areas > lakes > wetlands, which gives precedence to the first grid.

T & E fisheries (300 ft buffer polygons). This riparian buffer was created by attributing the T & E fish-bearing streams layer with a habitat value of 20 and creating a buffer with a width of 300 ft. This file was then converted to a grid aligned with the base grid.

Class 2-3 streams (150 ft buffer polygons). This riparian buffer was created by attributing all named streams not already attributed as T & E fisheries with a habitat value of 15 and creating a buffer with a width of 150 feet. The stream classification is essentially all class 2-3 streams lacking anadromous fish or bull trout. This file was then converted to a grid aligned with the base grid.

Class 4-5 (unnamed) streams (100 ft buffer polygons). This layer was created by attributing all unnamed streams not attributed above with a habitat value of 10 and buffering the polygons 100 ft. These are smaller streams that are intermittent or unclassified. This file was then converted to a grid aligned with the base grid.

9.f. Lakes. This layer is the Forest Service map of lakes on the Wenatchee, Okanogan and Colville National Forests. This version was downloaded from the Forest Planning GIS download website. Intermittent lakes were subtracted from this layer and added to the

wetlands layer. This layer is named lakes.shp. Intermittent lakes were taken out and added to the wetlands layer.

Perennial lakeshore (300 ft buffer polygons). The lakeshore buffer was created by buffering all perennial lakes in lakes.shp by 300 ft to create file lake300-buffers.shp. This file was unioned with the lakes to create lakes&buffers.shp. The buffer was only created on the outside of polygons, resulting in some holes where polygons were convoluted. The buffer width was based on buffer widths used in the Riparian Direction layer. The habitat value was assigned a value of 15. Intermittent and dry lakes in the original file were previously removed from this layer and merged into the wetland layer. The buffered lake layer was converted to grid lkbuf with the cell values of 15 taken from field [habitat].

9.g. Wetlands. The wetlands layer was created by merging the National Wetlands Inventory (NWI) wetlands layer (wetlands-nwi.shp) with intermittent or dry lakes mapped on the lakes layer provided by the National Forest Revision Team, to create a file wetlands-all.shp. Polygons overlapping lakes were erased from this layer (file name wetlands-all-no-lakes.shp).

Wetlands 150 ft buffers. The wetland layer wetlands-all-no-lakes.shp was buffered to a width of 150 feet to create file wetland150-buffers.shp, with an assigned habitat value of 10. The buffer width corresponds to INFISH (1995) recommendations rather than the Riparian Direction layer. The buffer was only created on the outside of polygons, resulting in some holes where polygons were convoluted. The buffered wetlands file was then unioned with the wetlands layer wetlands-all-no-lakes.shp to create the buffer and wetlands in the same file (wet&buffers.shp). The wetlands+buffer layer was converted to grid wetbuf using the habitat values of 10 taken from field [habitat].

9.h. Riparian Composite Grid of buffered riparian areas, lakes and wetlands. The grid files containing the riparian areas, lakes and wetlands were converted to a single grid layer. This layer contains values for T & E fisheries, riparian areas, lakes and wetlands. The sequence of operations to create this layer began by merging the Riparian Buffers grid with the Lake Buffers and then merging the result with the wetland buffers. Precedence in cell values was given to the earliest input file in the order streams > lakes > wetlands. The resulting grid was named rip-lk-wet.

Layer sets 10-13. Wide ranging carnivore core habitats. These map layers were provided on CD by the Forest Service. The source data are 100 m grid files representing core habitats for four focal carnivores: wolverine, lynx and grey wolf (Singleton and others 2002). Also included was a layer representing core habitat for all of these species combined ("generalized species model"), and a layer representing the weighted distance from the combined core habitats.

Modifications to the Singleton data included the following: (1) The early core habitat for grizzly bear was determined from a Forest Service model provided by Bill Gaines rather than the data set from Singleton. Core lynx habitat was modified by the addition of USFWS 2008 proposed critical habitat. Wolf habitat was modified by the addition of several thousand acres used by the Lookout Wolf Pack during late fall, early spring and winter, 2008-2009.

The grid files from Singleton were converted to shapefile polygons. Polygons of value 0 were subtracted, and the remaining polygons were generalized to 500 meters tolerance with the Vector Trans 1.0 Extension - Generalize Features command. These files were then reprojected into UTM Zone 10 NAD 1983. Final analyses using grids were made after converting the polygons to grids aligned with the 30m base grid used with this analysis.

Layer set 10. Lynx habitat. The lynx habitat map layer was created by unioning the data from Singleton and others (2002) with a digitized version of the revised 2008 USFWS critical lynx habitat map. The polygon file was named lynx-critical-ncascades2008_1083.shp. The screen was created by conversion of the polygon file to a grid.

Layer set 11. Wolf habitat. This layer is a map of core wolf habitat (Singleton and others 2002). The wolf core habitat was modified to include several thousand acres of winter habitat used in 2008-9 by the Lookout Wolf Pack in the Methow Valley. This area was added as a single additional polygon prior to converting the polygon to a grid.

Layer set 12. Wolverine habitat. This layer is a map of core wolverine habitat (Singleton and others 2002). The screen was created by conversion of the polygon file to a grid.

Layer set 13. Inverse weighted distance to composite carnivore core habitat. This layer contains the weighted distance to core habitat for four focal species of wide-ranging carnivores combined (Singleton and others 2002). This layer was converted to an approximation of its inverse by subtracting the original distance values from 11, to yield values ranging from 1 to 10, with 10 representing core habitat. The screen was created by conversion of the polygon file to a grid.

Layer set 14. Grizzly Bear habitat. This map was provided on CD by the Forest Service. The source data contained two separate layers, one showing early core habitats and the other showing middle season core habitats.

   The layer of grizzly bear habitat was developed from an informal document request fulfilled by Pat Murphy at the Wenatchee SO on October 26, 2007. There were four ArcInfo export coverages in UTM zone 10 NAD 1927: wengrizearl.e00 and wengrizmid.e00, okagrizmid.e00 and okagrizearl.e00. corresponding to Wenatchee and Okanogan grizzly bear core habitat coverages for the "early" season core, and the "middle/late" season core habitat, respectively.

   Part of the data development process was done in a separate project workspace begun in 2007 to address the Forest Planning process then underway.

   The four coverages were converted to shapefiles and then reprojected to UTM Zone 10 NAD 1983. The layers were processed using field values given in the table below. Data was processed so as to eliminate polygon boundary errors that were revealed during the original analysis in 2007.

Table of fields used in the development of the grizzly bear habitat layer.

Shapefile	Values indicating core habitat
okanogan early habitat	[core] = "core" or blank
okanogan mid habitat	[earlycode] = "core" or blank
wenatchee early habitat	[early] = "early" or blank [code] = "core" or "early season snow co" or "lakes" or "road and trail buffer"; all values of "early season snow co" are also marked "early" in [early]; some values of "lakes" also are marked "early" in [early]; the values in [code] were used to determine whether a polygon was core habitat or not
wenatchee mid habitat	[code] = "core" or "road and trail buffer" or "lakes"

   The procedure used for each shapefile was to separate the grizzly bear habitats into 8 separate files of core and non-core habitat based on the data fields above, followed by dissolving and then exploding the polygons in the created files to be sure there were no overlapping polygon boundaries. This produced 8 separate output files.

   The non-core habitats were not further used. The remaining 4 files were merged into 2 files by merging the Okanogan and Wenatchee data sets. This resulted in 2 Forest-wide coverages: one for early habitats and one for the middle/late habitats. These were also dissolved and then exploded.

It was not possible to union the early or mid habitats beyond this point within Arcview 3.2. There were probably too many crossed lines (several of the coincident boundaries are derived from grid data converted to polygons, causing large numbers of coincident vertices to be both inside and outside of data sets). The screen for grizzly bears used only the early core grizzly habitat map layer. The screen was created by conversion of the polygon file to a grid.

Layer set 15. Habitat travel screen (sum of all grid cell habitat scores). The final layer containing the travel screens was made by overlapping all of the screens and summing the habitat values of each overlapping cell to produce grid sumhab. Input grids were: Inverse distance to focal carnivores, wolverine habitat, wolf habitat, lynx habitat, grizzly bear early habitat, LSR+AMA , and composite riparian-lake-wetland.

Layer set 16. Line Density of roads, trails and snowmobile routes. Road density and other linear density analyses were processed in ArcGIS 9. Linear density in units of meters /sq meter was calculated using a radius of 1609.344 m (1 mi) and a 30 m grid cell size. The following 6 shapefiles were processed to create grid files of line density calculations; Major Highways and Railroads; FS Roads Levels 2-5; Level 1 roads (DNR Roads not Intersecting Forest Service Level 2-5 Roads); Snowmobile Trails; Motorized Trails; Nonmotorized Trails.

> **Line Density Grid in meters per square meter.** The default output of ArcGIS 9 was in meters/square meter. These initial results were stored in the density folder.

> **Line Density Grid in tenth miles per square mile.**

> Line density was created as output from ArcGIS in meters per square meter and converted to miles/square by multiplying the result in meters per square by the factor 1609.344.

>> **Line Density Grids aligned with a smaller base grid.** A new, smaller base grid was created for use in the next step. This grid was aligned with the base grid, but was only just large enough to contain the extent of all of the above files. The above grids were merged with grid newbase4 as the second file to align them all to the same extent as the grid newbase4. The final results were copied into folder linedensity with the filenames fs25, hwyrr, lev1, trlmoto, snomo, trail representing the themes for Forest Service level 2-5 roads; Highways and railroads; DNR roads not intersecting Forest Service level 2-5 roads; Nonmotorized trails; Snowmobile routes; Motorized trails.

>> **Non-FS Road Density (mi/sq mi) grid**. This is a grid file containing the summed road density from 3 different density grids: Highways and Railroads Road Density; DNR non-FS Road Density; and Motorized Trails Road Density. The summed road density grid is named nonfsden. This grid has some highways double-counted, e.g., Highway 20 on the ONF, and therefore its use was deprecated.

>> **FS Level 2-5 Road Density (mi/sq mi) polygon file**. This layer is a polygon shapefile (Fs25-rd-dens1&3.shp) converted from the FS Road Density grid. The values of gridcode in the shapefile were divided by 10 to load [mpsm] with the following density values: 1 mi / sq mi and 3 mi / sq mi. The two density polygons were unioned to create a single file with two different sets of polygons with the values 1 or 3 for mi / sq mi.

>> **Non-FS Road Density (mi/sq mi) polygon file**. This layer is a polygon shapefile containing road density polygons in values of mi/sq mi for two values of density: 1 mi / sq mi and 3 mi / sq mi. It was created by converting the grid file nonfsden to a shapefile. The values of gridcode in this shapefile were divided by 10 to load [mpsm] with the following density values: <1 mi / sq mi, ∃1 mi / sq mi and ∃3 mi / sq mi. This file was then dissolved on [mpsm]. This file is named Fs25-rd-dens1&3.shp. This file has some highways double-counted, e.g., Highway 20 on the ONF, and therefore its use was deprecated.

Snowmobile Route Density (mi/sq mi) polygon file. This layer is a polygon shapefile containing snowmobile density polygons in values of mi/sq mi for two values of density: 1 mi / sq mi and 3 mi / sq mi. It was created by converting the grid file snomo to a shapefile. The values of gridcode in this shapefile were divided by 10 to load [mpsm] with the following density values: <1 mi / sq mi, ∃1 mi / sq mi and ∃3 mi / sq mi. This file was then dissolved on [mpsm]. This file is named snomo-dens1&3.shp.

Trail Density (mi/sq mi) polygon file. This layer is a polygon shapefile containing road density polygons in values of mi/sq mi for two values of density: 1 mi / sq mi and 3 mi / sq mi. It was created by converting the grid file linedensity/trail to a shapefile. The values of gridcode in this shapefile were divided by 10 to load [mpsm] with the following density values: <1 mi / sq mi, ∃1 mi / sq mi and ∃3 mi / sq mi. This file was then dissolved on [mpsm]. This file is named trail-dens1&3.shp.

Road density showing new areas exceding 1mi/sq mi. This layer depicts all new areas with a road density >1 mi / sq mi that weren't included in the FS level 2 road density layer. This file is named correct-new-rd-dens1&3.shp.

Line density within the National Forest Service administrative boundary. These are the road density polygon files above, wherever they intersect the extent of the National Forest. These files are named with "clip-" prepended to the names above, e.g., clip-snomo-dens1&3.shp.

Habitat Screen Decile Means of areas where Motorized road density >1 mi / sq mi. These are areas not on the Forest Service layer of level 2-5 road density exceeding 1 mi/sq mi.

(under construction) Key ungulate species habitat. This map shows mountain sheep habitat and mountain goat habitat.

Other layers assembled but not used

DNR Hydrography (not used). This layer is the DNR Washington State Watercourse Hydrography layer. This layer contains Water Type Classifications used in conjunction with DNR Forest Practices regulations for Eastern Washington. this data could not be used on Forest Service stream data, because of variable data quality and non-coincident lines.

DNR uses stream types, which are defined somewhat differently from stream classes used here. DNR stream Types 1-5 are coded in field FP_WTRTY_1975_CD. Sream types 1-3 are roughly equivalent to stream classes 1-3. Perennial, non-fish bearing streams are DNR Type 4 streams. DNR type 5 streams are intermittent. DNR types 0 and 9 make up the bulk of remote, wilderness streams.

Although this layer is incomplete it is potentially useful. A set of DNR type 1 and 2 streams was extracted from the data, however due to variable data quality no further work was done with this data set.

State shorelines (DOE). This layer is the Department of Ecology map of State Shorelines of Significance. It is almost completely overlapped by the T & E fish layer, so it wasn't used.

Lakes and wetlands unioned. The lake shore and wetland layers were unioned (file name lakes&wetlands.shp). These were attributed in field [habitat] with a value of 15 for lakes and a value of 10 for wetlands. Preference for attribution was given to lakes. This layer was not used because it took too long to process and a quicker method was available.

Wild & Scenic Rivers. This layer contains proposed Wild, Scenic and Recreation River Corridors for the Colville, Okanogan and Wenatchee National Forests where eligibility screening and the suitability analysis were completed. All of these rivers overlapped those identified during the development of the riparian screens, therefore this data set wasn't used.