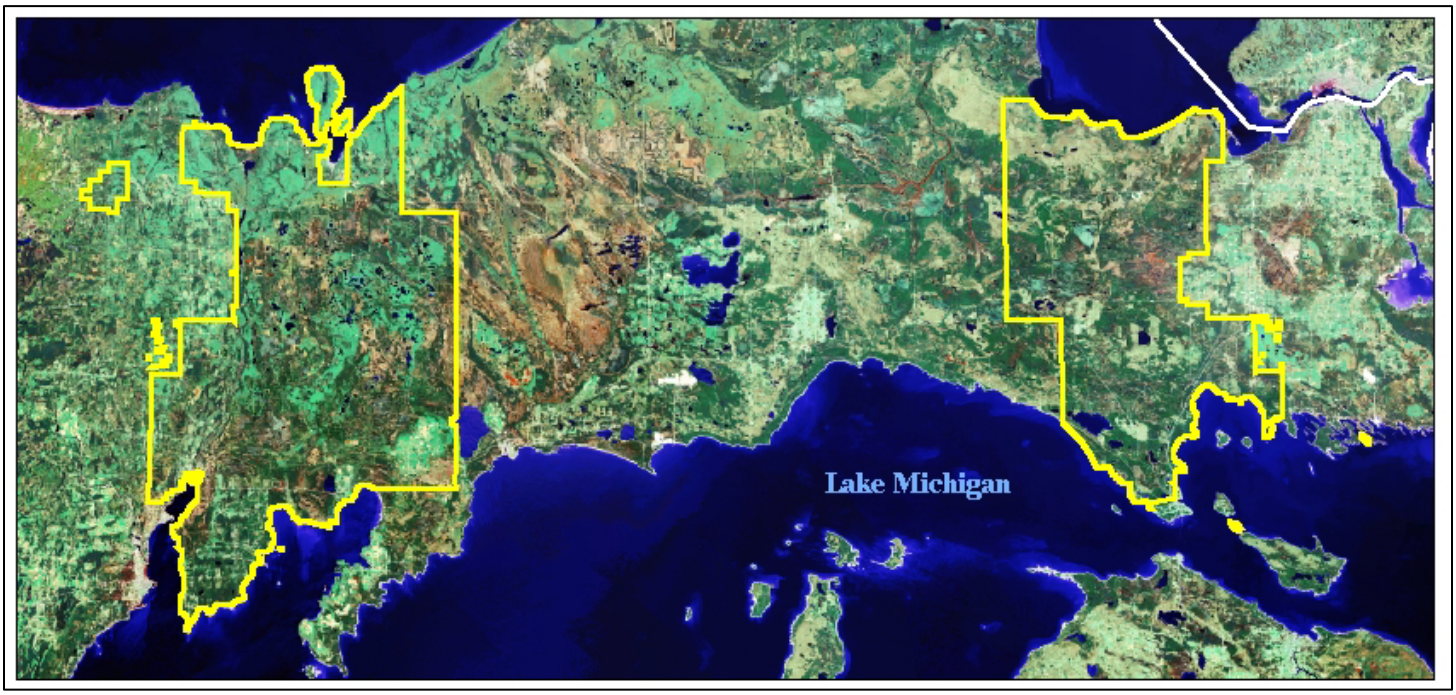
An Analysis of Roads and Roadless Areas on the Hiawatha National Forest, Michigan



Pacific Biodiversity Institute

AN ANALYSIS OF ROADS, TRAILS, AND ROADLESS AREAS ON THE HIAWATHA NATIONAL FOREST, MICHIGAN

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The Hiawatha National Forest provided most of the data used in this analysis. We made extensive use of 1998 infrared color orthophotos obtained online from the Michigan Geographic Data Library (Michigan Department of Information Technology). We also obtained land use-land cover data from the Michigan Geographic Data Library and used this in our roadless area mapping.

PROJECT FUNDING

This project was funded by Northwoods Wilderness Recovery (Marquette, MI), and Defenders of Wildlife (Washington, DC).

EXECUTIVE SUMMARY

Roads have strong ecological impacts, affecting habitat fragmentation, hydrologic functioning, soil erosion, wildlife movements, and many other issues. In order for natural resource managers to adequately understand and address these issues, reliable information on roads is required. Conversely, roadless areas provide important habitat for wildlife species that are sensitive to human disturbance. To intelligently manage wildlife resources managers need good information on the location, size and characteristics of roadless areas in various size categories.

We evaluated the quality of data related to roads, trails, and roadless areas that is maintained by the Hiawatha National Forest (HNF). We assessed the data in two ways. First, we examined the internal consistency of their data and information derived from that data as reported in Hiawatha National Forest documents. We compared original RARE II roadless areas with roadless data compiled by the HNF for the 2005 Forest Plan Revision Draft EIS (HNF, 2005). We also examined the HNF's GIS roads layers containing data on objective maintenance levels.

Second, we compared the Forest Service data to conditions on the ground. We used 1998 color infrared orthophotography for this comparison. We created data layers of roads/trails visible in the orthophotos but undocumented by the HNF's data. We also created a data layer of actual roadless areas, using the best available roads information, and compared this to HNF roadless data.

We found some problems and discrepancies with the HNF's roads, trails, and roadless area data. Problems include inconsistent and incomplete mapping of roads and roadless areas, poor spatial accuracy, and poor classification accuracy of some roads and trails. We document many examples of these problems through maps of Forest Service data overlaid on orthophotos and digital topographic maps.

During our analysis, by simply reviewing the Forest Service's GIS data in relation to orthophotography, we were able to provide substantial improvements to their data. Analytical results based on our improvements to the Forest Service data lead to dramatically different conclusions about the miles of road, road density, and acres of roadless areas in the National Forest than the conclusions one would reach with only the Forest Service data.

The most recent Forest Service data shows 4,338 miles of road within National Forest land on the HNF, with a road density of 3.09 miles per square mile. Using our road data improvements we calculated 5,573 miles of roads with a road density of 3.97 miles per square mile – a 22% increase in road miles and density. The Forest Service's RARE II roadless areas and the 2005 Forest Plan Revision Draft EIS map 7,820 acres of roadless lands within the Hiawatha National Forest. Using improved roads data and a clear methodology for consistent mapping of roadless areas, we found 439,500 acres of roadless lands within roadless areas of 5,000 acres or greater. In addition, we found many smaller roadless areas less than 5,000 acres in size.

The analyses we conducted on the Hiawatha National Forest highlight an assortment of mapping and documentation problems concerning roads and roadless areas. Left unaddressed, these problems have the potential to greatly compromise the reliability of transportation-related analyses and other assessments that the National Forest may make, based on the data.

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INTRODUCTION

It is widely recognized that roads have strong impacts on forest ecosystems. Roads affect habitat fragmentation, hydrologic functioning, soil erosion, wildlife movements, dispersal of invasive species, mortality of wildlife from vehicle collisions, patterns of insect and disease infestation, and many other issues (Ercelawn 1999). In order for natural resource managers to adequately understand and address these issues, reliable information on roads is needed.

Because of the significance of roads and trails for recreational and commercial activities as well as ecological issues, the Forest Service requires that each National Forest maintain current information on roads and trails. The National Forests have also been directed to evaluate the efficiency of their transportation networks for meeting transportation needs in the Forest while minimizing ecological impacts.

The objective of this project was to evaluate the quality of data related to roads and roadless areas that is maintained by the Hiawatha National Forest. The ability of the Forest Service to make good natural resource management decisions depends greatly on having reliable data and analyses on which to base those decisions.

METHODS

We assessed the quality of the Hiawatha National Forest's (HNF) roads and roadless area data in two ways. First, we examined the internal consistency of their data and information derived from that data as reported in Hiawatha National Forest documents. Second, we compared their data to conditions on the ground. We used 1998 color infrared orthophotography, digital topographic maps and digital hydrography data for this evaluation.

Data Descriptions

We obtained GIS data on roads, trails, and roadless areas from the Hiawatha National Forest at the end of 2005. We recognize that all these data are continually updated as road and trail status change. This report focuses on systemic problems that we found with the HNF's data rather than a few isolated errors that may have easily been updated between the release of this report and the time that we acquired the data.

Descriptions of the roads, trails, and other primary GIS data used in this assessment are provided below. In addition, a few other GIS layers were incorporated into the roadless area evaluation and these are referenced in the roadless area section of this report.

Roads

USFS Roads – This road infrastructure data layer contains roads classified as to their jurisdiction and objective maintenance level (OML). OML categories assigned by the Forest Service and used in this report are: (1) basic custodial care (closed), (2) high

clearance vehicles, (3) suitable for passenger cars, (4) moderate degree of user comfort, (5) high degree of user comfort, and (6) decommissioned. In addition, there are some roads with no assigned OML category. Jurisdiction categories include: county – parish – borough, forest service, other federal agency, private, state, state highway, and unknown. There are also roads with no assigned jurisdiction category, though these roads are not necessarily the same as the roads with no OML assignment.

Trails

USFS Trails – This layer was provided by the HNF and contains trails within the NF congressional boundary. Trails are labeled by their designated use categories.

Other Features

USFS Utility - This layer was provided by the HNF and contains utility line corridors and swaths.

Roadless Areas

RARE II Roadless Areas - This layer was provided by the HNF and contains all areas of the National Forest mapped as inventoried roadless areas under the RARE II process.

Inventoried Roadless Areas – These are roadless areas as mapped by the Forest Service in conjunction with Appendix C in the 2005 Draft EIS for the HNF Forest Plan Revisions.

Imagery

1998 Color Infrared Orthophotos – Orthophotos were obtained on-line from the Michigan Department of Information Technology website: http://www.mcgi.state.mi.us/mgdl/

Consistency of Data and Data Reporting

We looked at the consistency of mapping and categorizing of features within the USFS Roads data layer. For example, we checked whether the assignment of various road categories were consistent or if a wide variety of road types were inappropriately classified.

While conducting this review, we found that problems do exist with the HNF's roads data. Problems include poor spatial accuracy of some mapped roads and trails and inconsistent categorization and mapping of roads, trails, and roadless areas. As these issues are extremely difficult or time-intensive to assess in a quantitative manner, we documented examples and discuss these issues based on our intensive visual review of the data. Where possible, we conducted quantitative analysis related to these issues for limited areas.

Undocumented Roads and Motorized Trails

We systematically reviewed National Forest lands, mapping roads and motorized trails that are undocumented by the HNF. We measured miles of undocumented roads/trails and analyzed the effects of these on measurements of road density.

We overlaid the USFS Trails, USFS Roads, and USFS Utility layers on 1998 color infrared orthophotos and on-screen digitized at a 1:10,000 scale roads and motorized trails that were visible on the orthophotos but were not included in any of the HNF GIS layers. The assessment area included all Forest Service owned lands within the Hiawatha congressional boundary.

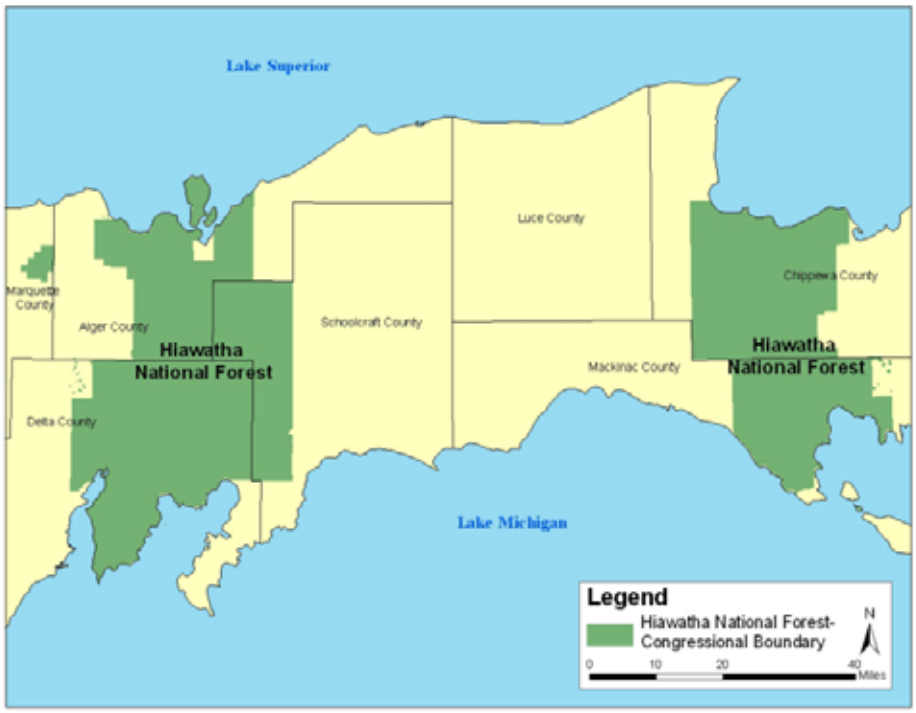

Figure 1. Map of the Hiawatha National Forest.

We combined the digitized, undocumented roads and motorized trails into a single roads/trails layer. We did this because it is not possible to reliably differentiate on orthophotos between potential well-maintained motorized "trails" and potential "roads". We did not digitize trails that we thought were not usable by motorized vehicles.

We categorized the digitized features according to the following five categories:

> Level 1 – Roads that appear to be well maintained and in current use and that correspond to OML levels 3, 4, and 5. Roads are likely to be passable by passenger cars.

Level 2 – Roads/trails that are not overgrown but not as well maintained as Level 1 roads. These roads correspond to OML level 2.

Level 3 – Roads/trails that are somewhat overgrown but may still provide paths for snowmobiles or OHVs. Some of these roads/trails may also be passable by some high clearance vehicles.

Level 4 - A utility corridor or other swath.

Level 5 – Old railroad grade.

Note - Level 1 and 4 features were used in creating a digital layer of roadless lands (see Roadless Areas section below).

We used the following guidelines in digitizing and categorizing undocumented roads/trails:

- We attempted to be conservative. For example, if the appropriate level for a feature was questionable, we typically classified it at the lower level. If it was questionable whether a route should be digitized at all, we generally did not digitize it.

- We did not re-digitize roads or trails from the HNF's GIS data that appeared to represent road or trail features visible on the orthophotos, but were simply mis-mapped. Mis-mapped HNF roads and trails were sometimes as far as 150 meters away from their true location.

- We mostly only digitized routes whose path could be traced back to the main road network. In cases where HNF roads and trails were mis-mapped, we connected our digitizing to the true location of the adjacent roads and trails rather than the mis-mapped data.

- We used local context and adjacent HNF mapped roads to aid in photointerpretation. For example, in areas of high canopy closure roads may appear substantially less prominent than in open areas. We used the classification of nearby HNF roads (e.g. OML 2 or, OML 3 road, etc.) as a guide in photointerpreting and categorizing undocumented features.

Roadless Areas

We used the best available information on roads and other permanent human disturbances to map roadless areas of 1,000 acres or greater in the Hiawatha National Forest. Methods used for mapping roadless areas were similar to those developed during Pacific Biodiversity Institute's first inventory of wildlands in Washington State (Morrison et al.

1998). These methods yield an objective assessment of roadless areas as defined by our input parameters (details provided below). We compared our roadless area map with the Forest Service roadless data.

Data Used Roadless Area Analysis

The data used to create our roadless area layer are described below.

Roads

We combined components of the USFS Roads and Improved Roads data to create a layer on which to base our roadless area analysis. We chose roads with OML levels 3, 4, or 5, and roads with a jurisdiction category of county, state, or state highway from the USFS Roads data, and combined these with the USFS mapped utility corridors and swaths, undocumented roads (Type 1 roads), and undocumented utility corridors and swaths. We compiled the data into a single "roads" layer.

Land Use

We used the Michigan DNR's 2001 Landsat-based Land Use-Land Cover dataset obtained online at http://www.mcgi.state.mi.us/mgdl/ to identify all permanently developed land use cover types, including gravel pits/mines, farmsteads and other rural developments, urban and industrial areas, roads, improved trails and rail lines.

Land Ownership and Protection Status

We used ownership GIS data obtained from the HNF to identify Forest Service owned lands.

Roadless Area Mapping Procedures

We defined roadless areas as any area greater than 20 meters from a road that was at least 1,000 acres in size with a minimum width of 400 meters. The calculation of minimum size was made after all developed and permanently disturbed areas (e.g. urban, agriculture, mines, etc.) were removed.

We used a grid cell size of 10 meters for all analyses. Due to the approximation of linear road features by square cells, the actual setback distance from the road will vary somewhat. While a smaller base grid cell size would result in more accurate delineation of roadless areas, the level of accuracy obtained from 10-meter cells was sufficient for the scale of this project.

We conducted the roadless area analysis on lands owned and managed by the Hiawatha National Forest. All other ownerships were excluded.

To delineate the roadless areas, we first calculated those areas greater than 20 meters from any road using a line-distance function. Next, we excluded any permanently developed or disturbed areas as well as major water bodies (lakes over 250 acres

according to USFS waterbodies data). Then we excluded any non-Forest Service owned lands. Any areas falling below the 1,000-acre minimum size were then eliminated.

To detect points of a roadless area below 400 meters in width, we used an algorithm to "shrink" and "expand" the roadless areas. This process effectively "pinched off" any narrow necks between larger areas or appendages to a roadless area. After this process, areas falling below 1,000 acres were again eliminated.

The final roadless area grid was converted to a polygon layer. We coded the roadless areas into three size classes - those between 1,000 and 2,500 acres, those between 2,500 and 5,000 acres, and those over 5,000 acres. This is the final roadless area layer used for mapping and comparison with Forest Service data.

RESULTS

We found the following problems with the Hiawatha National Forest's GIS roads, trails and roadless area data. The following sections describe and provide examples of problems regarding each of the topics listed below:

1) Spatial accuracy of roads mapped by the Forest Service
2) Misclassified road types.
3) Undocumented roads/trails
4) Incomplete roadless area maps.

Spatial Accuracy of Roads Mapped by the Forest Service

We found the spatial accuracy of the roads data to be variable and in some places, extremely poor. We did not conduct a quantitative assessment of spatial accuracy, which would be a large and complex task. We did however, record locations of particularly inaccurate road locations in our GIS as we were evaluating other aspects of the HNF's road and trail data. Figure 2 illustrates one area of poor spatial accuracy in the Forest Service roads layer in the Bass Lake area. We found many other examples of poorly mapped roads and trails, some as much as 166 meters from their true location (Figure 3).

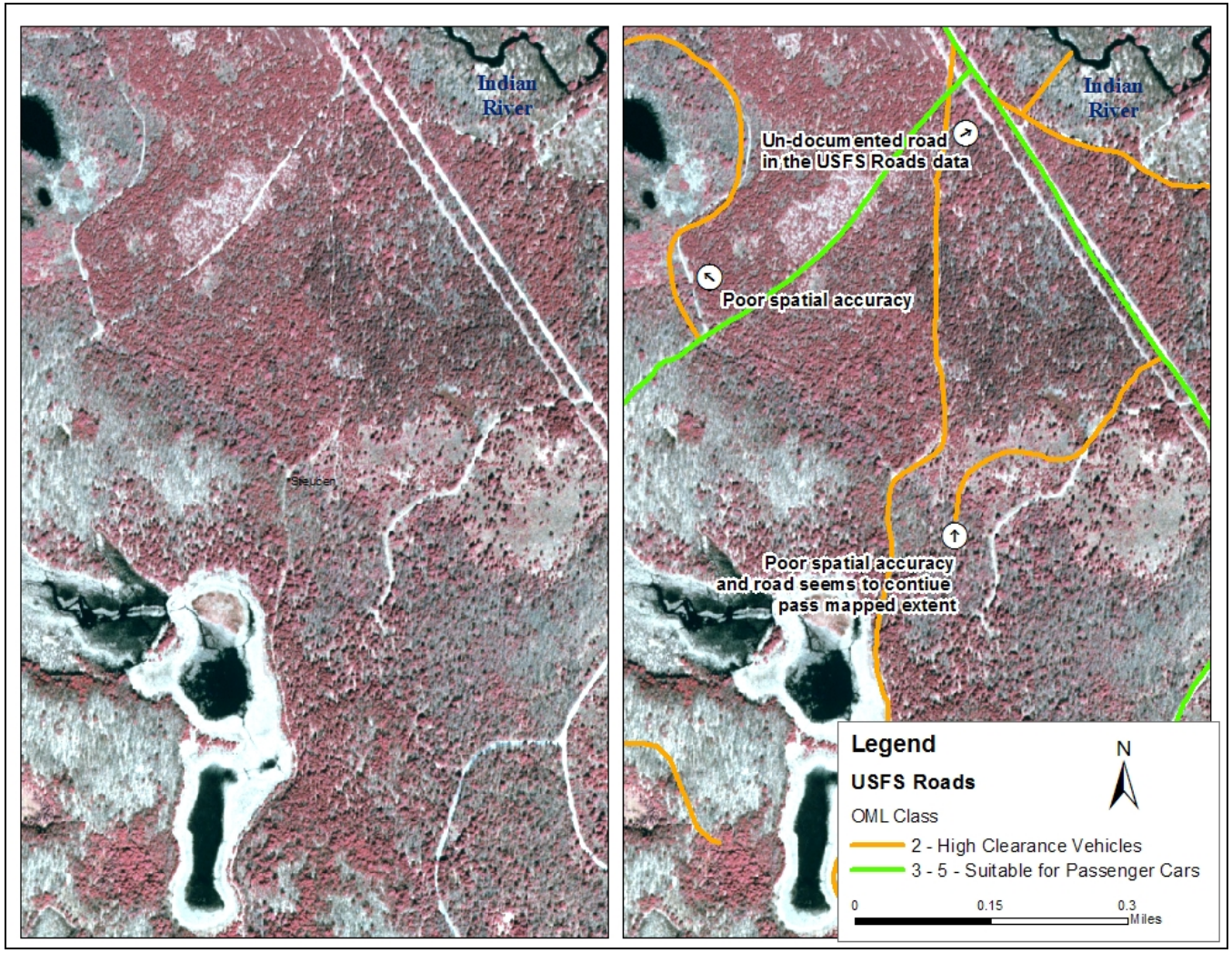

Figure 2. Paired maps showing an area where the USFS Roads layer exhibits poor spatial accuracy, and where a road clearly existing in the orthophoto is completely missing in the USFS roads data.

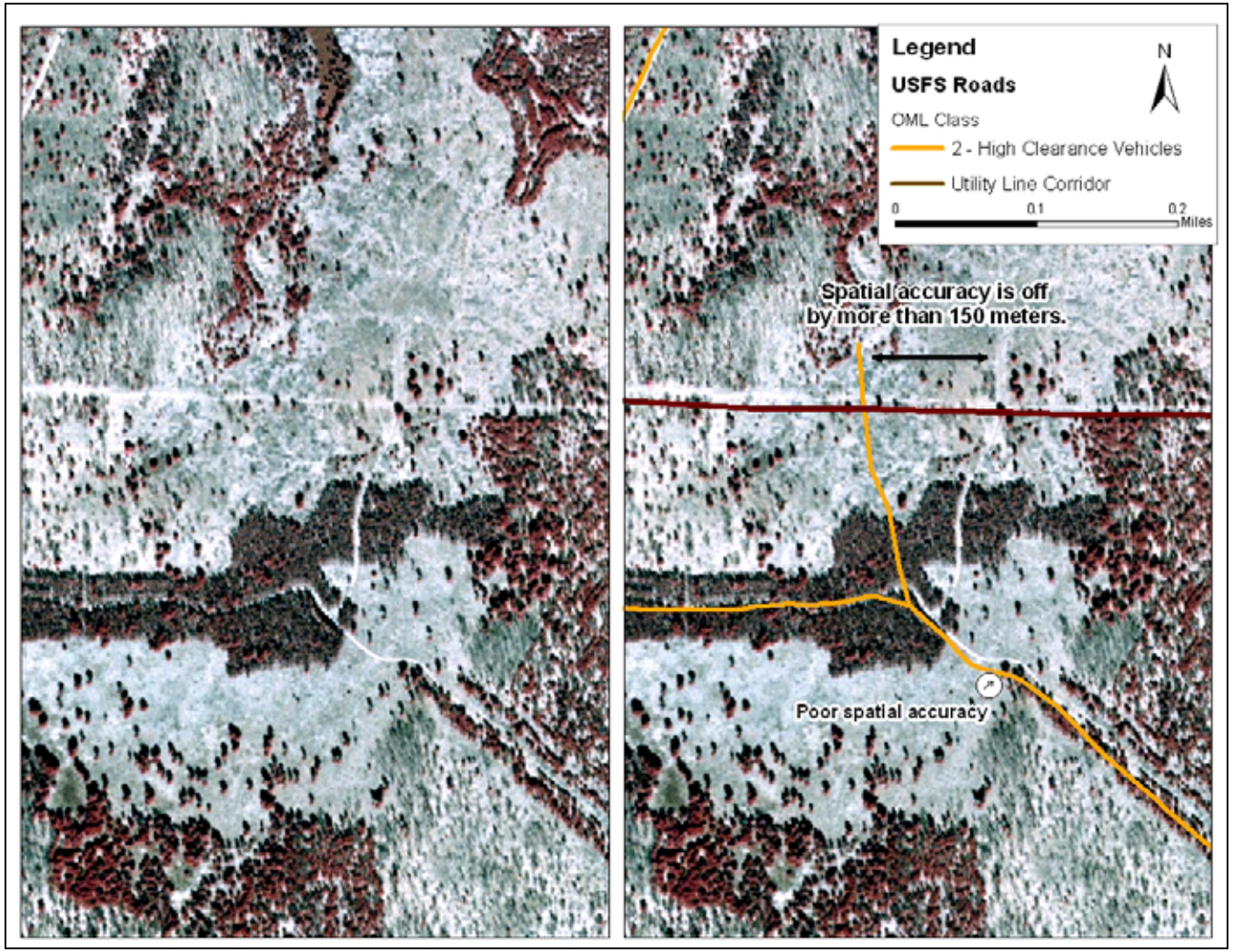

Figure 3. Paired maps showing poor spatial accuracy of a road mapped in the USFS Roads data layer.

Misclassified Road Types

Some of the roads mapped in the Forest Service roads data have questionable attribute values for important information such as OML Class and Jurisdiction. We did not conduct a quantitative assessment of the attribute variable accuracy of the Forest Service roads data. We did however, record a number of areas and road segments that appeared to have incorrect or misleading attribute values in our GIS as we were evaluating other aspects of the HNF's road and trail data. Figure 4 illustrates some of the attribute value problems of the Forest Service roads data occurring in the area south of Shingleton. The road attribute data does not correspond with the Forest Service ownership data.

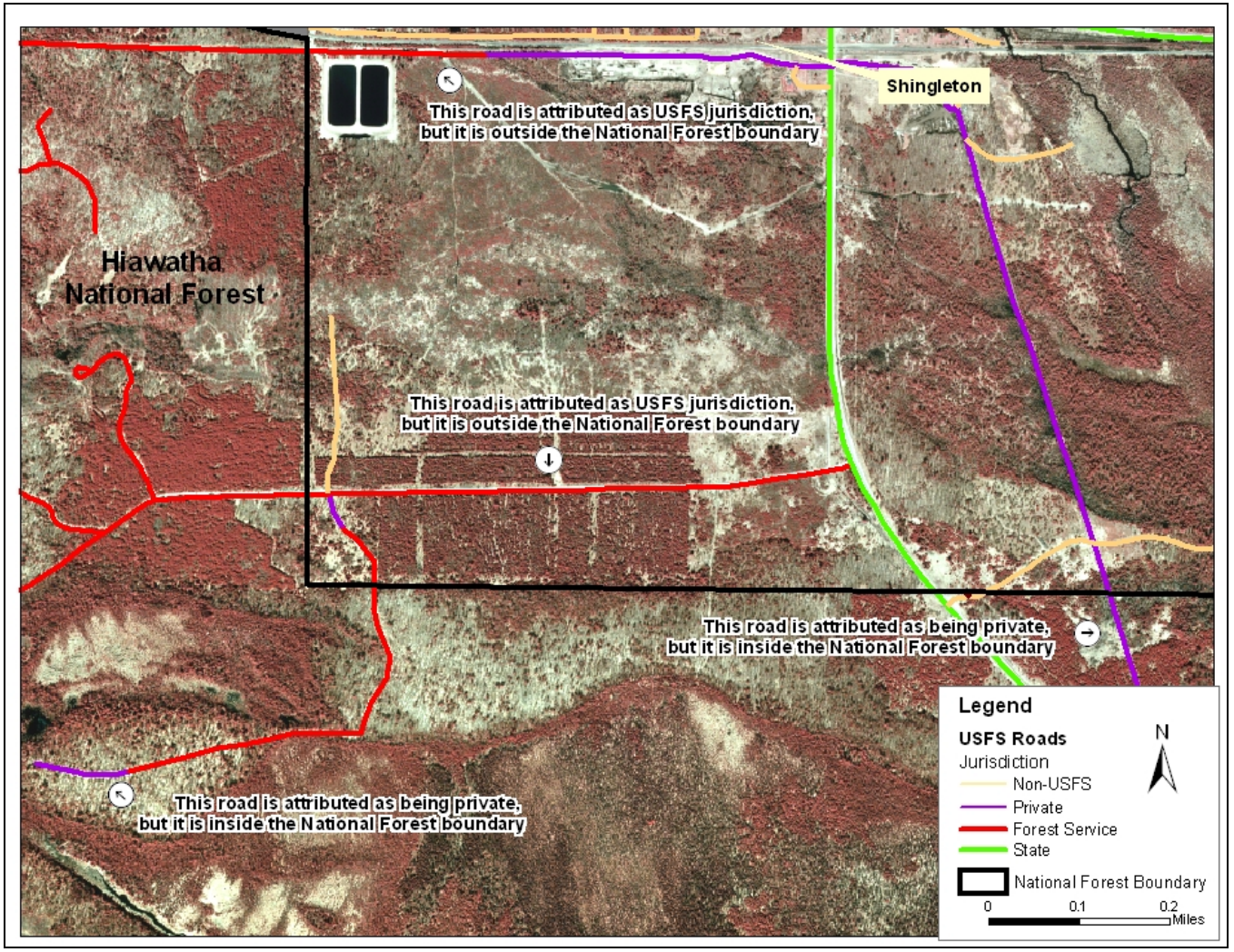

Figure 4. Paired maps illustrating roads misclassified by jurisdiction in the Forest Service roads layer.

Undocumented Roads/Trails

By examining the 1998 orthophotos we found 545 miles of roads/trails (PBI Level 1 and 2) on National Forest land that are likely usable by passenger vehicles, high clearance vehicles and/or OHVs but are not documented in the Forest Service roads data (Table 1). This is a conservative estimate and does not include an additional 690 miles of undocumented roads/trails (PBI Level 3), which appeared somewhat overgrown but potentially usable as snowmobile and/or OHV routes. Many of these PBI Level 3 features may also be usable by high clearance vehicles. An example of a PBI digitized roads is represented in Figure 5.

We combined the above types of undocumented roads with the Forest Service roads layer to calculate our best estimate of actual road mileage and density in the Hiawatha National Forest. We compared this to road mileage and density calculated from the Forest Service roads layer alone.

We found that the total road mileage for National Forest lands increased by 22%, from 4,338 miles to 5,573 miles, when undocumented roads were considered. Road density increased from 3.09 miles per square mile to 3.97 miles per square mile for the same area (Table 2).

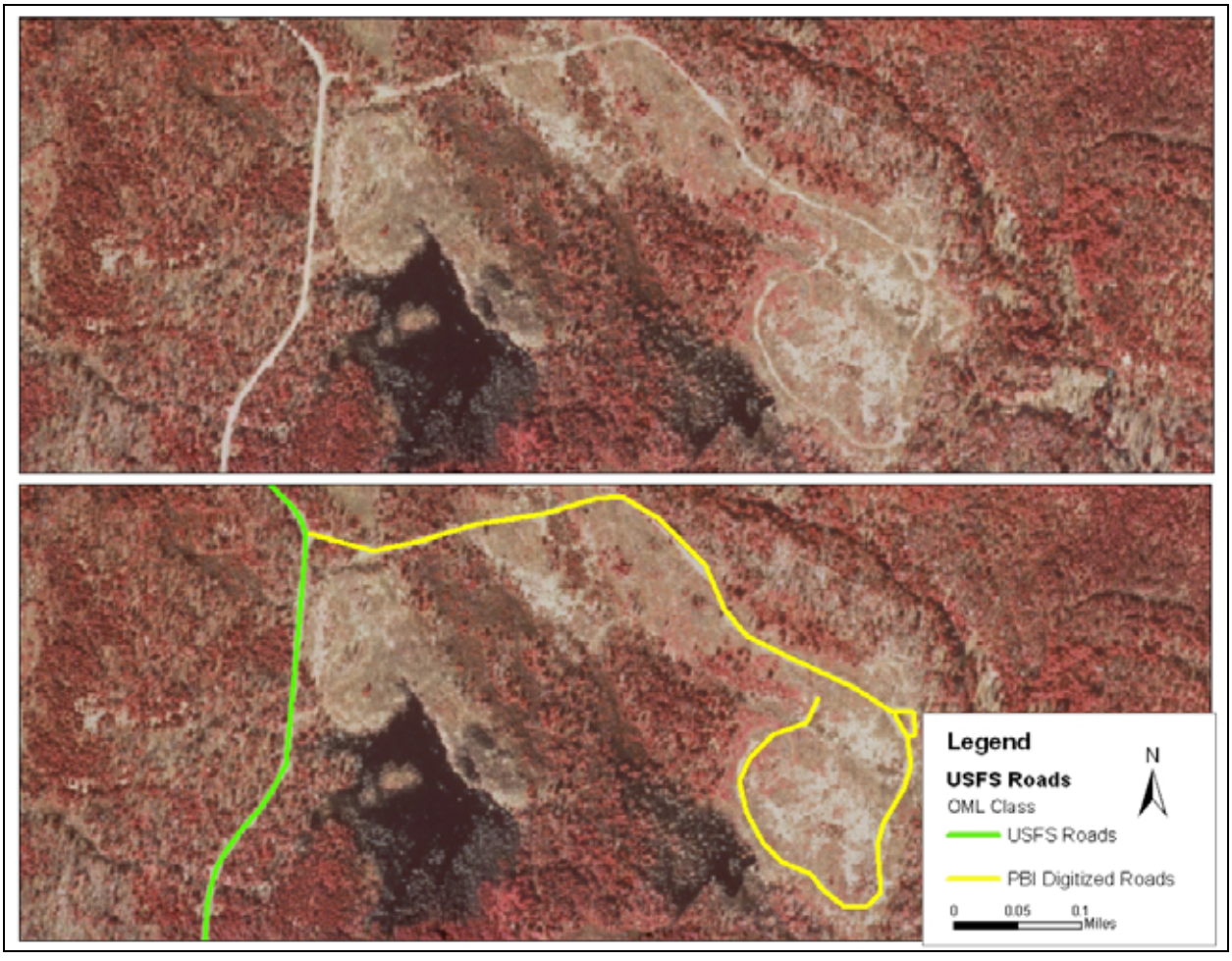

Figure 5. Paired maps showing a road undocumented by the Forest Service in the USFS Roads data.

Table 1. Miles of road on Forest Service ownership that are visible on 1998 orthophotos but not included in the Forest Service roads GIS layer.

Road Type	Miles of Road
Roads/Trails undocumented in both Forest Service roads and Improved Roads GIS layers that were photointerpreted and digitized by PBI	
PBI Level 1 roads/trails - passable by passenger vehicles	16
PBI Level 2 roads/trails - passable by high-clearance vehicles and/or OHVs	529
Total PBI Levels 1 & 2	**545**
PBI Level 3 roads/trails – overgrown, but probably passable by snowmobiles and/or OHVs, and possibly high-clearance vehicles	690
Total PBI Levels 1, 2, & 3	**1,235**

Table 2. Differences in road mileage and density when calculated for roads documented in the Forest Service roads layer versus actual roads (Forest Service roads plus undocumented roads).

Road Type	Miles of Road	Road Density (miles/square mile)
Forest Service roads	4,338	3.09
All actual roads and trail features not included in USFS layer (PBI Level 1 – 3 roads mileage from Table 3)	1,235	0.88
Total Roads	5573	3.97

Evaluation of Roadless Area Maps

Considering all the wilderness and roadless areas mapped by the HNF between RARE II and the latest roadless inventory described in the 2005 draft EIS, the Forest Service has identified only around 45,066 acres of roadless areas in the Hiawatha National Forest. (Only one polygon known as the Fibre Area totaling 7,822 acres was identified in the 2005 analysis).

In dramatic contrast to the roadless area mapping conducted by the Forest Service, Pacific Biodiversity Institute found 46 roadless areas over 5000 acres in size totaling 439,500 acres in the Hiawatha National Forest (Figures 8 and 9). We also found 94 roadless areas between 1000 and 5000 acres in size totaling 269,341 acres in the Hiawatha National Forest. The differences between our roadless inventory and those conducted in the past by the Forest Service are listed in Table 3 and illustrated in Figures 6 through 11.

Table 3. Comparison of Forest Service roadless area inventories with that of Pacific Biodiversity Institute.

Roadless Description	Area (acres)
Forest Service IRAs (IRAs from 2005 draft EIS and RARE II)	45,066
Actual roadless areas 1000 to 2500 acres in size as mapped by PBI	76,617
Actual roadless areas 2500 to 5000 acres in size as mapped by PBI	192,724
Actual roadless areas greater than 5000 acres in size as mapped by PBI	439,500
Actual roadless areas of all sizes mapped by PBI	708,841

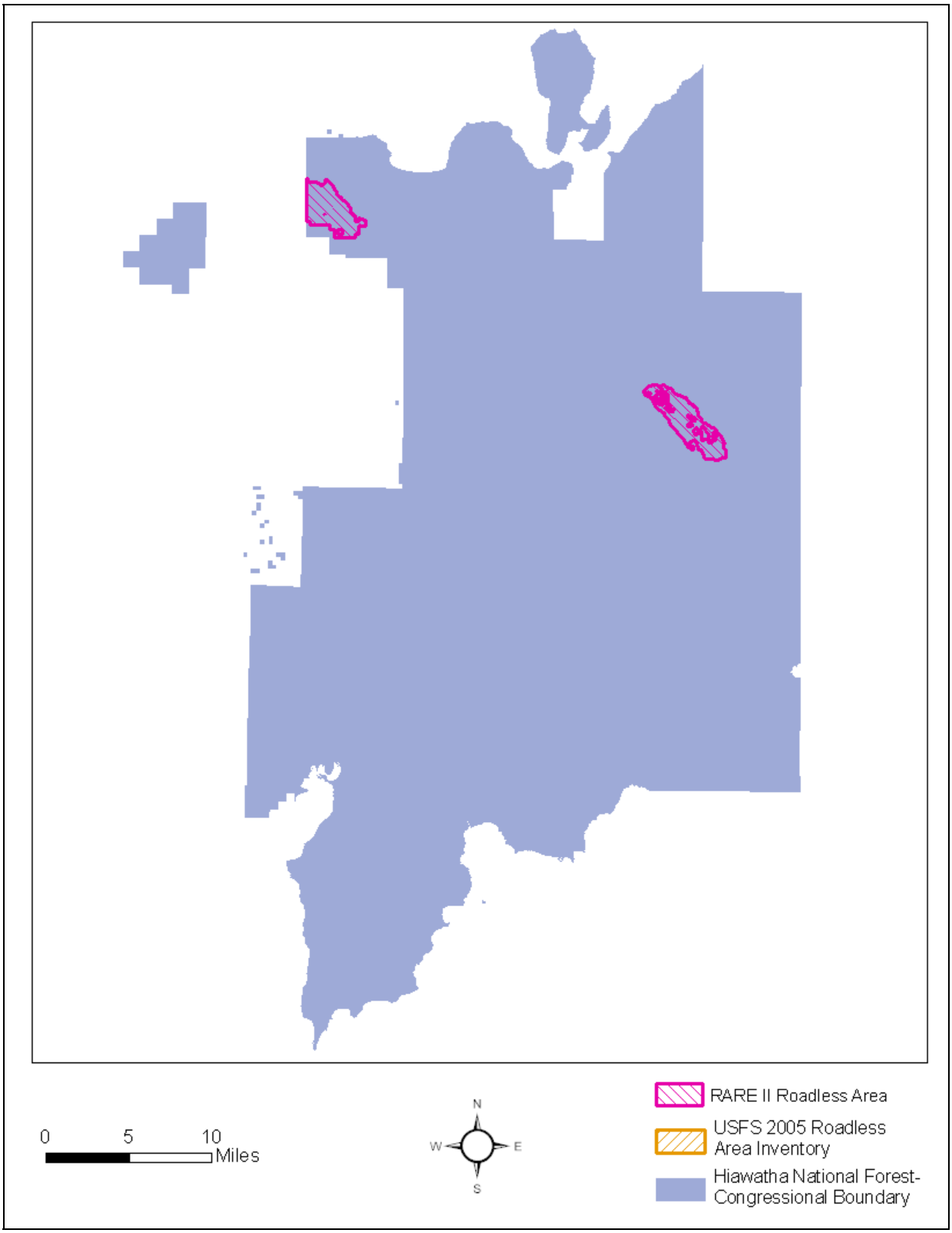

Figure 6. Map showing the RARE II roadless areas and Inventoried Roadless Areas delineated in the 2005 Forest Plan Revision Draft EIS on the western portion of the Hiawatha NF.

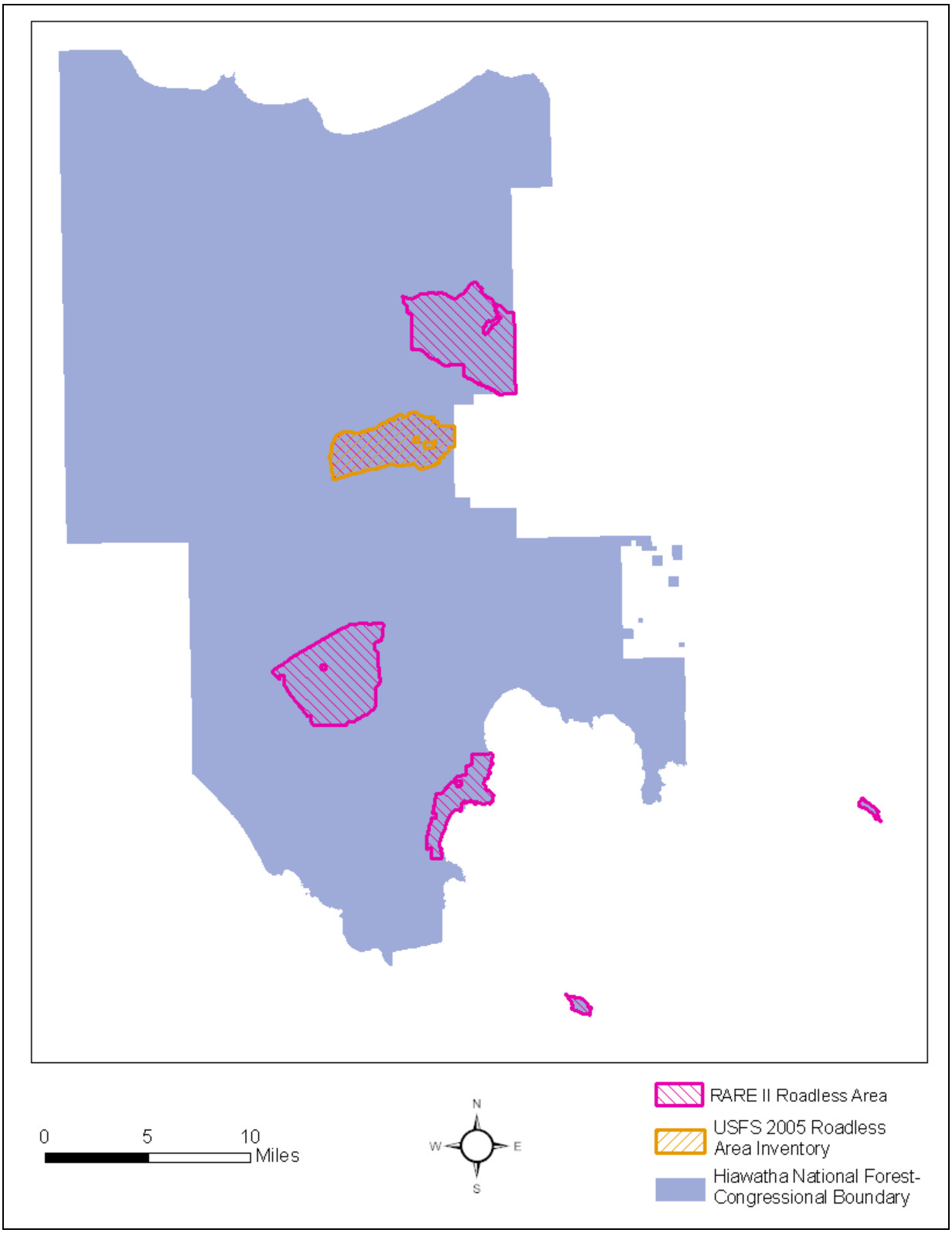

Figure 7. Map showing the RARE II roadless areas and Inventoried Roadless Areas delineated in the 2005 Forest Plan Revision Draft EIS on the eastern portion of the Hiawatha NF.

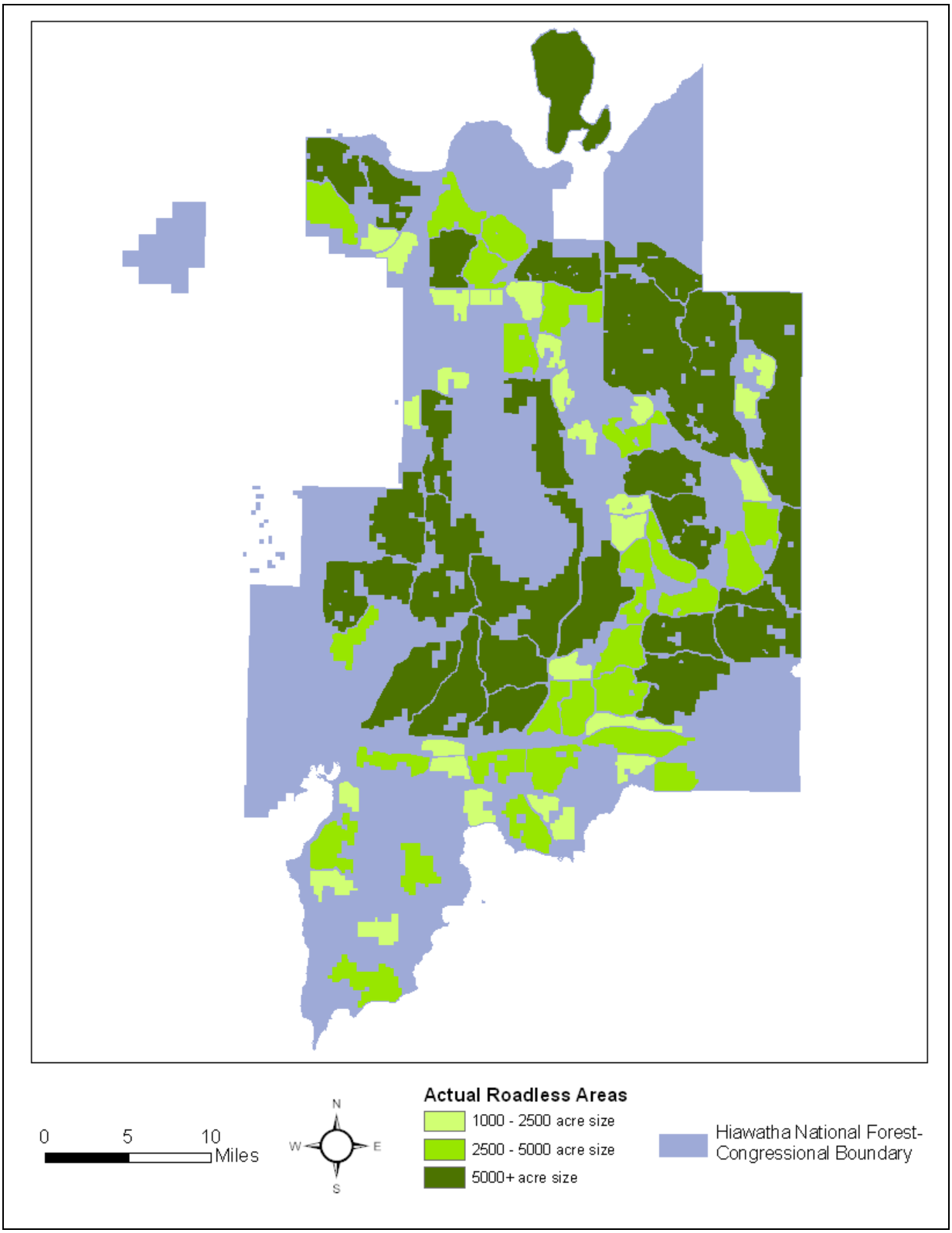

Figure 8. Actual roadless areas in the western portion of the Hiawatha NF delineated by Pacific Biodiversity Institute using the most current information on roads and development.

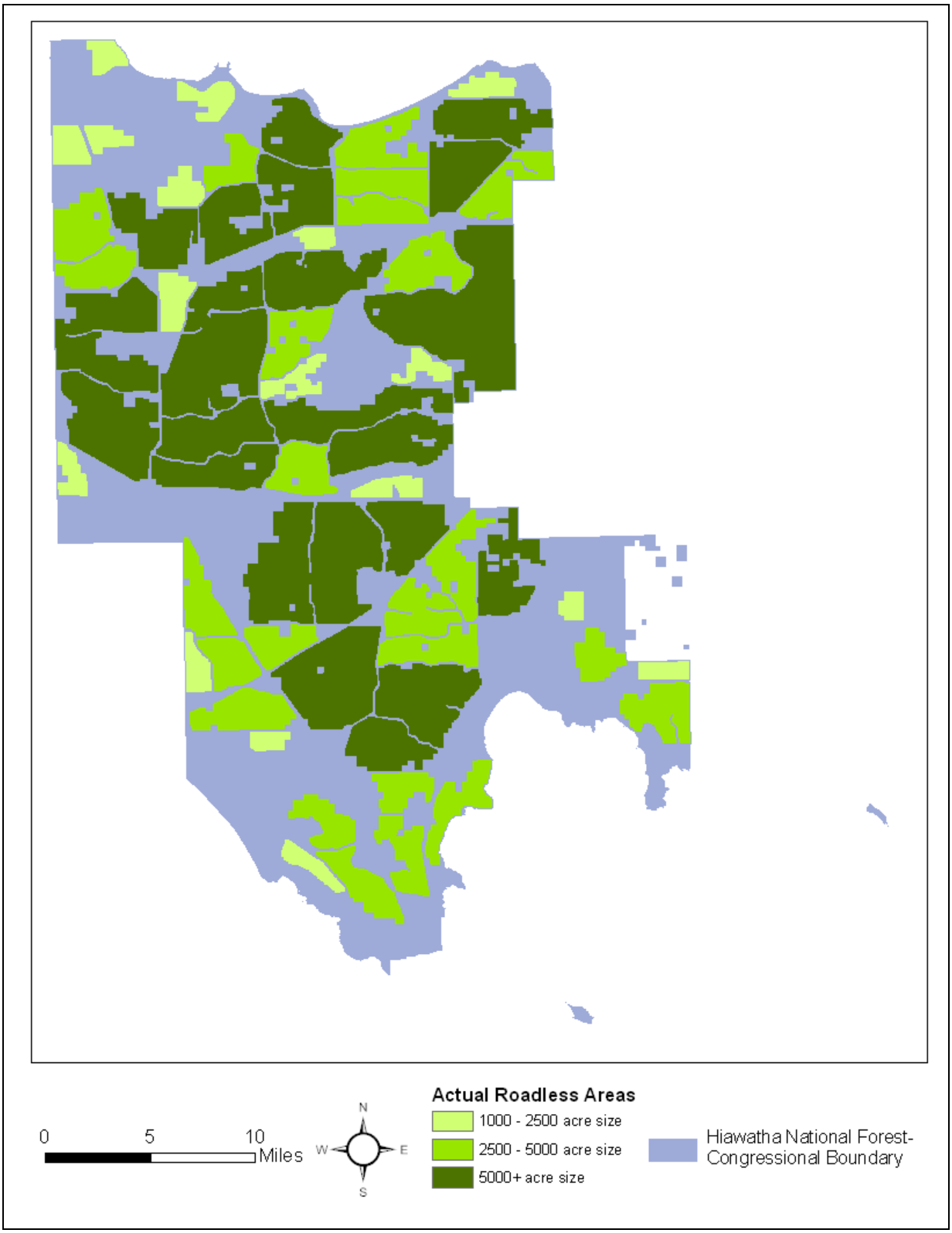

Figure 9. Actual roadless areas in the eastern portion of the Hiawatha NF delineated by Pacific Biodiversity Institute using the most current information on roads and development.

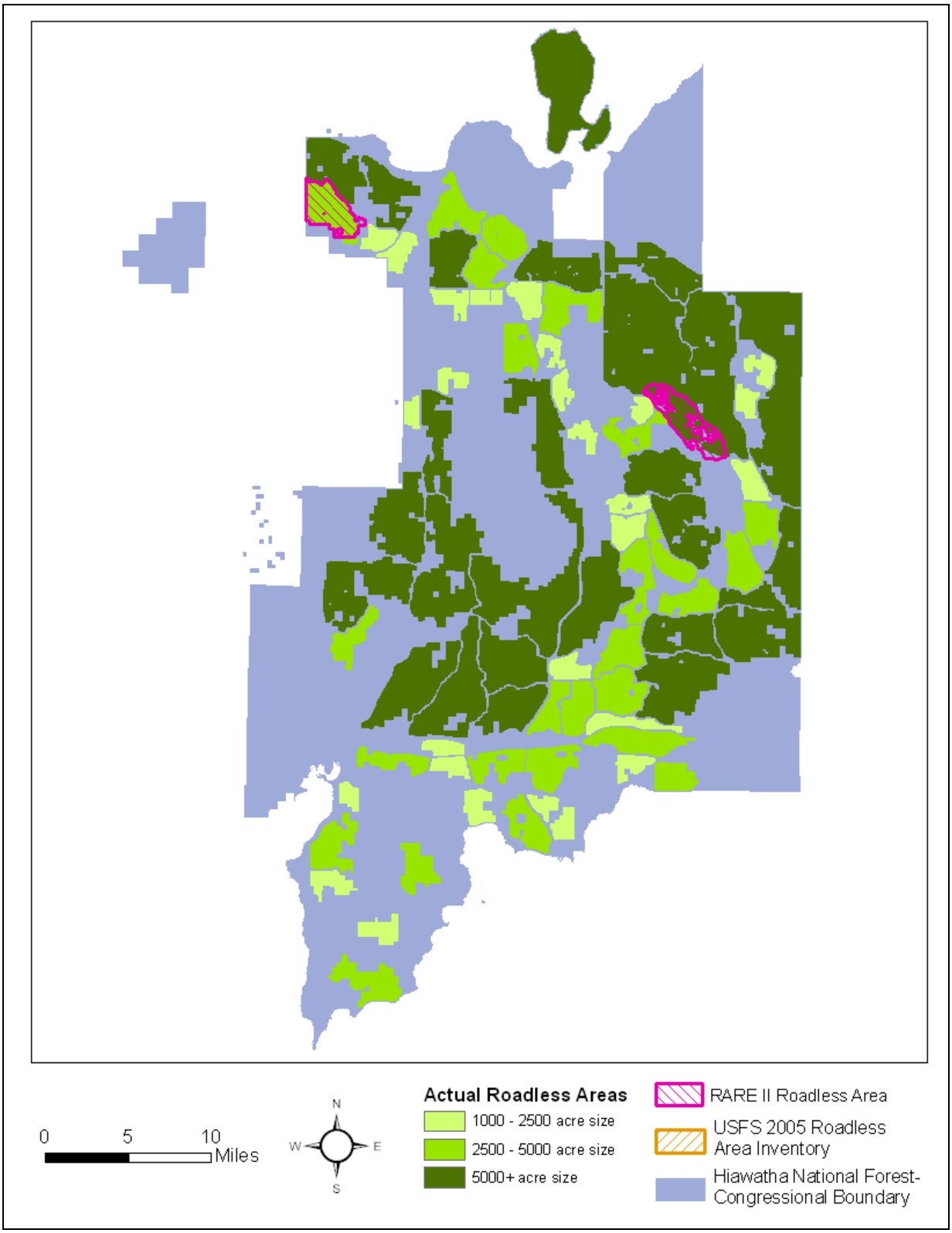

Figure 10. Map comparing the actual roadless areas delineated by Pacific Biodiversity Institute with Inventoried Roadless Areas delineated in the 2005 Forest Plan Revision Draft EIS and in RARE II in the western portion of the Hiawatha NF.

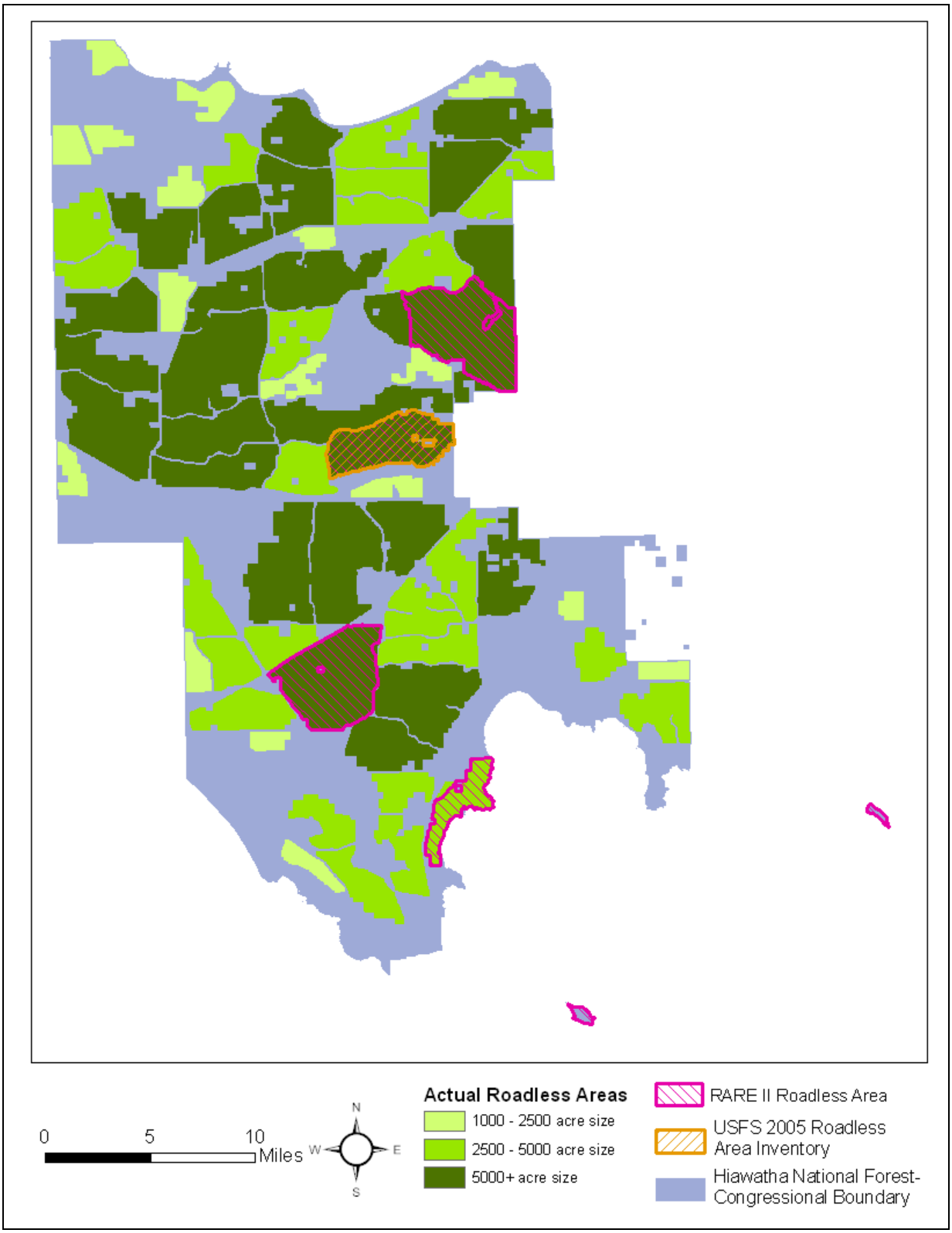

Figure 11. Map comparing the actual roadless areas delineated by Pacific Biodiversity Institute with Inventoried Roadless Areas delineated in the 2005 Forest Plan Revision Draft EIS and in RARE II in the eastern portion of the Hiawatha NF.

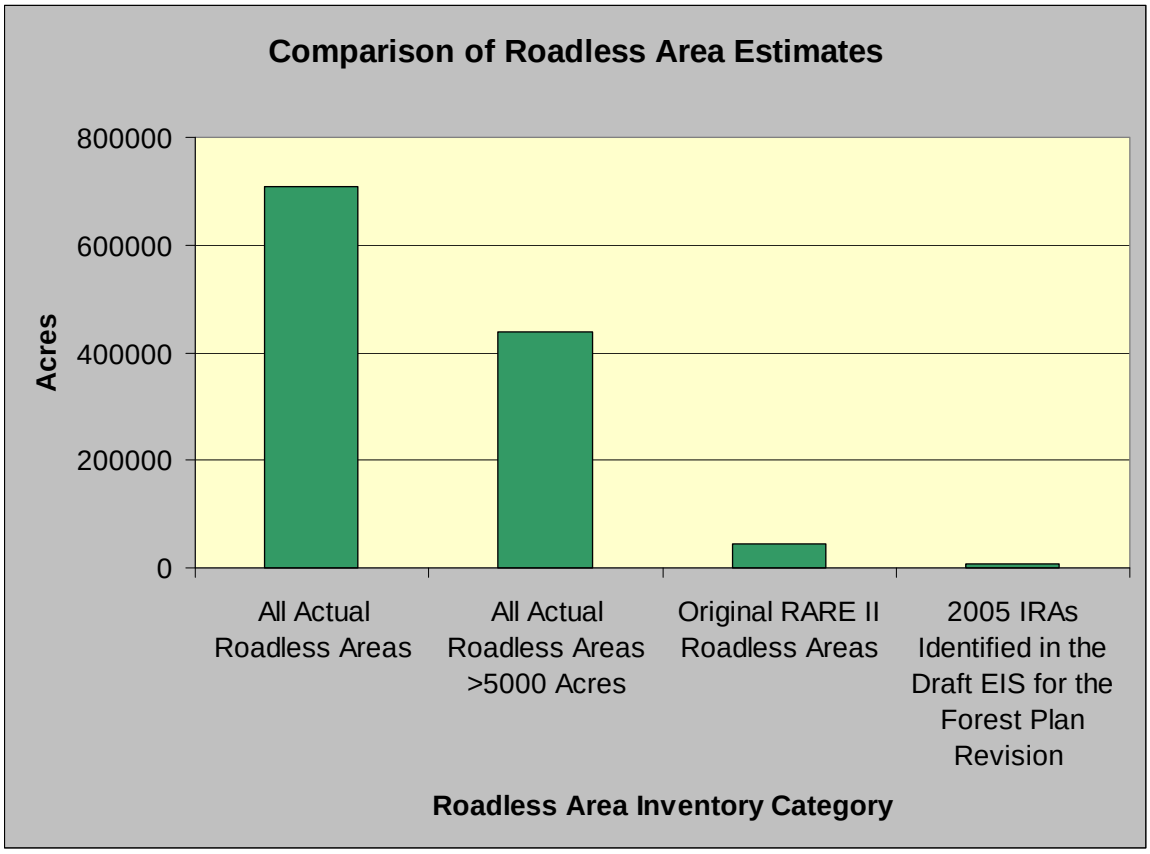

Figure 12. Comparison of actual roadless areas mapped by PBI in the Hiawatha National Forest in 3 size classes with the original Forest Service RARE II roadless areas and the Inventoried Roadless Areas delineated in the 2005 Forest Plan Revision Draft EIS.

DISCUSSION

Our staff has evaluated the quality of both road and roadless area maps and related GIS data in all National Forests of the United States. From the analysis we conducted for this report, we feel the road data and the data on roadless areas managed by the Hiawatha National Forest contain sufficient amounts of inaccurate information to warrant concern for the effects of these inaccuracies on transportation-related analyses and other assessments that the National Forest may make. Many National Forests across the country have developed highly accurate data on the location and classification of their transportation network. The accuracy of road data on many National Forests demonstrates that the Hiawatha National Forest could make substantial improvement in the accuracy of their road and roadless area data.

One of the greatest problems we found in working with the Hiawatha National Forest's roads data is the large number of roads seemingly not documented in its GIS data. Our

extensive review of the data in relation to current landscape conditions (as visible in the 1998 orthophotos) showed a troubling amount of roads excluded from their data layers (over 1,200 miles of road). The undocumented roads, coupled with misclassified road segments and inaccurate spatial representation of some roads leaves the Forest Service with roads data of questionable accuracy that could negatively influence transportation related analyses.

Typically, roads and trails are some of the easiest landscape features to map. Roads tend to be prominent features on aerial photography and their location can easily be checked using digital orthophotos and other image data. Roads can also be easily mapped on the ground using GPS technology. The Hiawatha National Forest has access to high quality, recent orthophotography that covers much of its area. While it cannot be used to classify or map roads at the level of detail needed by the Forest Service for management purposes, particularly in areas of high canopy cover, it can be used to easily improve spatial accuracy of roads and trails and identify some existing roads and trails that are missing from current data sets. In this report, we demonstrated several situations where, by simply reviewing the Forest's GIS data in relation to orthophotography, we were able to provide substantial improvements to their data.

The Forest Service data shows 4,388 miles of road with a road density of 3.09 miles per square mile. Using our data improvements we calculated 5,537 miles of roads with a road density of 3.97 miles per square mile – a 22% increase in road miles and density. Increases in road mileage are significant because they can have substantial and disproportionate influence on many measures of landscape fragmentation, such as patch size and core areas (Hawbaker and Radeloff 2004). Road density and fragmentation measurements are important for the management of some sensitive species in the Forest, including lynx and wolves (Mladenoff et al. 1995, Mech et al. 1988).

As for the roadless area mapping, there is a dramatic difference between our roadless area maps and those of the Forest Service from RARE II and the 2005 draft EIS. The Forest Service's RARE II roadless areas and Inventoried Roadless Areas under the 2005 Forest Plan Revision Draft EIS map 45,066 acres of roadless lands in the HNF. Using improved roads data from our digitizing work, and a clear methodology for consistent mapping of roadless areas, we found 439,500 acres of roadless lands within roadless areas of 5,000 acres or greater. In addition, we found many smaller roadless areas less than 5,000 acres in size.

The HNF did a decent job of mapping roadless areas under the "GIS exercise" portion of its 2005 roadless inventory, but many of the 86 polygons that came out of that exercise are inexplicably dropped from consideration as inventoried roadless areas. Only the Fibre Area roadless polygon is accepted as an inventoried roadless area. Through the "GIS exercise", the HNF found 86 polygons totaling 451,113 acres of roadless area mostly above 2,500 acres in size. Though this estimate of roadless areas is lower than our own, it illustrates the fact that far more roadless area potential exists in the National Forest, and that objective assessments of the roaded and roadless landscapes yield far

different results than the 45,066 acres of inventoried roadless areas officially being identified by the Hiawatha National Forest.

It is clear from this analysis that despite heavy roading in some areas, significant unprotected roadless lands remain within the Hiawatha National Forest. Many roadless areas are smaller than 5000 acres in size and are partially penetrated by roads. The wildlands that once existed in the Hiawatha National Forest are now highly fragmented, but some relatively large, and many small roadless patches remain throughout much of the forest. Given its inaccurate data on roadless areas, the Forest Service is unable to portray and consider the ecological value of these true roadless areas in its management decisions.

The many problems we found with the Hiawatha National Forest's roads, trails, and roadless area data have the potential to greatly compromise the reliability of transportation-related analyses and other assessments that the National Forest may make, based on the data. Special consideration should be given to the fact that, according to the Hiawatha National Forest, these data and analyses derived from them were used to inform the recent process of revising the Forest's Land Management Plan, which will guide Forest management for many years to come.

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