FINAL REPORT

GTI Phase II
DE-FG36-01GO11082

Developing Thermal Conversion Options for Biorefinery Residues

Task 5.1 Assess biomass resources in Nevada
Task 5.1a Inventory of Current and Future Feedstocks

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Executive Summary

Using existing data sets available for federal and state agencies, DRI personnel constructed an inventory of lignocellulosic feedstocks in the State of Nevada as well as portions of southwest Utah, northwest Arizona, and the Lake Tahoe Basin area of eastern California. DRI used existing inventories conducted by the U.S. Department of Agriculture (USDA), U.S. Forest Service (USFS) and associated contractors, Nevada county assessments, and land cover mapping conducted by the U.S. Fish and Wildlife Service (USFWS), i.e. GAP data, to produce meaningful biomass estimates for various administrative areas in Nevada, western Utah, and the Lake Tahoe Basin region.

This effort required close cooperation and communication with UNR, REII, as well as personnel from the USDS, USFS, and other related entities. The USFS, in particular, provided valuable assistance, advice and recommendations for working with its existing archives and data sets related to biomass inventories in the Western U.S. To relate the resultant biomass inventories to the techo-economic analysis conducted by REII, DRI staff worked closely with REII personnel to develop spatial constraint criteria when evaluating the levels of available feedstocks for specific regions in Nevada, Utah, and California.

Of the various Lake Tahoe Basin/Carson, NV area studies we evaluated, the Lake Tahoe Basin Multi-Jurisdictional Fuel Reduction and Wildlife Prevention Strategy Report (USDA et al., 2007) appears to be provide the most robust and defensible estimates of biomass, both actual and planned, out to year 2016. The numbers generated in this report were based on actual and predicted fuel reduction calculations in the Basin. The report estimates that the planned 5,000 acres/year in fuel reductions until 2016 would yield approximately 72,000 Green Tons per year (GT/year) of biomass, assuming a ratio of 14.4 Green Tons per acre (GT/acre), plus the yield from an additional 1,800 acres/year in maintenance thinning.

The state-wide inventory of biomass for Nevada using the Forest Inventory and Analysis (FIA) dataset yielded a total estimate of 112.28 million tons of biomass for all species, and 89.38 million tons of pinyon-juniper species. The National Forest Biomass Dataset (NFBD) dataset yielded a total estimate of 124.54 million tons of biomass for all species, and 98.30 million tons of pinyon-juniper species. It is interesting that the satellite-based NFBD method yielded greater estimates than the plot-based estimates derived in the FIA method. This is probably due to a combination of factors including the difference in how the FIA and NFBD methods each define forest land (Blackard et al., 2007), and the spatial mismatch between the relatively small size of a FIA plot relative to the coarse 250 meter Moderate Resolution Imaging Spectrometer (MODIS) pixels.

DRI's analysis of the availability of potential pinyon-juniper feedstocks for two hypothetical biofuel processing plant locations in eastern Nevada resulted in estimates for different sized study areas and scenarios around the towns of Ely and Pioche, NV, based on NFBD data. The complexity and thoroughness of these analyses provides the user with a variety of scenarios and

constraints related to several spatial and statistical parameters. A number of pinyon-juniper estimation scenarios were analyzed using four different distance radii from each town (25, 50, 75, and 100 miles respectively), with other spatial constraints related to specific land ownership (BLM, USFS, Other), and slope classes (percent slope). Statistically, estimates were provided for mean, low and high bar estimates using residual error data generated for each MODIS satellite pixel in the NFBD estimation process. Mean pinyon-juniper biomass estimates for 25, 50, 75, and 100 mile radii around Ely, NV were, respectively: 3.1 million Bone Dry Tons (BDT); 8.1 million BDT; 15.3 million BDT; and 23.4 million BDT. Mean pinyon-juniper biomass estimates for the same four distance radii around Pioche, NV were, respectively: 4.1 million BDT; 11.7 million BDT; 18.5 million BDT, and 26.5 million BDT. Estimates included only those pinyon-juniper feedstocks found within five miles of a primary or secondary road, on slopes less that 35%, and outside of Wilderness Areas.

The various data sets and analyses performed in this study all indicate that although reasonable estimates of lignocellulosic feedstocks can be derived for larger inventory areas (regional or state-wide studies), care must be taken to understand the estimation errors associated with these values. These errors come from many sources; in the case of the Lake Tahoe Basin studies, biomass estimates originally generated for entire counties or national forest administrative units were summed for a physical study area such as the Lake Tahoe Basin (five county estimates aggregated into one Basin estimate). In this scenario you may have a relatively small portion of a county or national forest unit that overlays the physical boundary of interest, but the entire biomass estimate summed for that administrative unit, most of it falling outside the physical area of interest, is included in the study area estimate, thus leading to an erroneous overestimate of feedstocks. The error propagation is compounded by the fact that the various reports analyzed acquired their data at different dates and used different criteria to classify the various feedstock sources (i.e. timber harvests, fuel reductions, urban waste, and agricultural waste). Areas like the Lake Tahoe Basin are complex in how the various agencies and states have estimated biomass, given that so many different agencies and two states (California and Nevada) control parts of the study area. These are some of the reasons the various Lake Tahoe Basin reports we evaluated were inconsistent in their final biomass estimates. For analysis of both within state study areas and interstate study areas like Lake Tahoe Basin and eastern Nevada/western Utah and Arizona, it was far more reasonable (and hopefully accurate) to use the FIA and NFBD national biomass datasets and analysis techniques to derive large area feedstock estimates.

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Task 5.1 Assess biomass resources in Nevada

Task 5.1a Inventory of Current and Future Feedstocks

I. Introduction

Using existing data sets available from federal and state agencies, DRI personnel constructed an inventory of lignocellulosic feedstocks in the State of Nevada as well as portions of southwest Utah, northwest Arizona, and the Lake Tahoe Basin area of eastern California. So as not to repeat work performed in previous studies, existing inventories conducted by the U.S. Department of Agriculture (USDA), U.S. Forest Service (USFS) and associated contractors, Nevada county assessments, and land cover mapping conducted by the U.S. Fish and Wildlife Service (USFWS), i.e. GAP data, were thoroughly evaluated and processed to produce meaningful biomass estimates for various administrative areas in Nevada and the Lake Tahoe Basin region (county, state, region).

This effort required close cooperation and communication with UNR, REII, as well as personnel from the USDS, USFS, and other related entities. The USFS, in particular, provided valuable assistance, advice and recommendations for working with its existing archives and data sets related to biomass inventories in the Western U.S. To relate the resultant biomass inventories to the techo-economic analysis conducted by REII, DRI staff worked closely with REII personnel to develop spatial constraint criteria when evaluating the levels of available feedstocks for specific regions in Nevada, Utah, and California.

This report describes the acquisition and processing of feedstock information, and the subsequent inventories and spatial analysis performed by DRI to derive feedstock estimates available to potential processing facilities in the state of Nevada.

II. Study Area

After lengthy dialog within the research group at DRI, UNR, and REII, as well as subsequent discussions with USFS personnel, we redefined the areas of study as limited to Nevada, a smaller sub-region of far eastern Nevada that also included portions of southwest Utah and northwest Arizona, and the Lake Tahoe area of Nevada and California. The defined study areas were based on locations of existing (Carson City, NV) or potential (Pioche, NV; Ely, NV) biofuel processing plants. Figures 1, 2, and 3 show the spatial extent of the various study areas. Figure 1 indicates the state of Nevada with counties. Figure 2 indicates the Lake Tahoe Basin area comprised of counties from both Nevada and California, and their proximity to Carson City. Figure 3 indicates the eastern Nevada/southwestern Utah/northwestern Arizona study area, with counties, and the location of Ely and Pioche, NV.

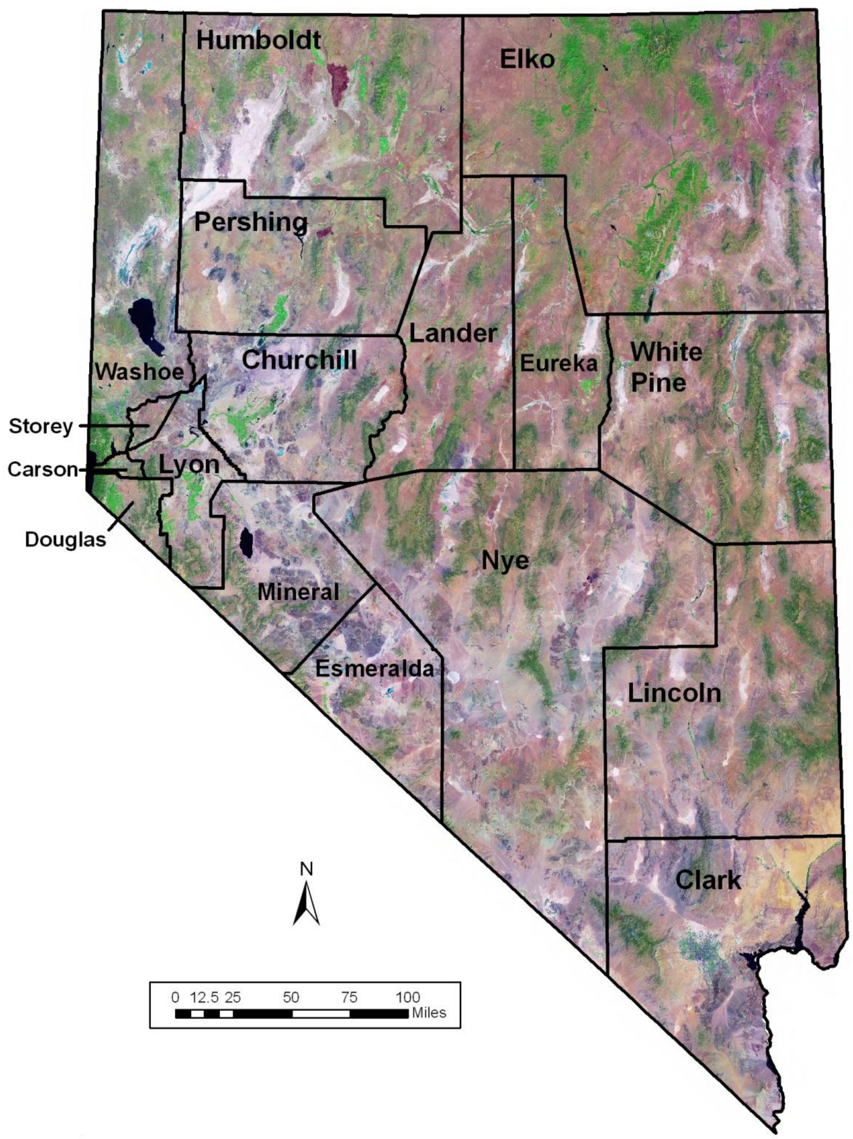

Figure 1. State of Nevada study area with counties. Image is a Landsat ETM+ satellite mosaic acquired 2000-2002.

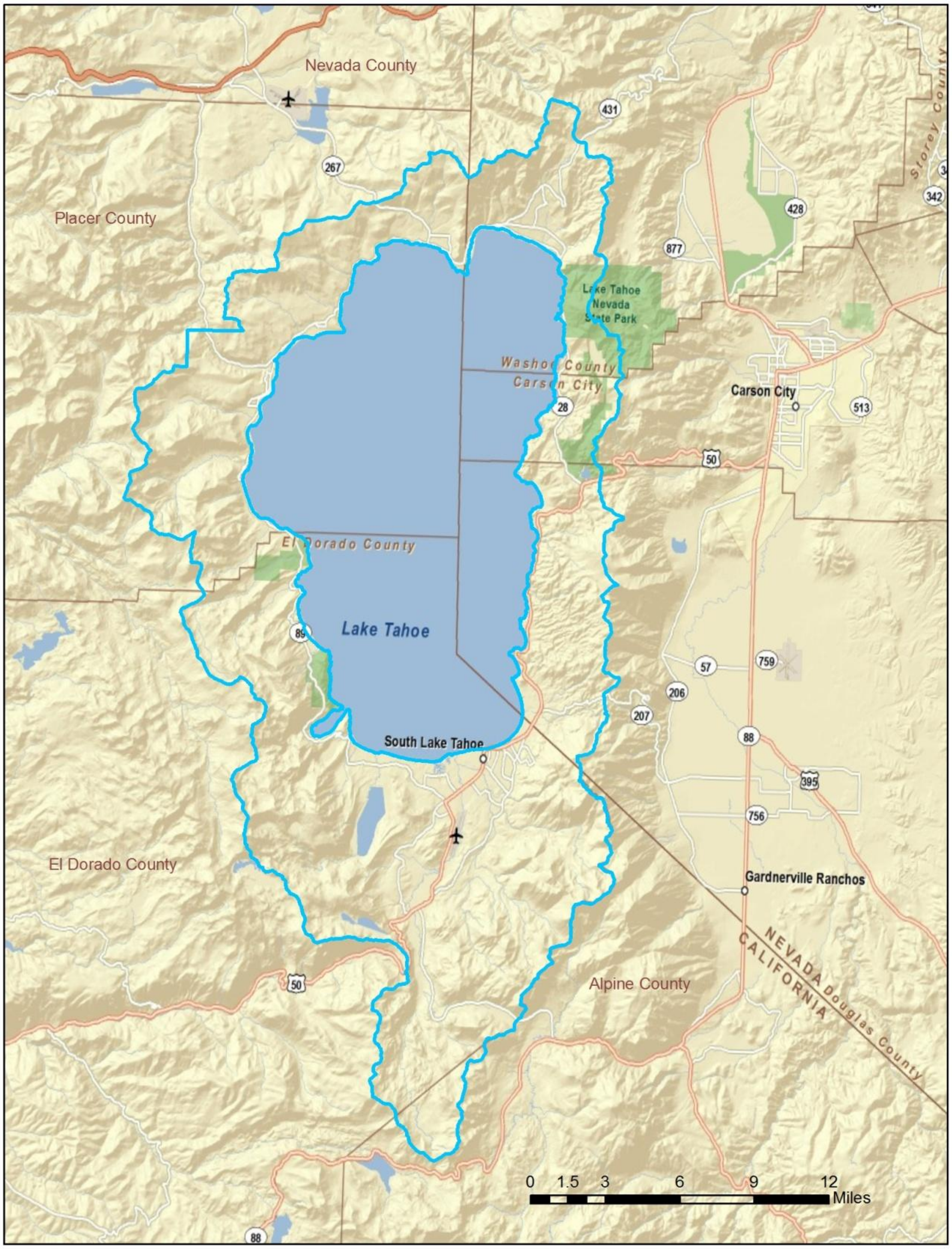

Figure 2. Lake Tahoe Basin with California and Nevada counties. Basin boundary in light blue.

Figure 3. Eastern Nevada/southwestern Utah/northwestern Arizona study area with counties and the location of Ely and Pioche, NV.

III. Methods

A. Review of Potential Biomass Data Sets

For Nevada (and western Utah), we first analyzed USFWS Southwest Regional GAP Analysis (SWReGAP) data (Prior-Magee et al., 2007). These data were developed from Landsat Enhanced Thematic Mapper (ETM+) imagery selected from 1999-2001 for three seasons: spring, summer, and fall. The basic thematic mapping unit used was the ecological system concept developed by NatureServe (Comer et al., 2003). Ecological systems represented recurring groups of biological communities that are found in similar physical environments and are influenced by similar dynamic ecological processes. The SWReGAP data provided aerial distributions of vegetation types (biological communities) across the Great Basin and southwest U.S. From this analysis, we determined that the Great Basin Pinyon-Juniper Woodland community was the most prevalent woody biomass source in Nevada (9.2 million acres of Pinyon Juniper Woodland (3.7 million hectares), or approximately 13% of the entire state land surface). Most of the Pinyon-Juniper (PJ) communities were found along the western edge of the state and in eastern Nevada. The pinyon-juniper community on the eastern side of the state extends into western Utah and northwestern Arizona. The SWReGAP data provided a sufficient mesoscale representation of the spatial distribution of the pinyon-juniper woodland community, but did not provide a satisfactory estimate of biomass per unit area.

These findings led DRI personnel to seek actual biomass per unit area data sets for the state of Nevada and western Utah using data available from the U.S. Forest Service (USFS). DRI staff met with REII personnel and Mark Nechodom of the USFS Pacific SW Research Station in Davis, CA and learned about the Forest Inventory and Analysis (FIA) Program, a country-wide, continuous forest census available for each of the 50 United States. FIA is a continuing endeavor mandated by Congress, with a primary objective of determining the extent, condition, volume, growth, and depletions of timber on forest land. The FIA data provided biomass estimates based multiple surveys. Annual surveys of each state were phased in starting in 1999 to replace the periodic surveys that had been occurring. Annual surveys of Nevada were only made in 2004 and 2005 due to budget limitations, but are ongoing in the other states. The FIA plots are laid out in a hexagonal grid with 1 plot per 6,000 acres and 10-20% of the total plots are sampled each year. The lower density of plots in Nevada is evident in Figure 4, which shows the approximate location of FIA plots in Nevada and surrounding states. DRI personnel downloaded biomass estimates broken down by tree species and tree diameter for the two sample periods for the state of Nevada and several counties in western Utah.

Preliminary results of DRI's SWReGAP and FIA investigations were presented to the Nevada Biomass Working Group, a collection of public and private parties in Nevada working towards solutions and ideas for promoting the harvest and use of biomass in the state for energy production. The group was coordinated by Doug Martin of the Nevada Tahoe Conservation District. Following DRI's presentation, two members of the Biomass working group, Scott Bell of the USFS, and Elmer Moller, the wood utilization manager for UNR's Small Business

Development Center, provided additional information sources for biomass assessments conducted in the Lake Tahoe Basin, the Carson City, NV area, and eastern Nevada/western Utah. Several recent studies, in particular the Coordinated Resource Offering Protocol (CROP) study conducted for the USFS on the California side of the Tahoe Basin (http://www.forestsandrangelands.gov/Woody_Biomass/supply/CROP/index.shtml) by Mater Engineering of Oregon (Mater, 2007), a Lincoln County, NV pinyon-juniper biomass assessment conducted for the Lincoln County Regional Development Authority (Intertech Services Corp., 2005), a multi-jurisdictional study of fuel reduction and wildfire prevention strategies in the Lake Tahoe Basin (USDA et al., 2007), and several studies conducted for the Tahoe and Carson areas by McNeil Technologies of Colorado (McNeil Technologies, 2003, 2004), provided updated information on both current and projected harvested feedstocks for these respective areas. These studies, in particular the CROP study, provide many critical biomass parameters, including volume, diameter sizes, species, harvest "type", i.e. fuel load reduction, timber sales, thinning, post and pole, locations of resource offering, National Environmental Policy Act (NEPA) phases, and road accessibility.

Although the biomass assessments recommended by the Nevada Biomass Working Group for the various areas described above were very detailed, they did not contain actual surface-based inventory cover or biomass data, but only harvested biomass yield data sometimes based on rather nebulous data sources. While actual harvested biomass data may provide useful information on commercially viable harvest potential, they are not very useful for answering the question of biomass stocks, biomass yields, and yield sustainability.

To determine the possibility of using plant material from agricultural production we analyzed data from the Census of Agriculture. The Census of Agriculture is published every five years by the U.S. Department of Agriculture and is a voluntary reporting process. Since the Census of Agriculture is a compilation of volunteered information it is difficult to properly determine the accuracy of the data contained in the census. Additionally, the census is only taken every five years and is not a compilation over the five year period, but rather the data for the year that data is taken. Since Nevada agriculture is highly dependent on water for irrigation, the year-to-year variability in crop production due to low and high water years is not accounted for in the census. This is a critical factor for determining a consistent source of biomass especially during a dry year or a series of dry years. Keeping in mind the limitations to the census, it did give us some information as to the major crops grown in Nevada and ballpark estimates of the acreage and quantity produced.

DRI staff returned to the FIA data as a more viable means of calculating biomass stocks across the state of Nevada and for specific sub-areas like the Lake Tahoe Basin and eastern Nevada/western Utah. Further investigations of FIA resources yielded a derivative data set based the integration of FIA plot data, Moderate Resolution Imaging Spectrometer (MODIS)-derived image composites and percent tree cover, land cover proportions, topographic variables, monthly and annual parameters, and other ancillary variables. The methods used to develop this data set, called the National Forest Biomass Dataset (NFBD), are described in Blackard et al., 2008. This method was applied to Nevada, as well as western Utah, northwestern Arizona, and California.

One limitation to using FIA based biomass estimates in Nevada is that the density of plots is much lower than other states (Figure 4) and measurements were only made in 1989 and 2004-2005. It is not clear what data was used for the NFBD since Blackard et al., (2008) indicate that samples from 1990-2003 were used. The NBCD year 2000 biomass estimate also doesn't indicate which FIA data were used or if the data were interpolated.

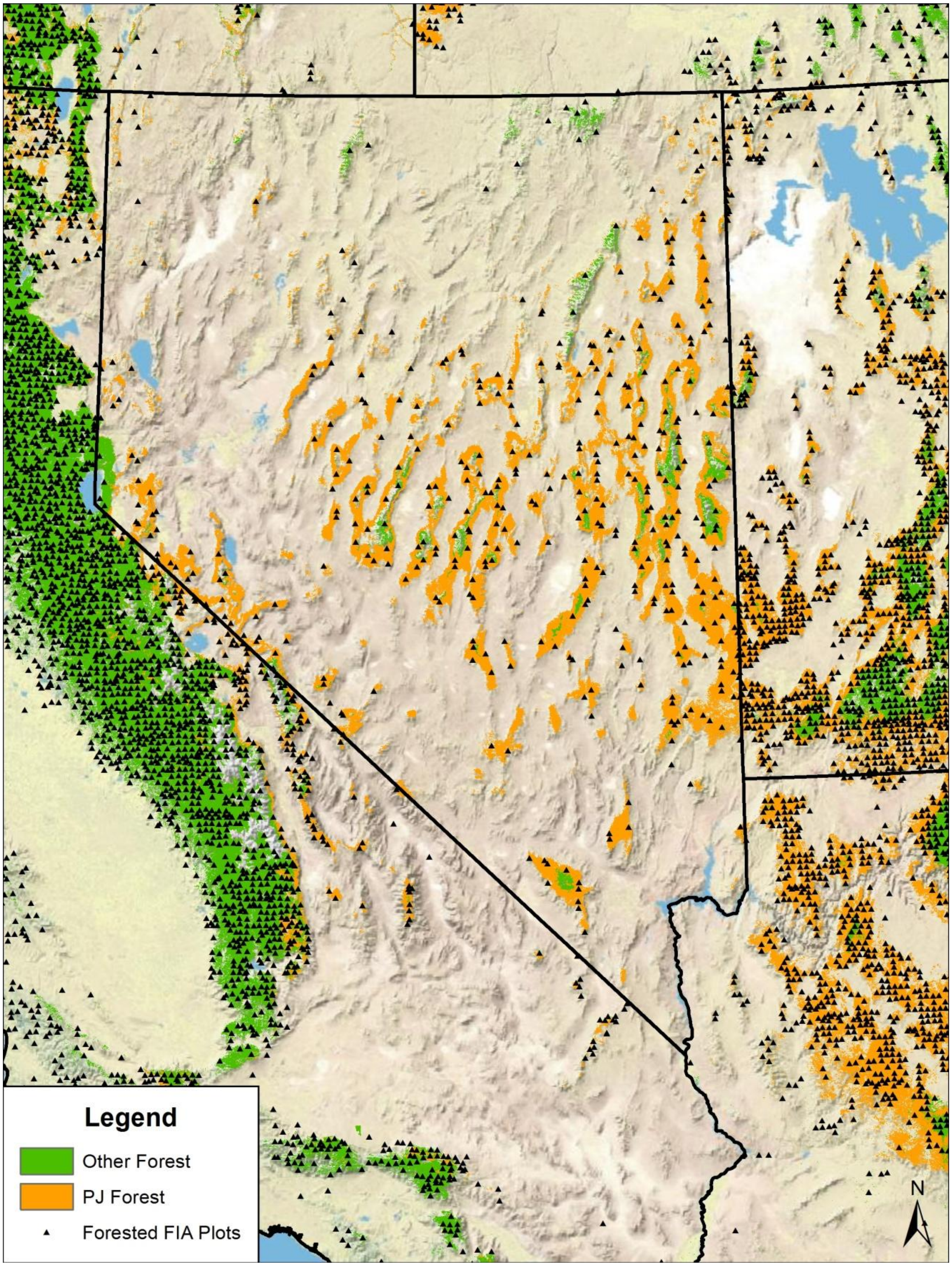

Figure 4. Distribution of forested FIA plots in Nevada and surrounding states. Forest lands data from the National Forest Biomass Dataset.

IV. Biomass Estimates

A. Estimation of Biomass in Nevada and Western Utah Using FIA Data

Initial analysis of FIA data focused on the tabular biomass data available through the FIA Forest Inventory Data Online database (FIDO) (http://fiatools.fs.fed.us/fido/index.html). FIA timber inventory calculations are derived from original plot scale (tree level) estimates scaled up to a per-acre basis using established equations created by the USFS (USDA, 2008). At each FIA plot, measurements of tree species, height, diameter, and condition are made at four subplots. Additional measurements relating to forest ecosystem function, condition, and health are made at ~6% of the plots. Each tree on a plot is scaled up to a per-acre basis based on the plot size and tree size. The sampling error increases and the reliability of the estimates decreases as the geographic area gets smaller because of the fewer number of plots. FIA estimates were derived based on forest land inventories conducted in 2004-2005 for Nevada and 2000-2009 for Utah. DRI selected several queries to determine biomass estimates across all species in all Nevada and western Utah counties and, biomass estimates for pinyon-juniper species only in eastern Nevada and western Utah counties. Table 1 shows the FIA forest land assessment results for all species and Table 2 show the results of the assessment for pinyon-juniper species. Figure 5 shows the biomass estimates for all forest land species by county in Nevada. The different colors for each estimate in each county reflect, respectively, the sampling errors for the estimates (white indicates 25% sampling error; green indicates greater than 25% and less than 50%; red indicates greater than 50% sampling error). Figure 6 shows similar biomass estimates by county for pinyon-juniper species only. The same color code classes related to sampling error used in Figure 5 were also used in Figure 6.

Working with Jim Menlove of the USFS Rocky Mountain Research Station in Ogden, Utah, DRI downloaded NFBD maps from the USFS FIA website (http://www.fs.fed.us/rm/ogden/map-products/intwest/iwmaps.shtml) showing distributions of the following parameters throughout the Great Basin states in the interior west region: predicted dry total biomass, in tons per acre (Figure 7); predicted forest types (Figure 8); and predicted forest volume, in net total stem cubic feet per acre (Figure 9).

Table 1. Total FIA biomass estimates for all tree species in Nevada and western Utah on forest land. Nevada inventory conducted during 2004-2005, Utah inventory conducted during 2000-2009.

Inventory -- Nevada, cycle 2, 2004-2005: area/vol/gro/mort

Nevada (32) -- Total gross biomass on forest land by U.S. Counties and Species (in short tons)

	Tree species																
County	white fir (15)	California red fir (20)	western juniper (64)	Utah juniper (65)	Rocky Mountain juniper (66)	common or two-needle pinyon (106)	lodgepole pine (108)	limber pine (113)	Jeffrey pine (116)	western white pine (119)	ponderosa pine (122)	singleleaf pinyon (133)	Great Basin bristlecone pine (142)	Douglas-fir (202)	curlleaf mountain-mahogany (475)	quaking aspen (746)	Gambel oak (814)	Total
Churchill (1)	--	--	--	34,423	--	--	--	--	--	--	--	1,099,889	--	--	--	--	--	1,134,312
Clark (3)	--	--	--	1,839,042	--	--	--	--	--	--	215,519	954,299	--	--	102,616	--	3,598	3,115,075
Douglas (5)	301,782	--	--	594,648	--	--	--	--	938,266	64,353	674,095	1,017,790	--	--	259,505	--	--	3,850,439
Elko (7)	768,000	--	--	5,320,229	498,757	--	--	87,465	--	--	--	2,367,983	--	--	718,303	1,028,205	--	10,788,941
Esmeralda (9)	--	--	--	658,509	--	--	--	--	--	--	--	665,658	--	--	277,796	--	--	1,601,963
Eureka (11)	--	--	--	1,395,597	--	--	--	--	--	--	--	2,094,971	--	--	228,278	--	--	3,718,847
Humboldt (13)	--	--	--	570,606	--	--	--	--	--	--	--	--	--	--	38,182	978,537	--	1,587,326
Lander (15)	--	--	--	1,540,706	--	--	--	775,152	--	--	--	2,490,107	--	--	239,817	--	--	5,045,781
Lincoln (17)	--	--	--	8,474,655	--	1,523	--	--	--	--	--	5,629,948	--	--	94,017	--	84,747	14,284,890
Lyon (19)	--	--	--	175,710	--	--	--	--	--	--	--	2,327,778	--	--	3,487	--	--	2,506,974
Mineral (21)	--	--	--	1,548,876	--	--	--	--	--	--	--	1,991,981	--	--	189,818	--	--	3,730,675
Nye (23)	101,973	--	--	5,537,103	--	--	--	27,181	--	--	--	13,522,885	--	--	1,283,143	--	--	20,472,285
Pershing (27)	--	--	--	839,676	--	--	--	--	--	--	--	178,993	--	--	--	--	--	1,018,670
Storey (29)	--	--	--	--	--	--	--	--	--	--	--	376,314	--	--	--	--	--	376,314
Washoe (31)	--	327,025	344,809	1,739,377	--	--	1,284,006	--	60,837	119,091	--	243,721	--	--	138,521	--	--	4,257,386
White Pine (33)	4,348,683	--	--	14,182,365	201,503	--	--	2,876,691	--	--	--	9,117,594	480,564	1,281,859	1,350,520	506,169	--	34,345,949
Carson City (510)	295,301	--	--	36,092	--	--	--	--	--	--	2,712	110,664	--	--	--	--	--	444,768
Totals:	**5,815,739**	**327,025**	**344,809**	**44,487,613**	**700,260**	**1,523**	**1,284,006**	**3,766,489**	**999,103**	**183,445**	**892,326**	**44,190,574**	**480,564**	**1,281,859**	**4,924,003**	**2,512,911**	**88,345**	**112,280,593**

Inventory -- Utah, cycle 2, 2000-2009: area/vol/gro/mort

Utah (49) -- Total gross biomass on forest land by U.S. Counties and Species (in short tons)

	Tree species																	
County	white fir (15)	subalpine fir (19)	Utah juniper (65)	Rocky Mountain juniper (66)	Engelmann spruce (93)	blue spruce (96)	common or two-needle pinyon (106)	limber pine (113)	ponderosa pine (122)	singleleaf pinyon (133)	Great Basin bristlecone pine (142)	Douglas-fir (202)	bigtooth maple (322)	curlleaf mountain-mahogany (475)	quaking aspen (746)	Fremont cottonwood (748)	Gambel oak (814)	Total
Beaver (1)	108,239	468,305	4,614,741	56,529	189,955	--	679,613	7,041	407,497	1,418,665	6,429	123,634	31,333	547,745	505,917	--	320,855	9,486,497
Iron (21)	1,368,191	757,443	6,329,190	291,526	219,779	--	1,076,907	48,905	129,398	1,307,644	27,316	865,421	7,596	558,687	2,924,824	--	468,939	16,381,766
Juab (23)	730,631	40,866	2,546,428	95,309	129,354	--	49,525	308,990	--	393,178	--	890,568	256,940	272,572	8,777	--	465,248	6,188,385
Millard (27)	803,507	--	2,623,027	242,454	--	--	247,365	--	--	589,790	--	160,514	127,770	300,112	375,174	--	1,150,618	6,620,331
Tooele (45)	137,589	195,342	3,166,387	16,518	--	--	68,451	17,877	--	303,861	--	733,227	--	106,191	222,943	--	120,312	5,088,697
Washington (53)	550,337	5,827	3,472,968	164,568	392,111	42,148	191,219	23,460	532,609	848,462	--	164,189	29,966	212,131	126,482	4,393	2,299,862	9,060,731
Totals:	**3,698,494**	**1,467,784**	**22,752,741**	**866,903**	**931,199**	**42,148**	**2,313,080**	**406,273**	**1,069,505**	**4,861,599**	**33,744**	**2,937,552**	**453,604**	**1,997,438**	**4,164,115**	**4,393**	**4,825,834**	**52,826,408**

(The color of each estimated value represents its percent sampling error (pse); if estimate is **black**, pse is less than or equal to 25%; if estimate is **teal**, pse is greater than 25% and less than or equal to 50%; if estimate is **gold**, pse is greater than 50%)

Table 2. Total FIA biomass estimates for all pinyon-juniper species in Nevada and western Utah on forest land. Nevada inventory conducted during 2004-2005, Utah inventory conducted during 2000-2009

Inventory -- Nevada, cycle 2, 2004-2005: area/vol/gro/mort

Nevada (32) -- Total gross biomass on forest land by U.S. Counties and Species (in short tons)

	Tree species				
County	Utah juniper (65)	Rocky Mountain juniper (66)	common or two-needle pinyon (106)	singleleaf pinyon (133)	Total
Churchill (1)	34,423	--	--	1,099,889	1,134,312
Clark (3)	1,839,042	--	--	954,299	2,793,341
Douglas (5)	594,648	--	--	1,017,790	1,612,438
Elko (7)	5,320,229	498,757	--	2,367,983	8,186,968
Esmeralda (9)	658,509	--	--	665,658	1,324,167
Eureka (11)	1,395,597	--	--	2,094,971	3,490,569
Humboldt (13)	570,606	--	--	--	570,606
Lander (15)	1,540,706	--	--	2,490,107	4,030,813
Lincoln (17)	8,474,655	--	1,523	5,629,948	14,106,126
Lyon (19)	175,710	--	--	2,327,778	2,503,488
Mineral (21)	1,548,876	--	--	1,991,981	3,540,857
Nye (23)	5,537,103	--	--	13,522,885	19,059,988
Pershing (27)	839,676	--	--	178,993	1,018,670
Storey (29)	--	--	--	376,314	376,314
Washoe (31)	1,739,377	--	--	243,721	1,983,098
White Pine (33)	14,182,365	201,503	--	9,117,594	23,501,462
Carson City (510)	36,092	--	--	110,664	146,756
Totals:	**44,487,613**	**700,260**	**1,523**	**44,190,574**	**89,379,970**

Inventory -- Utah, cycle 2, 2000-2009: area/vol/gro/mort

Utah (49) -- Total gross biomass on forest land by U.S. Counties and Species (in short tons)

	Tree species				
County	Utah juniper (65)	Rocky Mountain juniper (66)	common or two-needle pinyon (106)	singleleaf pinyon (133)	Total
Beaver (1)	4,614,741	56,529	679,613	1,418,665	6,769,547
Iron (21)	6,329,190	291,526	1,076,907	1,307,644	9,005,267
Juab (23)	2,546,428	95,309	49,525	393,178	3,084,440
Millard (27)	2,623,027	242,454	247,365	589,790	3,702,636
Tooele (45)	3,166,387	16,518	68,451	303,861	3,555,217
Washington (53)	3,472,968	164,568	191,219	848,462	4,677,217
Totals:	**22,752,741**	**866,903**	**2,313,080**	**4,861,599**	**30,794,324**

(The color of each estimated value represents its percent sampling error (pse); if estimate is **black**, pse is less than or equal to 25%; if estimate is **teal**, pse is greater than 25% and less than or equal to 50%; if estimate is **gold**, pse is greater than 50%)

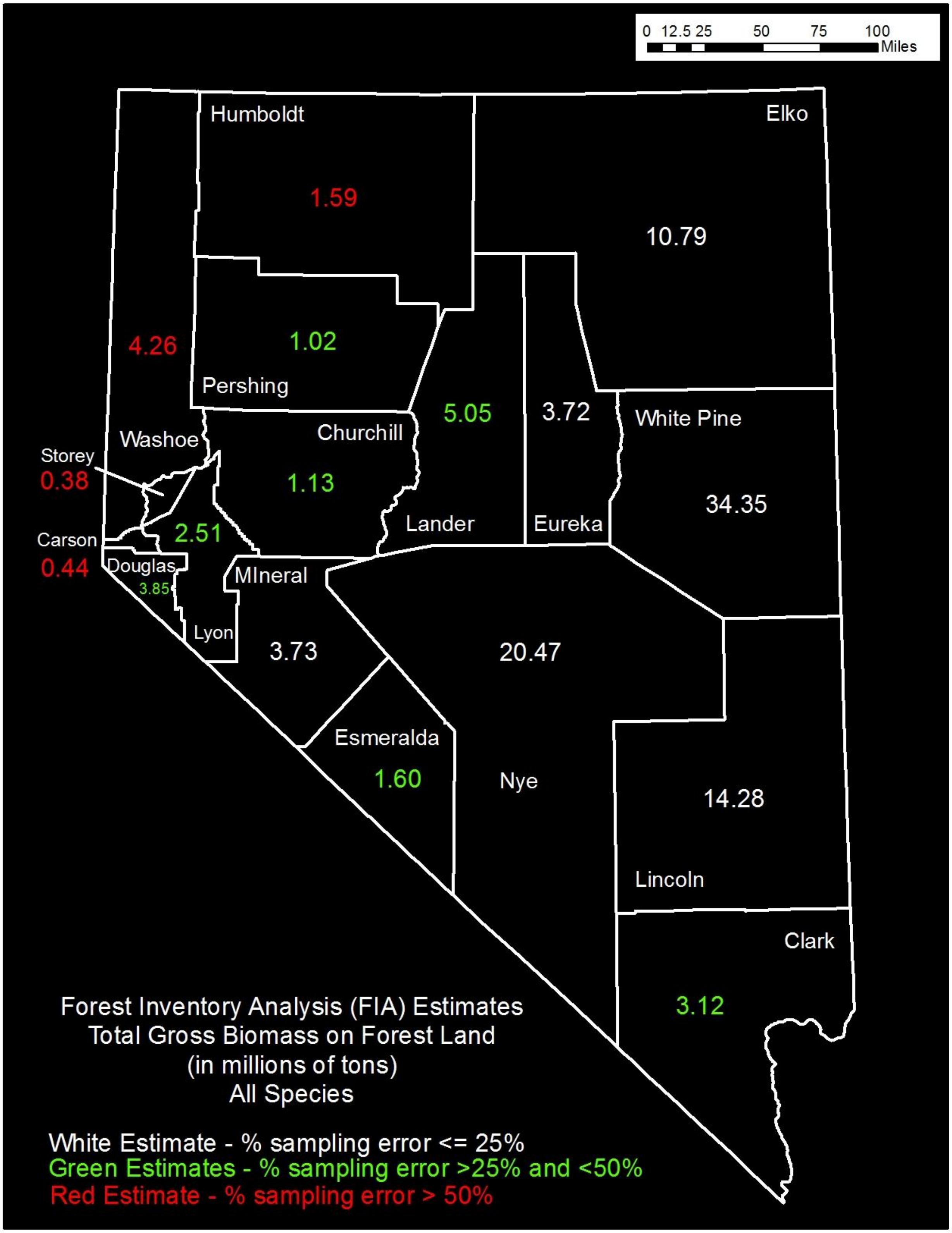

Figure 5. FIA estimates of total gross biomass of all species on forest land in Nevada counties, based on 2004-2005 inventory.

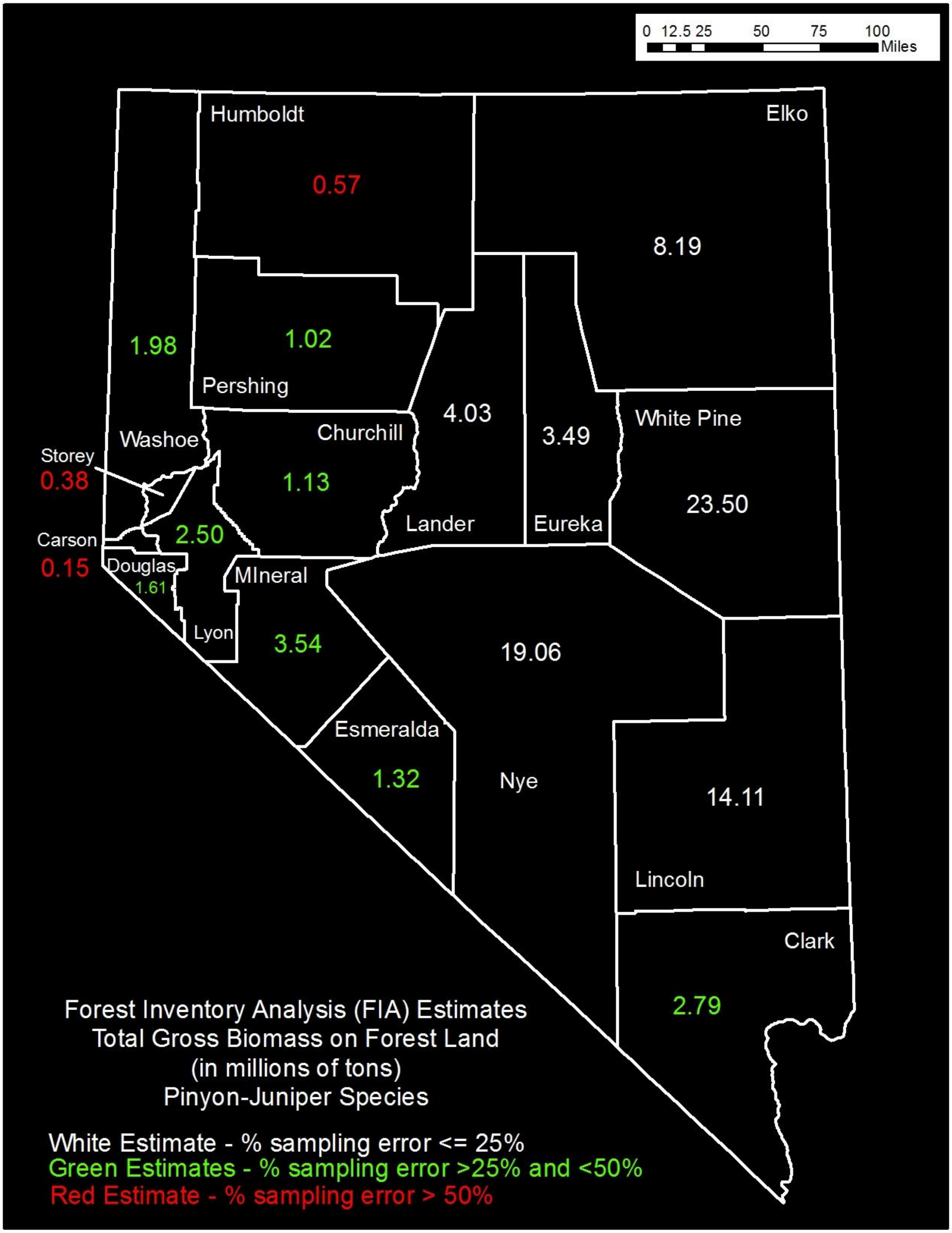

Figure 6. FIA estimates of total gross biomass of pinyon-juniper species on forest land in Nevada counties, based on 2004-2005 inventory.

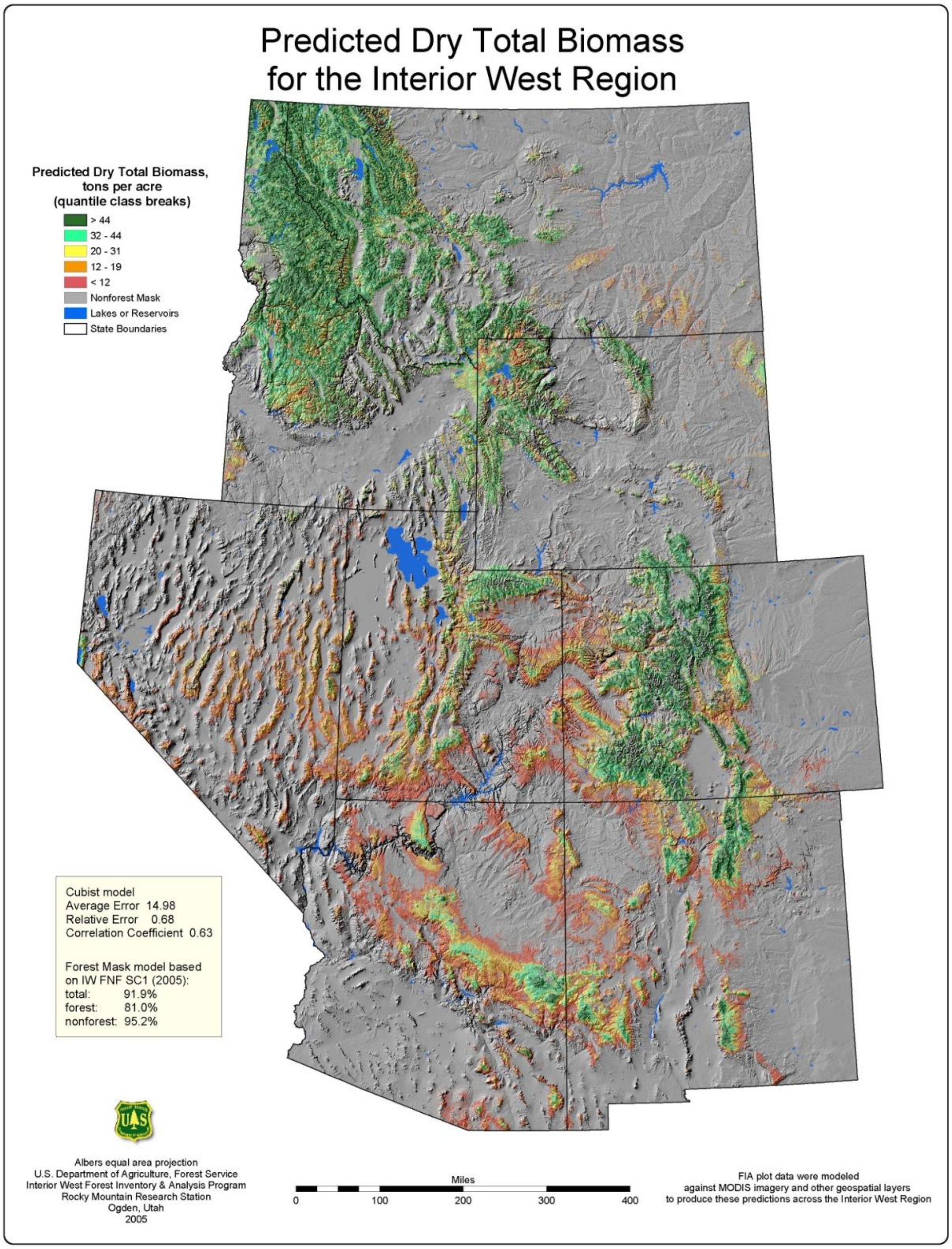

Figure 7. Predicted Dry Total Biomass, in tons per acre. Map obtained from USFS FIA website (http://www.fs.fed.us/rm/ogden/map-products/intwest/iwmaps.shtml).

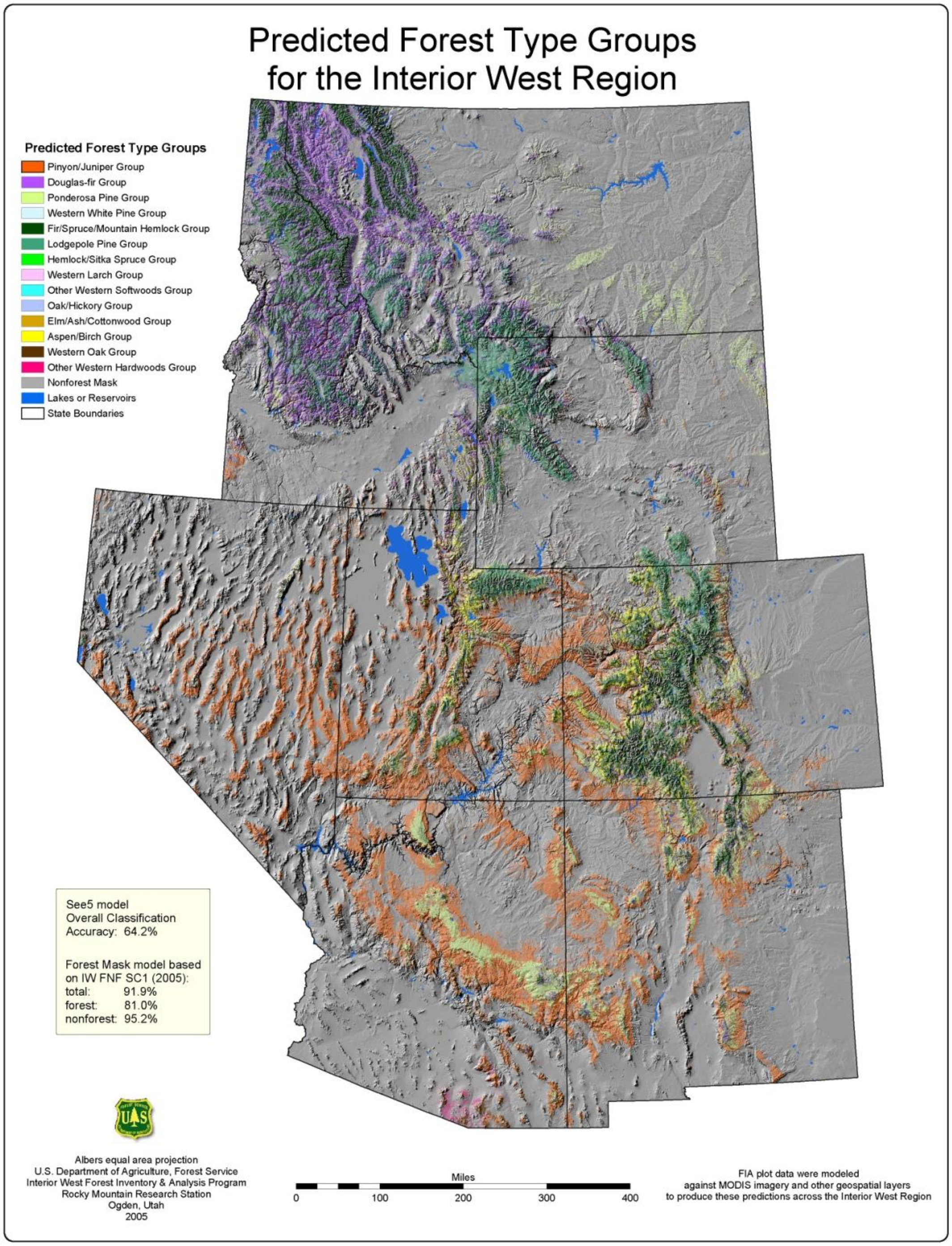

Figure 8. Predicted forest type groups for the interior west region. Map obtained from USFS FIA website (http://www.fs.fed.us/rm/ogden/map-products/intwest/iwmaps.shtml).

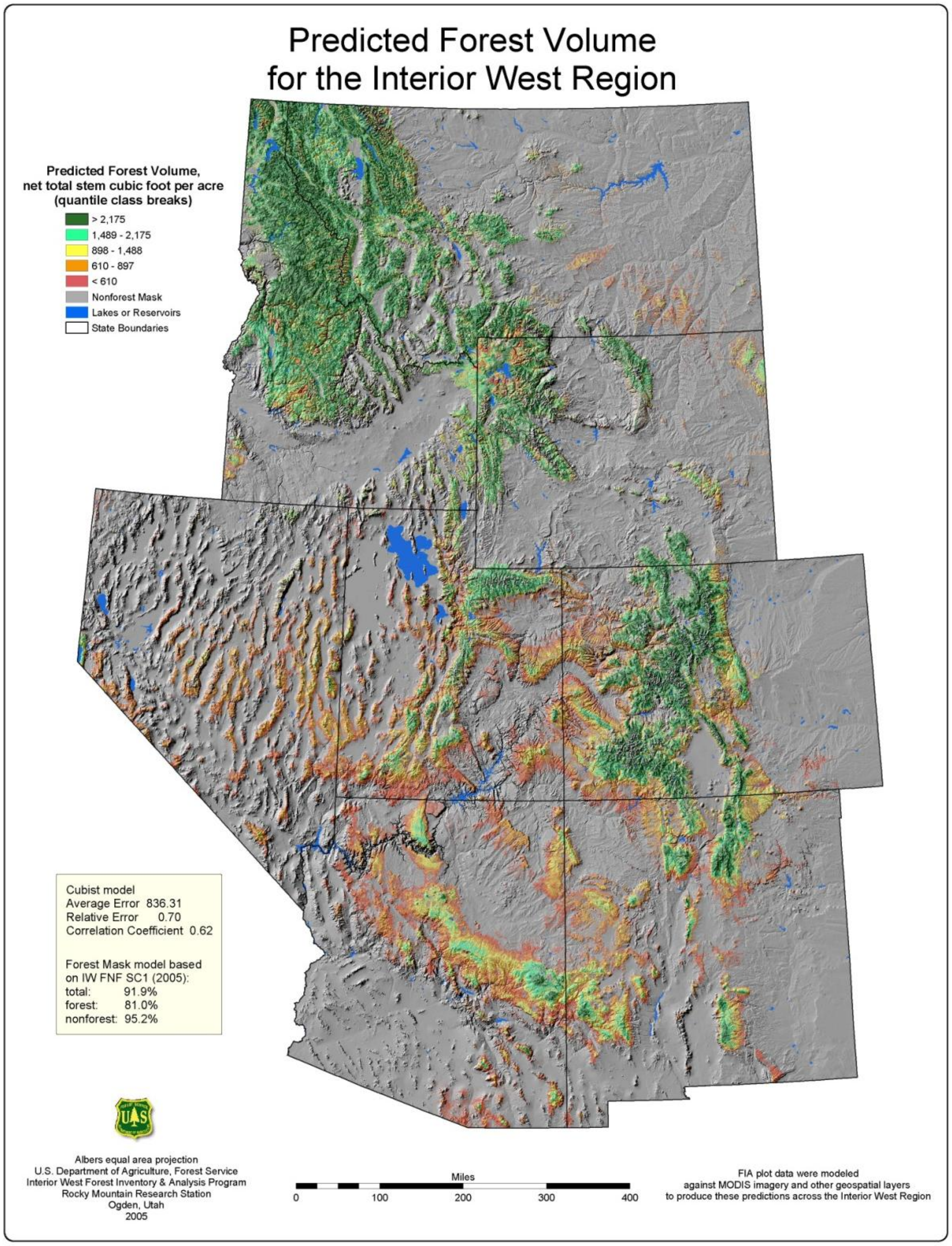

Figure 9. Predicted forest volume, in net total stem cubic feet per acre. Map downloaded from USFS FIA website (http://www.fs.fed.us/rm/ogden/map-products/intwest/iwmaps.shtml).

B. Estimation of Biomass in the Carson City and Lake Tahoe Basin Regions Using Biomass Resource Assessment Data, Fuel Reduction Data, and CROP Data

Based on recommendations from members of the Nevada Biomass Working Group described above, DRI staff analyzed several existing reports on biomass resource assessment and fuel reduction in the Carson and Lake Tahoe Basin regions.

1. Carson City Region (McNeil, 2004)

DRI analyzed data from a McNeil Technologies report (McNeil, 2004) that assessed biomass within a 50 mile radius of Carson City, NV (Figure 10). The estimated average available biomass for this area, based on the report published in 2004, was 189,000 Bone-Dry-Tons (BDT) per year, with a minimum of 97,000 BDT/year and a maximum of 297,000 BDT/year. All fuel and timber values assumed that the wet basis Moisture Content (MC) was 55% (55% of the green weight is water). The available biomass was calculated by assuming that 50% of the generated timber harvest biomass and 42% of the generated fuel reduction biomass would be available for use. The counties included in the analysis were Alpine, Amador, El Dorado, Mono, Nevada, Placer, and Sierra counties in California, and Carson, Douglas, Lyon, Storey, and Washoe counties in Nevada. Some of these counties have considerable area outside of the 50 mile radius study area around Carson City and should probably have been excluded from the study.

The total estimated available biomass from the McNeil, 2004 report was broken down into four principal categories of biomass: timber harvests; fuel reductions; urban waste; and agricultural. Timber harvests and fuel reductions were each broken down into two sub-categories based on land ownership; government and private lands.

Timber harvests in the area accounted for 93,700 BDT/year, with 16,300 BDT/year from government lands and 77,400 BDT/year from private lands. The estimates were based on FIA data and interviews with local USFS staff. The report included all timber harvest activity occurring in the adjacent national forests, even those that have considerable area outside the study area. Also, the private land estimates include all activity in the adjacent counties, even though a significant portion of the area may be outside the study area.

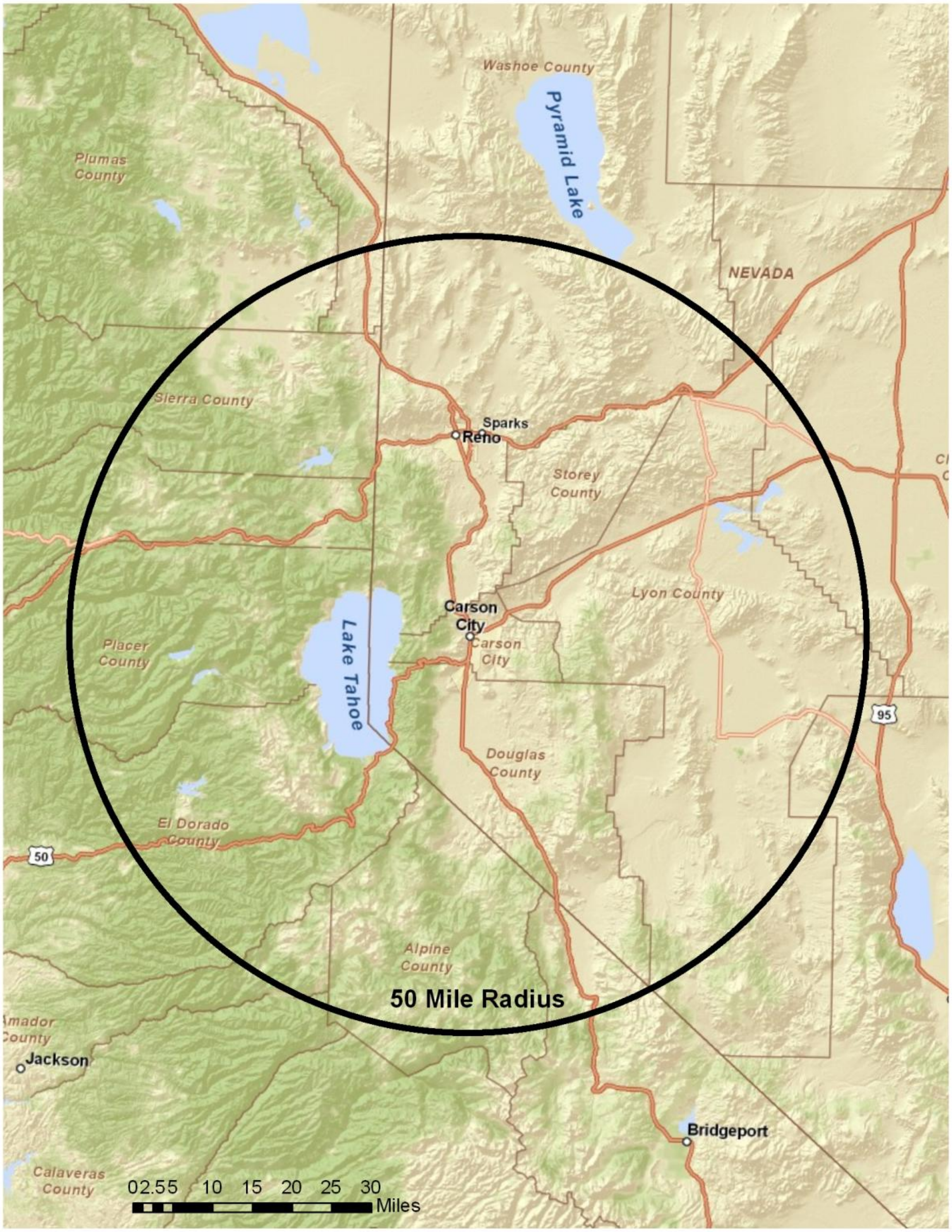

Figure 10. Fifty mile study area radius around Carson City, NV used for McNeil Technologies biomass assessment report.

Fuel reductions in the study area accounted for 37,300 BDT/year, with 14,200 BDT/year being generated on government lands. The fuel reduction rate in the Tahoe Basin was estimated at 11,000 BDT/year, but more current estimates are 2-3x higher (see subsequent Lake Tahoe Basin sections). For areas outside the Tahoe Basin, estimates of biomass availability were calculated from planned project acreage and yield estimates of 5 Green Tons per acre (GT/acre) for pinyon-juniper stands and 10 GT/acre for all other forest types. Private lands accounted for 23,100 BDT/year of the fuel reduction biomass. Private fuel reduction numbers were calculated by assuming that 1% of the total private forest land would have fuel reduction treatments applied annually and would generate 10 GT/acre of biomass. The total private forest acreage for all the counties touching the study area was calculated at 1.232 million acres (from the FIA database for all counties touching the study area), but approximately 580,000 acres of private forest acreage are actually within the 50 mile radius from Carson City. Using the private forest acreage within the study area would reduce the estimate to 13,000 BDT/year.

Urban waste in the Carson City study area accounted for 51,000 BDT/year, but once again this number is likely an overestimate because it includes urban waste from portions of counties that are well outside the 50 mile radius of Carson City.

Agricultural crop residue biomass was estimated at 7,000 BDT/year, although the actual is likely much less. The primary sources of residue are counties that are almost entirely outside the 50 mile radius from Carson City and it is unclear the actual amount of agricultural residue produced within the study area. The report also indicates that agricultural residue is not an economically viable source for medium to large sized biomass plants because of the limited availability and high cost of collection and transportation.

a) Lake Tahoe Basin (McNeil, 2003)

The McNeil Technologies report from 2003 estimated biomass availability for the Lake Tahoe Basin based on a 14.4 GT/acre ratio. The total calculated available biomass was 25,500 Green Tons per year (GT/year), or approximately 11,000 BDT/year based on a MC value of 55%. USFS lands generated approximately 22,000 GT/year (~9,900 BDT/year @ 55% MC), based on 1992-2001 actual fuel reductions, and 2002-2008 planned reductions.

b) Lake Tahoe Basin (USDA et al., 2007)

The Lake Tahoe Basin Multi-Jurisdictional Fuel Reduction and Wildfire Prevention Strategy Report (USDA et al., 2007), used the 14.4 GT/acre ratio from the McNeil 2003 study to calculate actual and planned reductions for the 2000-2016 time period. Actual reductions between 2000 and 2006 were estimated at 28,800 GT/year (2000 acres/year), and planned reductions through 2016 were estimated at 93,600 GT/year (6,500 acres/year). These estimates are much higher than those reported in the McNeil reports because of increased fuel reduction efforts in the Lake Tahoe Basin. The data for the Lake Tahoe Basin Fuels Plan was based on work done by Holl Consulting (http://www.trpa.org/, Fire Info, Final Fuel Reduction and Forest Restoration Plan, Chapter 5). They estimated 5,000 acres/year of fuel reduction projects till 2016 with an additional 1,800 acres/year in maintenance (Figure 11). This would result in an estimated 72,000 GT/year of biomass for the Lake Tahoe Basin plus the additional biomass generated through maintenance, but it may be inappropriate to assume 14.4 GT/year for all areas due to the variability in density and species of the potential feedstocks.

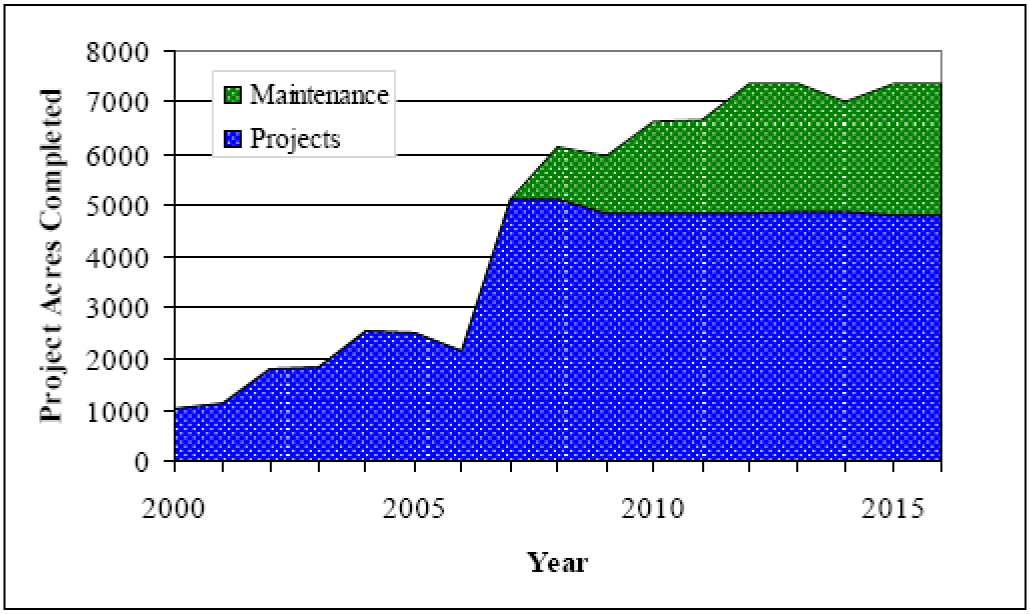

Figure 11. Fuel reduction acreage in the Lake Tahoe Basin

c) Lake Tahoe Basin (Mater, 2007)

As part of the USFS Lake Tahoe region CROP biomass assessment, Mater Engineering, in their 2007 report, estimated available biomass at 106,244 GT/year. This biomass estimate only includes trees smaller than 7”, so there could be additional biomass in the slash of larger trees. This estimate includes all timber sales and fuel reduction projects for the El Dorado National Forest, Humboldt-Toiyabe National Forest (Carson Ranger District only), Tahoe National Forest, Lake Tahoe Basin Management Unit (LTBMU), Nevada BLM (Carson City District), and the Nevada Division of Forestry (NDF). Biomass availability for just the LTBMU is estimated at 11,330 GT/year, which considerably lower than the LTB Multi-Jurisdictional Fuel Reduction Plan estimate, but does not include biomass from slash or trees larger than 7”. The biomass estimates for the Eldorado NF may be incorrect since only two unique values are reported for four ranger districts.

These reports all used different data sources, study areas, and dates, so it is difficult to directly compare the biomass estimates between them. Even if not stated, there is considerable uncertainty in the biomass estimates. One of the major issues is that the study area boundaries do not match up with the reporting area boundaries (counties and national forests). Many of the reporting area are quite large and it is not possible to determine the exact location of the biomass generation within the reporting area or if it is economically viable to transport. The other key problem is that these reports are estimates of how much biomass is being generated, but they are not surface level inventories. They do not address the total volume, the sustainability, or the distribution of biomass within these regions.

C. Estimation of Agricultural Biomass in Nevada

Data for estimates of agricultural biomass within Nevada were gathered using the Census of Agriculture. The Census of Agriculture is published every five years and the data contained in the census is gathered by voluntary cooperation with farmers throughout the United States. The United States Department of Agriculture (USDA) is required by law to publish the census every five years; however, farmers are not required to participate in the census, it is a completely voluntary process. Regardless, we used the census as a means to at least give rough approximations as to the amount of biomass from various crops produced in within Nevada. We downloaded the census from the USDA website (http://www.agcensus.usda.gov/Publications/2007/Full_Report/index.asp). The census is comprised of tables sorted in a variety of ways (e.g., entire U.S., state, crop, irrigated, not irrigated). We synthesized several different data tables within the census into one summary table for this report (Table 3). The categories that were most useful for this current report were crop, number of farms, acreage, and yield ("quantity").

Table 3. Census of Agriculture data from 2007 for the state of Nevada

	Harvested		
		2007	
Crop	Farms	Acres	Quantity (tons)
Forage (Tons, Dry Equivalent)	1,436	464,598	1,582,983
Hay (Tons, Dry)	1,417	470,068	1,558,120
Alfalfa hay (Tons, Dry)	1,128	274,004	1,217,586
Wild Hay (Tons, Dry)	248	130,091	181,088
Corn for Silage or Greenchop (Tons)	36	5,451	134,522
Other Tame Hay (Tons, Dry)	240	47,003	100,950
Small Grain Hay (Tons, Dry)	194	18,970	58,496
All Haylage, Grass Silage, and Greenchop (Tons, Green)	55	9,975	50,299
Haylage or Greenchop from Alfalfa or Alfalfa Mixtures (Tons, Green)	40	No data	39,534
Wheat for grain, All (bushels)	42	12,826	38,378
Other Haylage, Grass Silage, and Greenchop (Tons, Green)	22	No data	10,765
Winter Wheat for grain (bushels)	37	11,838	5,728
Other Spring Wheat for grain (bushels)	8	988	2,650
Barley for grain (bushels)	9	1,062	2,236
Alfalfa seed (pounds)	19	6,498	2,119
Corn for grain (bushels)	10	473	2,049
Oats for grain (bushels)	2	No data	No data
Sorghum for grain (bushels)	1	No data	No data
Triticale (bushels)	1	No data	No data
Field and Grass Seed Crops, All	19	6,498	No data
Mint for Oil, Peppermint (Pounds of Oil)	4	1,467	No data
Other Crops	4	475	No data

Census data from Nevada indicates that in 2007 there were 1,462,285 acres farmed throughout the entire state with a total production of 4,987,503 tons of biomass. Forage and hay crops were by far the highest in terms of farms, acreage, and production (Table 3). It should be noted that alfalfa production is included in the forage and hay categories making alfalfa the predominant crop grown in the state with 274,004 acres in production yielding 1,217,586 tons. In contrast, in the 2002 Census of Agriculture, it was reported that there were 1,142 farms, 304,033 acres, and 1,236,920 tons of alfalfa produced in the state of Nevada. The voluntary nature of the Census of

Agriculture does not allow us to determine if the actual production of alfalfa went down in 2007 or if just fewer growers actually participated in the census. This complication outlines the difficulty of using the Census of Agriculture as a reliable indication of biomass feedstocks available in Nevada. At this time, the census only gives us rough approximations of agricultural feedstocks within the state of Nevada and does not allow accurate accounting of these feedstocks, nor does it reliably indicate the sustainable production of agricultural feedstocks.

D. Estimation of Biomass Using the NFBD Data Set

Biomass estimates were generated from the National Forest Biomass Dataset (NFBD) for this study. This dataset was generated using data from USFS Forest Inventory Analysis (FIA) and a variety of remote sensing products (primarily MODIS) to show the distribution of biomass within the United States. The original units of the biomass dataset were in Mg (megagram) per hectare, but they were converted to Bone-Dry-Tons per acre for this study. The biomass data is stored in a raster with a 250m resolution, which corresponds to the MODIS data that was used to estimate the distribution. The raster data was converted to a shapefile with 2 BDT per acre groups (for example 0-2, 2-4, 4-6, etc.).

To separate biomass estimates by land ownership, spatial data sets representing federal, state, and private lands were used in the analysis. Land ownership was based on data downloaded from the National Integrated Land System's (NILS) GeoCommunicator website (www.geocommunicator.gov). The NILS is an attempt by the BLM and USFS to track all federal land parcels in the US. Biomass estimates were separately made for the BLM, USFS, and all other lands. The estimates were calculated using this ownership breakdown since these two federal entities manage the majority of lands that contain PJ biomass and harvest activity would most likely be managed differently between the two agencies.

Wilderness area spatial data was also used in the biomass estimate calculations. The wilderness area information was obtained from www.wilderness.net. The site is run by the Wilderness Institute out of the College of Forestry and Conservation at the University of Montana. They provide Keyhole Markup Language (KML) files (converted to ArcGIS native shapefiles) of all wilderness areas, including the most recent additions made under the Omnibus Public Lands Act of 2009. Wilderness area lands were excluded from the study areas since it is unlikely they will able to mechanically harvest biomass on these lands.

In order to understand how the FIA and NFBD biomass estimates compared, DRI first collected forested area and forested biomass estimates for all counties in California and Nevada (Table 4). The forested area estimates were then plotted in Figure 12 and the biomass estimates in Figure 13. The NFBD data includes an uncertainty estimate map that was used to generate the error bars in Figure 13. The large uncertainty in the NFBD biomass estimates is a result of the low forest biomass densities in the western United States, the spatial mismatch between the size of an FIA plot and the MODIS pixel, and the difference in how the FIA and NFBD define forest land (Blackard et al., 2007). However, over large areas, the NFBD data should provide a useful surface level biomass inventory.

Table 4. FIA and NFBD forested area and biomass estimates for California and Nevada counties (California inventory from 2001-2009, Nevada inventory from 2004-2005).

		FIA			NFBD		
COUNTY		FOREST AREA (ACRE)	FOREST BIOMASS (BDT)	SAMPLING ERROR (BDT)	FOREST AREA (ACRE)	FOREST BIOMASS (BDT)	SAMPLING ERROR (BDT)
Alameda	California	96,132	4,295,111	1,215,516	2,620	159,938	131,105
Alpine		396,370	17,686,343	2,824,509	442,786	34,620,600	23,809,300
Amador		218,823	11,705,399	2,740,234	185,528	15,028,000	11,551,790
Butte		533,242	41,820,794	5,507,799	477,764	46,511,300	35,171,100
Calaveras		422,264	23,204,757	3,691,877	345,665	29,910,800	22,387,080
Colusa		203,889	5,229,885	1,511,960	58,206	4,115,520	3,376,294
Contra Costa		47,083	2,187,051	840,046	12,416	642,469	557,986
Del Norte		627,516	75,137,007	13,494,606	600,734	67,788,200	48,481,200
El Dorado		855,427	63,991,696	6,450,363	821,424	78,000,900	54,155,100
Fresno		1,295,217	70,991,814	6,282,776	1,225,023	96,519,700	67,855,000
Glenn		201,201	11,500,938	2,610,713	175,558	13,840,000	11,671,110
Humboldt		1,817,792	222,624,954	15,494,697	1,817,144	200,285,000	142,853,000
Imperial		60,032	90,261	41,087	8,640	76,030	65,804
Inyo		586,090	6,655,016	871,807	541,868	15,149,700	12,625,270
Kern		798,663	15,951,833	1,995,574	736,310	33,552,100	28,673,890
Lake		397,777	18,266,904	3,032,306	283,044	23,478,500	18,634,340
Lassen		1,362,556	38,957,909	3,564,649	1,210,444	56,537,900	44,184,000
Los Angeles		250,738	5,444,387	1,173,265	190,436	12,391,500	9,093,290
Madera		713,295	44,842,217	5,663,572	600,866	45,014,300	33,595,700
Marin		92,262	8,825,992	3,315,043	55,583	5,386,600	3,862,700
Mariposa		667,143	38,425,005	5,083,628	578,363	44,023,500	33,415,300
Mendocino		1,705,658	148,931,329	10,306,048	1,478,358	151,625,000	112,820,200
Merced		38,383	750,214	400,314	3,943	77,946	77,946
Modoc		1,406,406	26,693,662	2,690,721	1,238,837	44,216,100	39,000,010
Mono		864,837	18,068,333	2,135,677	823,221	34,576,000	26,595,340
Monterey		528,904	22,711,012	4,510,407	329,562	26,025,300	17,124,850
Napa		170,104	9,765,566	2,309,556	56,235	4,429,880	3,298,280
Nevada		414,199	26,192,573	3,921,028	457,137	39,574,700	28,618,900
Orange		14,967	194,540	97,893	3,306	320,447	251,631
Placer		619,657	45,234,834	5,600,072	614,888	59,888,000	42,513,200
Plumas		1,397,947	92,281,771	6,994,958	1,498,584	118,860,000	89,616,900
Riverside		135,938	2,645,021	921,261	129,389	7,424,930	4,988,800
Sacramento		8,319	170,232	166,555	0	1,409,850	1,055,563
San Benito		164,696	3,820,843	1,172,235	26,413	24,556,300	17,347,300
San Bernardino		538,348	11,113,960	1,929,383	410,388	13,541,600	11,090,770
San Diego		142,737	2,770,413	876,559	207,049	9,141	8,927
San Joaquin		29,304	2,181,815	1,187,562	1,441	28,767	28,767
San Luis Obispo		293,029	11,479,808	1,987,155	30,933	1,560,700	1,269,148
San Mateo		93,285	10,814,077	3,607,576	80,766	9,577,570	6,013,050
Santa Barbara		309,789	8,494,839	1,566,448	96,496	4,699,370	4,095,224
Santa Clara		292,132	12,968,863	2,300,676	74,741	5,763,830	4,544,760
Santa Cruz		180,227	29,626,752	6,100,148	165,118	18,337,700	12,363,780
Shasta		1,903,581	107,347,748	7,503,608	1,736,196	150,162,000	115,954,000
Sierra		487,532	33,972,931	5,048,378	547,369	50,368,200	36,361,300
Siskiyou		3,123,860	201,979,685	10,947,299	3,285,723	262,447,000	198,619,300
Solano		27,223	429,088	209,266	2,206	94,792	84,232
Sonoma		483,965	43,347,098	7,061,242	262,000	25,893,000	19,842,630
Stanislaus		93,672	1,891,665	533,260	2,774	65,408	64,772
Sutter		30,483	1,412,508	733,939	1,328	43,358	42,814
Tehama		1,023,248	47,137,278	5,331,226	753,523	55,695,800	42,827,300
Trinity		1,845,194	169,974,208	10,776,365	1,951,474	184,481,000	136,142,900
Tulare		1,355,516	76,516,048	7,062,431	1,572,183	121,428,000	83,436,700
Tuolumne		1,047,427	72,337,602	7,023,981	1,129,893	91,419,900	69,156,000
Ventura		287,597	4,183,037	898,098	167,483	6,667,660	5,925,814
Yolo		59,945	1,181,573	449,470	4,871	101,154	98,809
Yuba		184,272	15,770,031	3,614,491	123,114	11,060,300	8,664,360
Churchill	Nevada	221,485	1,134,312	461,098	245,048	2,120,080	1,472,604
Clark		363,859	3,115,075	971,903	379,376	6,333,100	4,155,930
Douglas		317,621	3,850,439	1,428,128	169,388	8,688,090	6,862,090
Elko		1,176,320	10,788,941	1,540,661	769,111	7,629,010	5,060,850
Esmeralda		206,136	1,601,963	664,654	170,382	1,985,350	1,334,419
Eureka		506,451	3,718,847	596,131	421,484	4,209,160	2,715,290
Humboldt		141,348	1,587,326	826,362	80,041	1,757,640	1,626,098
Lander		464,567	5,045,781	1,274,060	404,469	3,872,430	2,594,670
Lincoln		1,935,699	14,284,890	1,439,917	1,611,300	18,527,400	11,602,760
Lyon		208,474	2,506,974	1,054,684	145,296	2,835,380	2,171,700
Mineral		447,250	3,730,675	880,439	358,239	3,455,900	2,202,980
Nye		2,065,354	20,472,285	1,862,978	1,952,376	22,666,100	15,001,010
Pershing		172,587	1,018,670	487,841	92,654	509,881	386,414
Storey		23,525	376,314	376,314	12,506	327,951	327,417
Washoe		389,443	4,257,386	2,299,840	256,953	11,308,300	9,084,780
White Pine		2,465,513	34,345,949	3,510,156	1,976,799	26,125,900	16,906,320
Carson City		63,524	444,768	324,369	49,566	2,191,180	1,808,074

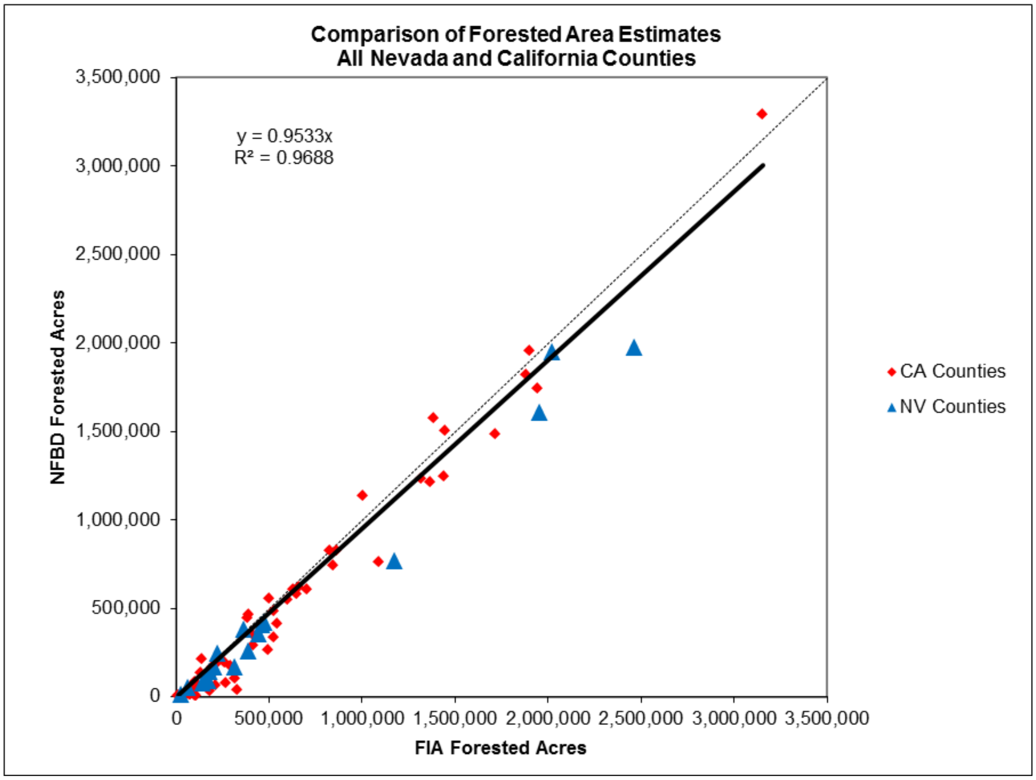

Figure 12. FIA and NFBD forested area estimates.

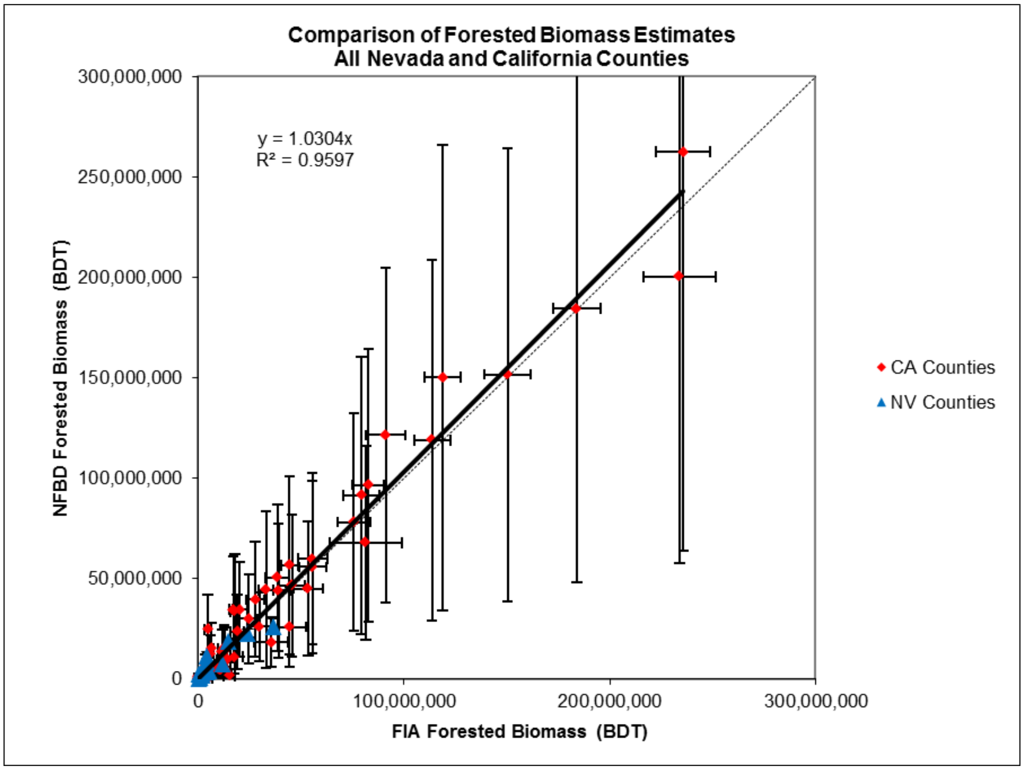

Figure 13. FIA and NFBD forested biomass estimates with error bars.

E. GIS Data Integration and Analysis

In response to requests from REII for geospatial support for their economic assessment work, DRI continued to develop pinyon-juniper biomass estimates for likely candidate areas where temporary or permanent biofuel processing plants might be located or constructed. This included the application of spatial constraints for feedstocks in proximity to potential processing plants, as it was important for REII to understand the potential availability of feedstocks given transportation, slope, land ownership and power availability constraints. Based on initial FIA and NFBD biomass estimates conducted by DRI, and the resultant spatial distribution of potential biomass in eastern Nevada/western Utah, a decision was made to use both Pioche, NV in Lincoln county and Ely, NV in White Pine county as potential processing plant locations (temporary or permanent). To understand distance and proximity relationships between Ely and Pioche and the nearby feedstocks, circular study areas around the two towns were generated with the following radii: 25, 50, 75, & 100 miles. Spatial analysis operations were performed on the biomass estimates as a means of constraining estimates by landownership, wilderness areas, slope values (as calculated from elevation data), and proximity to roads. Attempts to integrate power grid information were unsuccessful, as requests for power data submitted to Nevada Energy were turned down due to Homeland Security restrictions concerning dissemination of power grid and substation locations. The radii distances and constraint parameters were developed by DRI personnel in consultation with REII.

Digital elevation data was used to develop slope values to calculate biomass estimates as they related to slope classes in the study areas. The 30m National Elevation Dataset (NED) was downloaded from the USGS Seamless Data Distribution System (http://seamless.usgs.gov/). The percent slope was calculated from the NED and a mean focal filter (3x3 box) was applied. The following slope regions were grouped: 0-20, 20-35, 35-50, & > 50 percent slope. ArcGIS native format shapefiles of the groups were generated.

Based on discussions with REII personnel interested in the economic aspects of harvesting Pinyon-Juniper in the study areas, road data were incorporated into the analysis in order to determine biomass estimates within certain distances of primary and secondary roads. The road information was taken from 100k Digital Line Graph (DLG) files downloaded from the Nevada state Bureau of Land Management (BLM) websites (www.nv.blm.gov/gis/geospatial_data.htm). Five mile buffers of the primary & secondary roads were generated using ArcGIS ArcToolbox. The DLG's are not the most current road data available but they do have similar attribute information and are relatively consistent across state boundaries. This could be a major source of error, since it is difficult to determine the quality and size of a road from available one meter USDS National Agricultural Imagery Program (NAIP) imagery. A large portion of the study area is within the 5 mile buffer though, so even if some of the roads no longer exist or are not the right class, it should not have a major impact on the results.

The study area circles, biomass groups, land ownership, slope groups, & road buffers, were then unioned using ArcToolbox functions. The pinyon-juniper biomass for each resulting polygon was calculated by multiplying the average of the biomass group value (for example 13 for the 12-14 BDT per acre group) by the acreage of the polygon. The calculated biomass estimates can be found in Tables 5 through 8. Table 5 contains the biomass estimates for each of the four radii around the two towns, with additional low and high error bar estimates for each site. Table 6 contains the biomass estimates for each of the slope classes for each of the radii for the two study sites. The U.S. Forest Service team that generated the NFBD biomass estimates for the United States, also generated a residual error map for the same areas. The residual errors were calculated by comparing the regression model biomass estimates with the FIA biomass measurements. The residual errors were then estimated for each 250m MODIS pixel. To estimate a high error bar for the eastern Nevada/western Utah study areas centered around Pioche and Ely, NV, we added the residual error value to the biomass estimate for each pixel. For the low error bar, we subtracted the residual error values from the biomass estimates but adjusted any negative values to zero. Table 7 contains the low bar slope-based estimates for each of the radii for the two study sites, Table 8 contains the high bar data. Figure 14 shows the spatial distribution of the biomass classes (in bone-dry-tons per acre) relative to Ely and Pioche, NV, their respective distance radii, and primary roads. Figure 15 shows the distribution of pinyon-juniper relative to the primary and secondary roads found in the respective study areas for both towns.

Table 5. Summary of biomass estimates by landowner and distance from site

ESTIMATED BIOMASS SUMMARY
Estimates are in Bone Dry Tons (BDT)
Estimates only include Pinyon-Juniper biomass
Estimates only include biomass within 5 miles of a primary or secondary road
Estimates only include biomass not in Wilderness Areas
Estimates only include biomass on a slopes less than 35 percent

Ely Site

ESTIMATED BIOMASS	LAND OWNER			
STUDY AREA RADIUS	BLM	USFS	OTHER	TOTAL
25 Miles	2,074,227	835,950	199,869	3,110,046
50 Miles	5,595,465	2,051,718	420,790	8,067,974
75 Miles	12,319,310	2,126,462	810,196	15,255,968
100 Miles	18,082,576	4,198,428	1,117,623	23,398,627
LOW ERROR BAR	LAND OWNER			
STUDY AREA RADIUS	BLM	USFS	OTHER	TOTAL
25 Miles	777,363	313,999	75,176	1,166,539
50 Miles	2,105,617	777,983	162,193	3,045,792
75 Miles	4,615,655	806,130	302,885	5,724,669
100 Miles	6,706,874	1,552,542	413,227	8,672,644
HIGH ERROR BAR	LAND OWNER			
STUDY AREA RADIUS	BLM	USFS	OTHER	TOTAL
25 Miles	3,385,741	1,375,947	327,782	5,089,470
50 Miles	9,144,221	3,349,107	685,800	13,179,129
75 Miles	20,154,085	3,471,122	1,336,798	24,962,006
100 Miles	29,671,660	6,879,269	1,848,393	38,399,323

Pioche Site

ESTIMATED BIOMASS	LAND OWNER			
STUDY AREA RADIUS	BLM	USFS	OTHER	TOTAL
25 Miles	3,945,277	0	149,890	4,095,167
50 Miles	10,108,804	1,010,967	576,570	11,696,341
75 Miles	14,097,238	3,099,985	1,263,855	18,461,078
100 Miles	19,241,066	4,646,755	2,657,817	26,545,637
LOW ERROR BAR	LAND OWNER			
STUDY AREA RADIUS	BLM	USFS	OTHER	TOTAL
25 Miles	1,579,916	0	63,123	1,643,039
50 Miles	3,863,584	381,862	205,286	4,450,732
75 Miles	5,171,176	1,011,186	403,138	6,585,501
100 Miles	6,329,764	1,555,988	720,331	8,606,083
HIGH ERROR BAR	LAND OWNER			
STUDY AREA RADIUS	BLM	USFS	OTHER	TOTAL
25 Miles	6,336,328	0	238,611	6,574,939
50 Miles	16,430,010	1,641,696	952,330	19,024,036
75 Miles	23,266,795	5,290,078	2,165,399	30,722,272
100 Miles	32,891,534	7,867,117	4,733,385	45,492,035

Table 6. Mean biomass estimate by landowner, distance from site, and slope

ESTIMATED BIOMASS

Estimates are in Bone Dry Tons (BDT)
Estimates only include Pinyon-Juniper biomass
Estimates only include biomass within 5 miles of a primary or secondary road
Estimates only include biomass not in Wilderness Areas

Ely Site

STUDY AREA RADIUS	PERCENT SLOPE	LAND OWNER			
		BLM	USFS	OTHER	TOTAL
25 Miles	<20	1,311,633	423,145	128,398	1,863,175
	20-34	762,594	412,805	71,471	1,246,870
	35-49	346,220	162,868	26,952	536,040
	>=50	109,945	59,300	9,368	178,613
50 Miles	<20	3,333,536	1,030,840	242,135	4,606,512
	20-34	2,261,929	1,020,878	178,656	3,461,462
	35-49	1,262,873	529,474	110,432	1,902,780
	>=50	515,885	252,284	56,389	824,557
75 Miles	<20	7,442,451	1,055,045	481,487	8,978,982
	20-34	4,876,859	1,071,418	328,709	6,276,986
	35-49	2,746,563	596,050	204,363	3,546,976
	>=50	1,187,783	305,227	91,340	1,584,350
100 Miles	<20	10,996,993	2,056,617	686,359	13,739,969
	20-34	7,085,583	2,141,810	431,264	9,658,657
	35-49	4,224,243	1,303,445	270,589	5,798,277
	>=50	1,987,444	640,492	115,149	2,743,086

Pioche Site

STUDY AREA RADIUS	PERCENT SLOPE	LAND OWNER			
		BLM	USFS	OTHER	TOTAL
25 Miles	<20	2,887,087	0	87,637	2,974,724
	20-34	1,058,191	0	62,252	1,120,443
	35-49	490,061	0	44,008	534,069
	>=50	173,206	0	15,127	188,332
50 Miles	<20	7,132,144	653,989	417,209	8,203,342
	20-34	2,976,661	356,978	159,360	3,492,999
	35-49	1,393,955	123,521	83,374	1,600,850
	>=50	522,081	23,749	26,681	572,511
75 Miles	<20	9,590,209	1,699,836	871,099	12,161,144
	20-34	4,507,029	1,400,149	392,756	6,299,934
	35-49	2,251,789	720,488	222,915	3,195,193
	>=50	983,375	324,442	98,278	1,406,094
100 Miles	<20	12,782,827	2,469,701	1,661,326	16,913,853
	20-34	6,458,239	2,177,053	996,491	9,631,784
	35-49	3,328,819	1,081,414	579,874	4,990,108
	>=50	1,729,690	479,208	348,945	2,557,843

Table 7. Low biomass estimate by landowner, distance from site, and slope.

LOW ERROR BAR

Estimates are in Bone Dry Tons (BDT)
Estimates only include Pinyon-Juniper biomass
Estimates only include biomass within 5 miles of a primary or secondary road
Estimates only include biomass not in Wilderness Areas

Ely Site

STUDY AREA RADIUS	PERCENT SLOPE	LAND OWNER			
		BLM	USFS	OTHER	TOTAL
25 Miles	<20	477,848	159,393	477,848	685,308
	20-34	299,516	154,606	299,516	481,231
	35-49	137,544	59,447	137,544	206,868
	>=50	45,057	21,908	45,057	70,542
50 Miles	<20	1,211,035	384,360	1,211,035	1,687,263
	20-34	894,581	393,623	894,581	1,358,529
	35-49	507,553	198,765	507,553	748,685
	>=50	205,039	90,388	205,039	316,101
75 Miles	<20	2,699,018	393,132	2,699,018	3,266,858
	20-34	1,916,637	412,998	1,916,637	2,457,812
	35-49	1,084,228	225,410	1,084,228	1,388,195
	>=50	460,823	111,922	460,823	606,428
100 Miles	<20	3,945,964	738,671	3,945,964	4,928,944
	20-34	2,760,910	813,872	2,760,910	3,743,700
	35-49	1,662,931	493,687	1,662,931	2,262,082
	>=50	769,852	236,991	769,852	1,049,970

Pioche Site

STUDY AREA RADIUS	PERCENT SLOPE	LAND OWNER			
		BLM	USFS	OTHER	TOTAL
25 Miles	<20	1,126,151	0	1,126,151	1,162,253
	20-34	453,765	0	453,765	480,786
	35-49	208,933	0	208,933	227,293
	>=50	69,500	0	69,500	75,838
50 Miles	<20	2,648,100	240,977	2,648,100	3,029,621
	20-34	1,215,484	140,885	1,215,484	1,421,110
	35-49	567,305	47,325	567,305	649,578
	>=50	204,320	8,663	204,320	224,002
75 Miles	<20	3,425,686	552,965	3,425,686	4,243,027
	20-34	1,745,490	458,222	1,745,490	2,342,473
	35-49	867,784	224,484	867,784	1,173,253
	>=50	364,038	92,445	364,038	490,377
100 Miles	<20	4,121,920	820,948	4,121,920	5,378,885
	20-34	2,207,844	735,041	2,207,844	3,227,198
	35-49	1,131,863	351,175	1,131,863	1,651,582
	>=50	538,482	148,419	538,482	780,549

Table 8. High biomass estimate by landowner, distance from site, and slope

HIGH ERROR BAR

Estimates are in Bone Dry Tons (BDT)
Estimates only include Pinyon-Juniper biomass
Estimates only include biomass within 5 miles of a primary or secondary road
Estimates only include biomass not in Wilderness Areas

Ely Site

STUDY AREA RADIUS	PERCENT SLOPE	LAND OWNER			
		BLM	USFS	OTHER	TOTAL
25 Miles	<20	2,152,019	693,050	2,152,019	3,055,631
	20-34	1,233,722	682,898	1,233,722	2,033,839
	35-49	559,553	272,987	559,553	877,686
	>=50	177,079	98,993	177,079	291,811
50 Miles	<20	5,488,402	1,684,186	5,488,402	7,568,818
	20-34	3,655,819	1,664,921	3,655,819	5,610,311
	35-49	2,033,282	871,796	2,033,282	3,085,285
	>=50	834,692	420,613	834,692	1,348,336
75 Miles	<20	12,265,032	1,724,344	12,265,032	14,790,839
	20-34	7,889,053	1,746,778	7,889,053	10,171,167
	35-49	4,435,142	978,556	4,435,142	5,748,137
	>=50	1,929,968	505,351	1,929,968	2,586,777
100 Miles	<20	18,186,050	3,390,184	18,186,050	22,724,249
	20-34	11,485,610	3,489,085	11,485,610	15,675,073
	35-49	6,824,599	2,125,721	6,824,599	9,391,000
	>=50	3,225,780	1,051,255	3,225,780	4,466,684

Pioche Site

STUDY AREA RADIUS	PERCENT SLOPE	LAND OWNER			
		BLM	USFS	OTHER	TOTAL
25 Miles	<20	4,668,905	0	4,668,905	4,809,253
	20-34	1,667,423	0	1,667,423	1,765,687
	35-49	772,963	0	772,963	843,279
	>=50	277,831	0	277,831	302,106
50 Miles	<20	11,675,802	1,067,771	11,675,802	13,441,810
	20-34	4,754,208	573,925	4,754,208	5,582,227
	35-49	2,227,391	198,991	2,227,391	2,558,876
	>=50	844,798	38,736	844,798	926,432
75 Miles	<20	15,920,656	2,893,291	15,920,656	20,317,429
	20-34	7,346,139	2,396,787	7,346,139	10,404,843
	35-49	3,673,737	1,249,637	3,673,737	5,297,601
	>=50	1,621,824	576,683	1,621,824	2,365,682
100 Miles	<20	21,935,015	4,177,110	21,935,015	29,091,534
	20-34	10,956,519	3,690,007	10,956,519	16,400,501
	35-49	5,664,253	1,855,327	5,664,253	8,536,229
	>=50	3,023,102	834,443	3,023,102	4,479,550

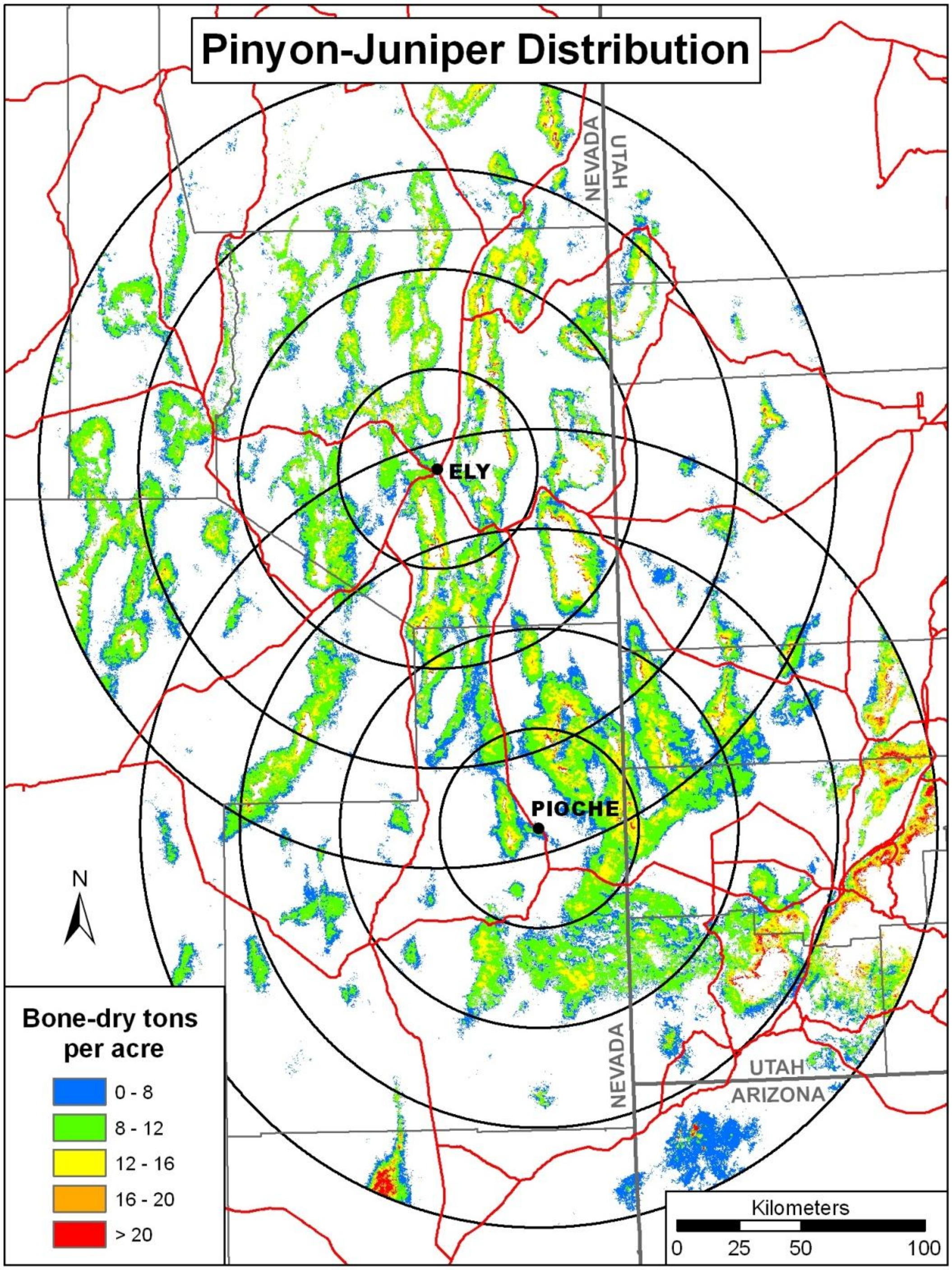

Figure 14. Location of biomass feedstocks, in bone-dry tons per acre, relative to the towns of Ely and Pioche in eastern Nevada. Black concentric circles radiating from each town represent the following distances from the town centers: 25, 50, 75, and 100 miles. Red lines represent primary roads.

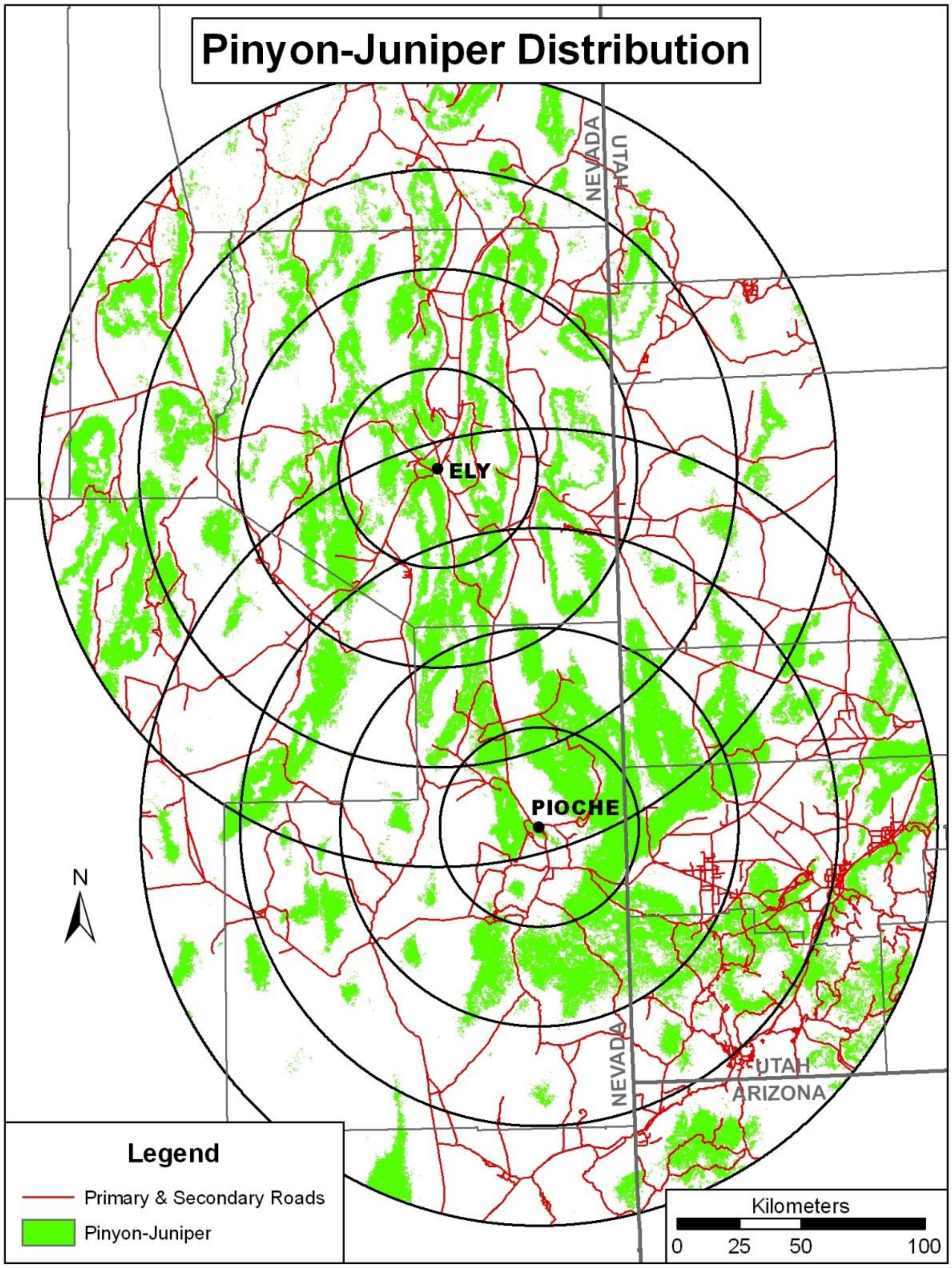

Figure 15. Distribution of pinyon-juniper relative to the primary and secondary roads found in the respective radii study areas for both Ely and Pioche, NV.

V. Discussion/Conclusions

Of the various Lake Tahoe Basin/Carson, NV area studies we evaluated, the Lake Tahoe Basin Multi-Jurisdictional Fuel Reduction and Wildlife Prevention Strategy Report (USDA et al., 2007) appears to provide the most robust and defensible estimates of biomass, both actual and planned, out to year 2016. The numbers generated in this report were based on actual and predicted fuel reduction calculations in the Basin. The report estimates that the planned 5,000 acres/year in fuel reductions until 2016 would yield approximately 72,000 GT/year of biomass, assuming a ratio of 14.4 GT/acre, plus the yield from an additional 1,800 acres/year in maintenance thinning.

The assessment of available agricultural biomass in Nevada using USDA census data provided a rough approximation of agricultural feedstocks that was not reliable for estimating these kinds of biomass, nor did the data indicate the potential sustainability of these feedstocks.

The state-wide inventory of biomass for Nevada using the FIA dataset yielded a total estimate of 112.28 million tons of biomass for all species, and 89.38 million tons of pinyon-juniper species. The NFBD dataset yielded a total estimate of 124.54 million tons of biomass for all species, and 98.30 million tons of pinyon-juniper species. It is interesting that the satellite-based NFBD method yielded greater estimates than the plot-based estimates derived in the FIA method. This is probably due to a combination of factors including the difference in how the FIA and NFBD methods each define forest land (Blackard et al., 2007), and the spatial mismatch between the relatively small size of a FIA plot relative to the coarse 250 meter MODIS pixels.

DRI's analysis of the availability of potential pinyon-juniper feedstocks to two hypothetical biofuel processing plant locations in eastern Nevada resulted in estimates for different sized study areas and scenarios around the towns of Ely and Pioche, NV, based on NFBD data. The complexity and thoroughness of these analyses provides the user with a variety of scenarios and constraints related to several spatial and statistical parameters. A number of pinyon-juniper estimation scenarios were analyzed using four different distance radii from each town (25, 50, 75, and 100 miles respectively), with other spatial constraints related to specific land ownership (BLM, USFS, Other), and slope classes (percent slope). Statistically, estimates were provided for mean, low and high bar estimates using residual error data generated for each MODIS satellite pixel in the NFBD estimation process.

The various data sets and analysis performed in this study all indicate that although reasonable estimates of lignocellulosic feedstocks can be derived for larger inventory areas (regional or state-wide studies), care must be taken to understand the estimation errors associated with these values. These errors come from many sources, in the case of the Lake Tahoe Basin studies, for example, the aggregation of biomass estimates from original county or national forest administrative units into data for a physical (topographic) study area such as the Lake Tahoe Basin. In this scenario there may be a relatively small portion of a county or national forest that overlays the physical boundary of interest, but the entire biomass estimate for that county or national forest, most of it falling outside the physical study area of interest, is included in the study area estimate, leading to an erroneous overestimate of feedstocks. The error propagation is compounded by the fact that the various reports analyzed acquired their data at different dates and used different criteria to classify the various feedstock sources (i.e. timber harvests, fuel reductions, urban waste, and agricultural waste). Areas like the Lake Tahoe Basin are complex in how the various agencies and states have estimated biomass, given that so many different agencies and two states (California and Nevada) control parts of the study area. These are some of the reasons the various Lake Tahoe Basin reports we evaluated were inconsistent in their final biomass estimates. For analysis of both within state study areas and interstate study areas like Lake Tahoe Basin and eastern Nevada/western Utah and Arizona, it was far more reasonable (and hopefully accurate) to use the FIA and NFBD national biomass datasets and analysis techniques to derive large area feedstock estimates.

Since the completion of the biomass analysis for this project, a new, potentially more accurate biomass data product has been released nationwide. The Woods Hole Research Center released the National Biomass and Carbon Dataset for the year 2000 (NBCD) in May of 2011. One of the products is an above ground live dry biomass estimate for the conterminous United States. The estimates were generated based on the FIA plots, Landsat ETM+ satellite imagery from 1999-2002, and InSAR measurements of vegetation height from the 2000 Shuttle Radar Topography Mission. The data is at a much higher resolution (30m) than the NFBD data (250m) since it is based on Landsat imagery instead of MODIS. Although this data set was released too late for use in the present biomass assessment analysis, it could provide additional, possibly more spatially accurate, biomass estimates for future analysis by DRI and/or REII.

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