Results of Forest Thinning Activities at the Alpine Cascade Ranch

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Contents

Summary

This report summarizes both phase one and phase two of field activities and data analysis of forest mensuration activities, pre and post-thinning at the Alpine Cascade Ranch, tract 1. The following report examines the forest conditions as characterized by species composition, density of stems and basal area of trees on the property and compares the pre-thinning conditions (2011) with post-thinning conditions (2012). Overall, forest thinning activities reduced the number of trees on the property from an initial average density of 251 stems/acre, to a post-thinning average density of 105 stems/acre, comprising a 58% reduction. There was also an increase in the average distance between stems, from 62 ft. (19.8 m) in 2011 to 82 ft. (25.2 m) in 2012 (24.4% increase). The reduced density of stems was also reflected in the number of trees sampled, which decreased by 12% (783 in 2011 to 697 in 2012), due mainly to the reduced number of trees in the fixed radius plots. Conversely, the average diameter of the remaining trees was larger, increasing from an average of 12.2 inches under the pre-thinning conditions to 14.0 inches following thinning, an increase of 15%. The species composition also shifted following thinning, with fewer stems for all species, with the greatest percent reduction in the number of Juniper stems (58%), followed by Gamble Oak (50%), Douglas Fir (33%), and a small percent reduction in Ponderosa stems (6%).

Site Description

Tract 1 of the Alpine Cascade Ranch is located in near the north east corner of the property between Echo Canyon, the San Juan River and Echo Canyon Reservoir (**Figure 2**). This section of the property slopes generally to the west and has an average elevation of 7,316 ft. (7,614 max, 7001 min) and is underlain primarily by Cretaceous age sandstones and shales. The dominant forest cover is Ponderosa Pine with some Douglas Fir, Rocky Mountain Juniper, and an understory of Gamble Oak.

Forest thinning activities comprised mainly of removing smaller diameter trees and clearing understory Gamble Oak, and was conducted during the winter and spring months of 2012, with logs being cut, stacked, and later chipped using a Bruks chipper, www.bruks.com (**Figure 1**).

Figure 1. Bruks chipper processing cut ponderosa pine.

Field Sampling

In September of 2011 and June of 2012 forest mensuration activities were conducted on the Alpine Cascade Ranch, tract 1, (**Figure 2, 3**) to examine forest character (density and basal area) and composition (species). We used two complementary methods for our investigation, employing both plot (fixed radius) (Bray and Curtis, 1957) and plot-less (point-centered quarter) sampling techniques (Cottam and Curtis, 1956; Mitchel, 2007). We used these two techniques to independently cross-check the data validity of each method. The data presented below compare the pre-thinning forest composition and character, with post-thinning completed during Winter/Spring of 2012.

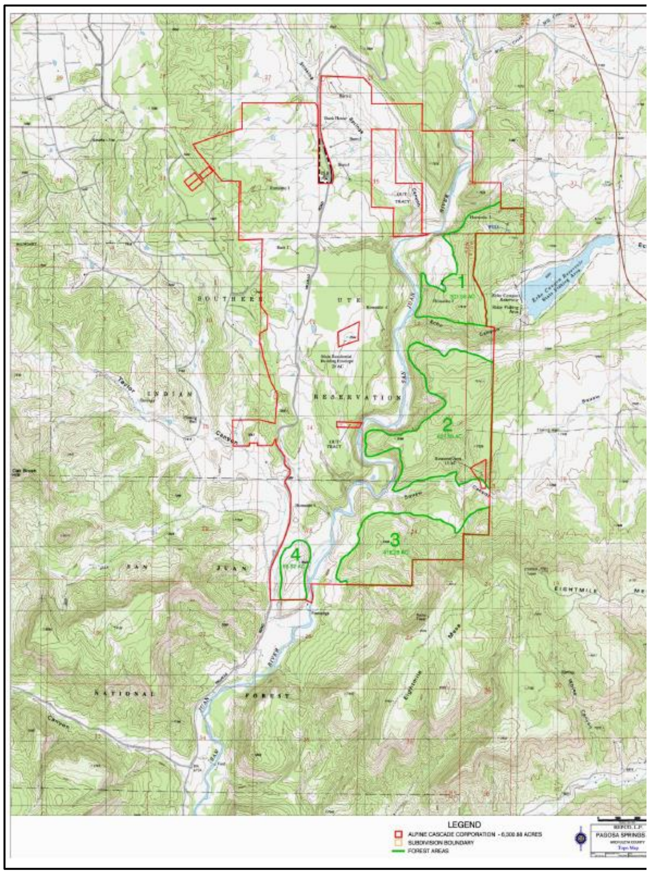


Figure 2. Alpine Cascade Corporation Ranch Area with thinning areas outlined in green. Field activities in 2011 were conducted in Section 1, in the north-east quarter of the Ranch.

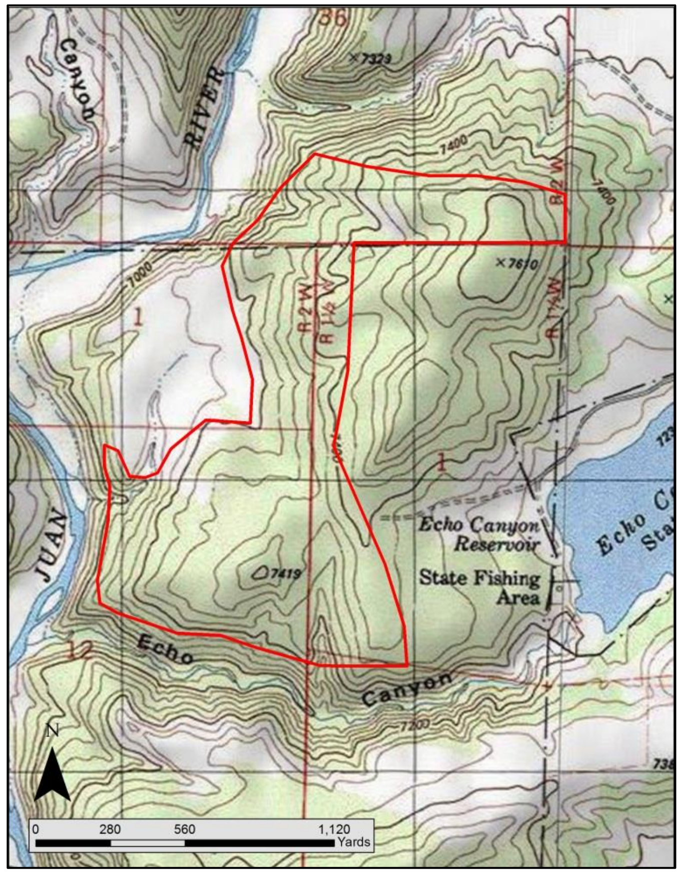


Figure 3. Alpine Cascade Ranch, section 1 (Study Area).

We use abbreviations derived from the first two letters of the Latin names which denote the different species of tree, and are as follows:

Ponderosa Pine – PIPO – *Pinus ponderosa*
Douglas Fir – PSME – *Pseudotsuga menziesii*
Gamble Oak – QUGA – *Quercus gambelii*
Rocky Mountain Juniper – JUSC - *Juniperus scopulorum*

Basal Area – BA	Point Centered Quarter – PCQ
Density – D	Fixed Radius - FR

Methods

We measured forest composition and character in tract 1 of the Alpine Cascade forest thinning area using both plot and plot-less based sampling techniques (**Figure 4, 5**). We sampled 33 transects (18 in 2011, and 16 in 2012) totaling 4,654 meters (2.9 miles) in 2011 and 4,067 meters (2.5 miles) in 2012, taking 1,486 measurements of species and diameter at breast height (DBH). We also measured distance to the nearest tree at 372 points, using variable length (132 – 494 m) transects and the point-centered quarter (PCQ) method. We also sampled 35 fixed radius (FR) circular plots (13 in 2011 and 22 in 2012) measuring DBH and species for 1,123 trees (712 in 2011, 412 in 2012), giving a total of 2,609 trees measured.

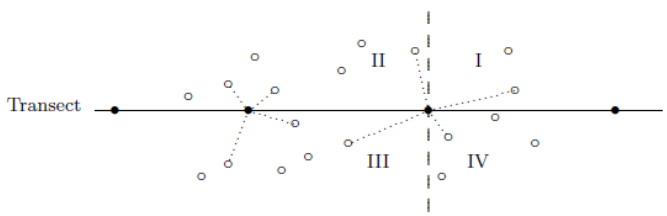


Figure 4. Point Centered-Quarter Transects (PCQ) Dotted lines indicate distance to nearest stem, circles are individual stems, and numerals I-IV indicate quadrants.

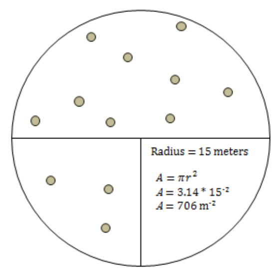


Figure 5. Fixed Radius Plots (FR) Radius of fixed plots – 15 meters, total area 706 square meters. Dots indicate trees that would be counted.

For each transect, stem density was calculated by following the methods outlined in Mitchell (2007), and consists of traveling along a transect of consistent azimuth and at regular intervals (20, 30 meters) stopping and taking the distance measurements to the closest tree in each of four quadrants (**Figure 4**) and applying the following equation(s):

$$\text{Absolute Density} = D = \frac{1}{Avg\ distance^2} = \text{stems/ft}^{-2}$$

The **absolute density** of individual species (*Ds*) is the density of each species (i.e., # of stems of Ponderosa, Oak, Juniper, and Doug Fir/ square meter) and is found by calculating the proportion of quarters in which each species is found and multiplying that by the absolute density of all trees. Absolute density of individual species are multiplied by stems per acre or hectare to get an estimate of the number of individual species we would expect to find in the entire area of Section 1, and can be found by:

$$\text{Absolute Density of Individual Species} = Ds = \frac{\#\ of\ quarters\ with\ species\ x}{4 * number\ of\ sampled\ points} * D$$

We also calculate **relative density** of each species by multiplying Ds by 100 to get the proportion of each species for the entire area, total should sum to 100 with small rounding error. The relative density is a percentage of the species that we are estimating occur throughout the entire area.

$$\text{Relative Density of Individual Species} = Dsr = Ds * 100$$

We also want to know how much wood (i.e., area-of-wood/ square meter) is on the land and we calculate this by determining the total **basal area** (BA) and BA by species and average BA for each transect. We estimate BA for an area by multiplying average density (stems/area) by the total basal area (cm) at each PCQ point to get an estimate of BA per area, (i.e., area of wood (ft^2)/ surface area (ft.) for the whole area and by each species. BA for each tree is found by applying the equation:

Basal Area (individual stem) = $BA = \pi d^2/4$

d = Diameter at Breast Height (DBH)

To get basal area/acre we calculate the density at each point (stems/ft^{-2}) and multiply this by the absolute density of stems/acre (# stems/ac) and divide this all by 10,000 to get square feet of wood/ acre.

For the fixed radius plots (FR) we first calculate the number of stems found in each FR which gives the number of stems found in $7600^{\wedge 2}$ feet, which we then divide by 7600 to get stems/ square foot. BA for the FR plots is calculated in similar way, with BA for individual stems summed for the entire plot and this number divided by 7600 to get BA/square foot. We can also do this for individual species by summing each species BA in the plot and dividing this by 7600 to get BA/species/square foot.

Results

Species Composition

The predominant species found at the site is Ponderosa pine (*Pinus ponderosa* – PIPO) comprising 94% of the stems measured and 98% of the total basal area (**Table 1**). The next most common species we found were Gamble oak (*Quercus gambelii* – QUGA) 8%, Rocky Mountain Juniper (*Juniperus scopulorum* – JUSC), and Douglas fir (*Pseudotsuga menziesii* – PSME) 1% of all stems (**Figure 6**). When the data is viewed by sample type (i.e., Fixed Radius or PCQ) we see similar patterns with PIPO being the dominant species in both the PCQ transects and the Fixed Radius plots (**Figure 7, 8**).

Table 1: Species composition and % basal area for both FR and PCQ transects 2011 and 2012.

Species	**# of Stems**		**% of Species (stems)**		**% of Basal Area**	
Year	2011	2012	2011	2012	2011	2012
JUSC	59	19	4	2	3	1.0
PIPO	1300	1047	87	94	96	98
PSME	16	8	1.1	0.7	0.7	0.8
QUGA	119	34	8	3	0.6	0.2

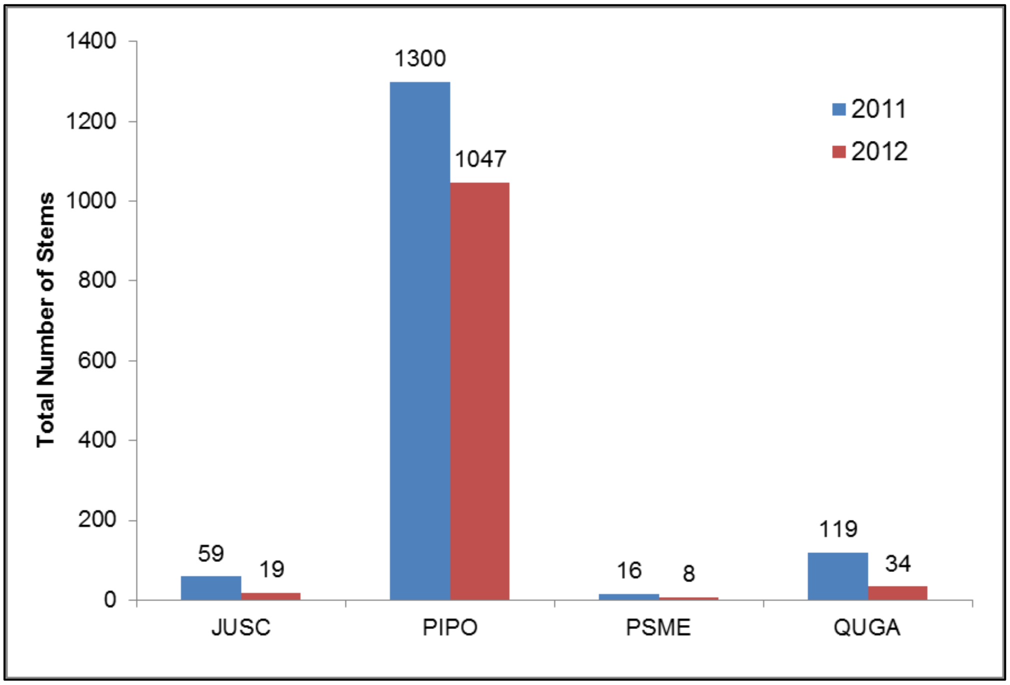


Figure 6. Total number of stems by species for PCQ and FR plots combined.

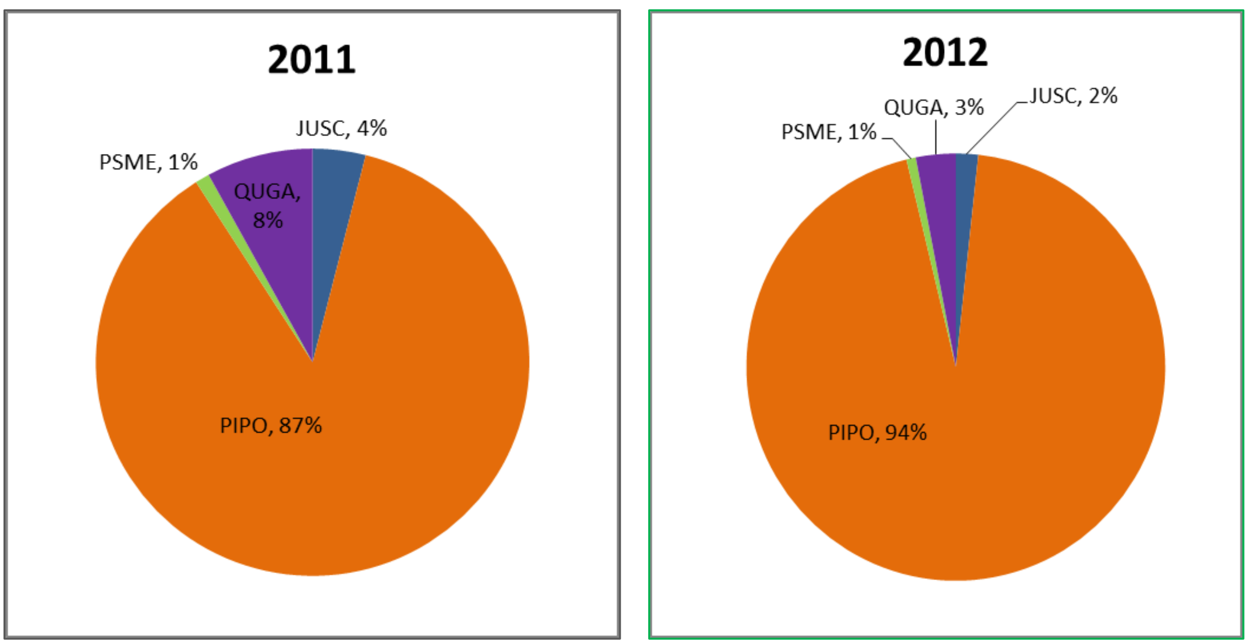
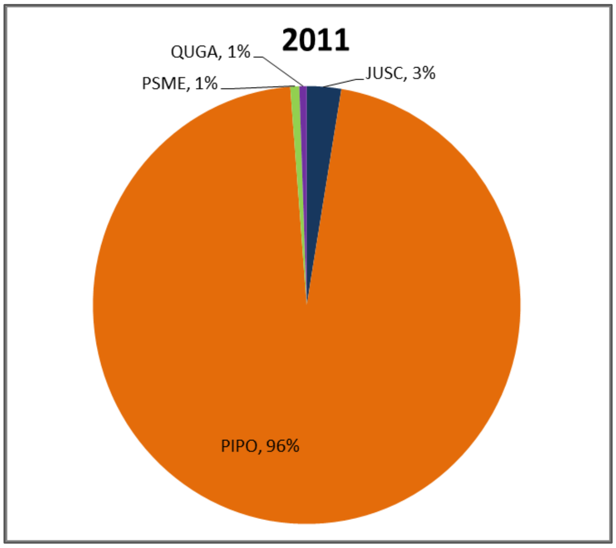


Figure 7. Percentage of stems by species for PCQ and FR plots combined.



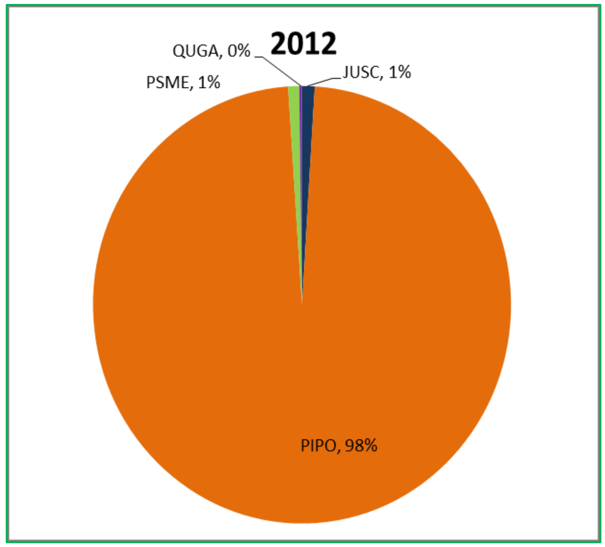


Figure 8. Percentage of basal area by species for PCQ and FR plots combined.

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Stem Density

Overall, the average stem density of trees in the study area was reduced from 251 stems/acre in 2011, to 105 stems/acre in 2012. The variability of stem density was also decreased in 2012 with the densities ranging from 52 to 214 (162 range), as compared to pre-thinning (2011) where stem densities ranged from 71 to 411 (340 range) (**Table 2, Figure 9**). This pattern is also evident when we compare stem density for transects and fixed radius plots in 2011 and 2012 (**Table 3, 4)** where we observed that average stem density for transects declined from 188 stems/acre in 2011 to 103 in 2012 (45% decrease) (**Figure 10**). We also see this in the fixed radius plots; where in 2011 average stem density was 315 stems/acre decreasing to 107 in 2012, a 66% decrease.

Table 2. Overall stem density (trees/acre) in 2011 and 2012.

Year	Average Density (stems/ac)	Maximum	Minimum
2011	251	477	71
2012	**105**	**214**	**52**

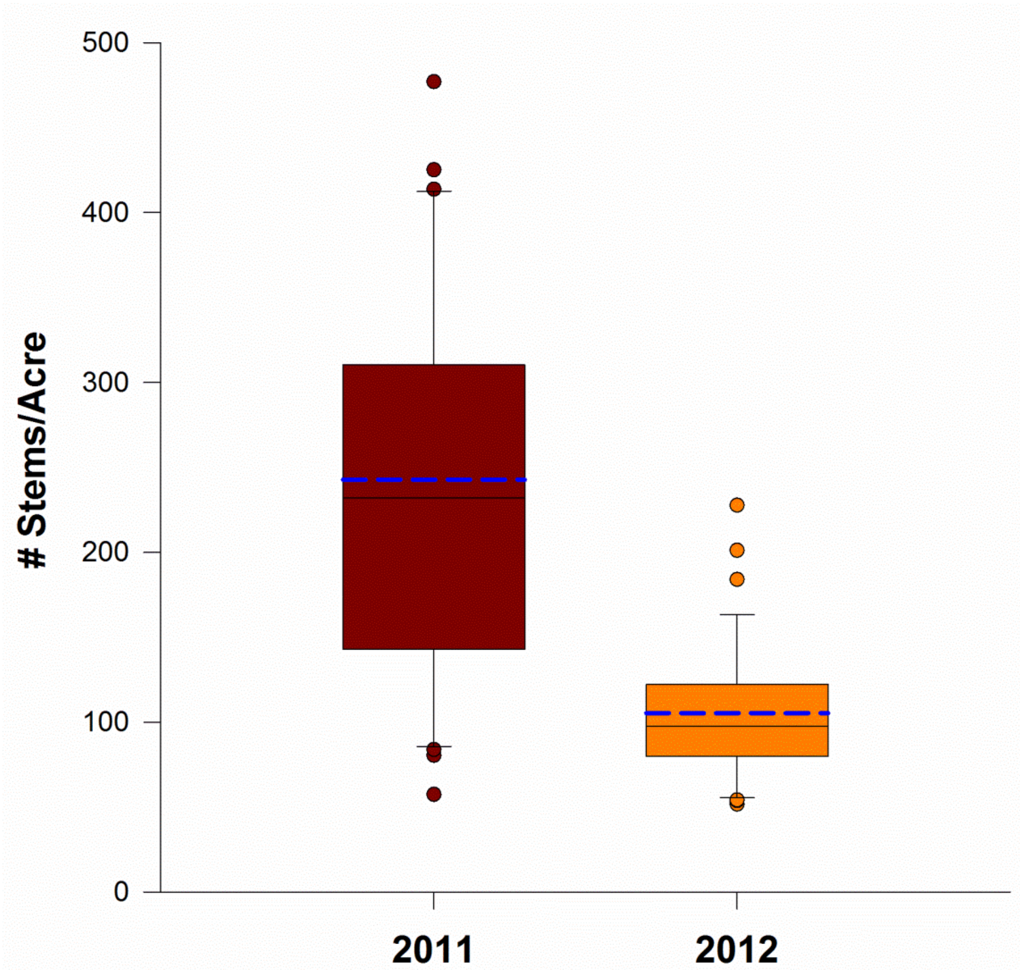

Figure 9. Stem density (# Stems/Acre) for all species and all transects and fixed radius plots, dashed lines indicate mean, solid line indicates median value.

Table 3. Stem density (trees/acre) for PCQ transects.

Year	Average Density (stems/ac)	Maximum Density	Minimum Density
2011	188	310	84
2012	**103**	**228**	**54**

Table 4. Stem density (stems/acre) Fixed Radius plots.

Year	Average Density (stems/ac)	Maximum Density	Minimum Density
2011	315	477	57
2012	**107**	**201**	**52**

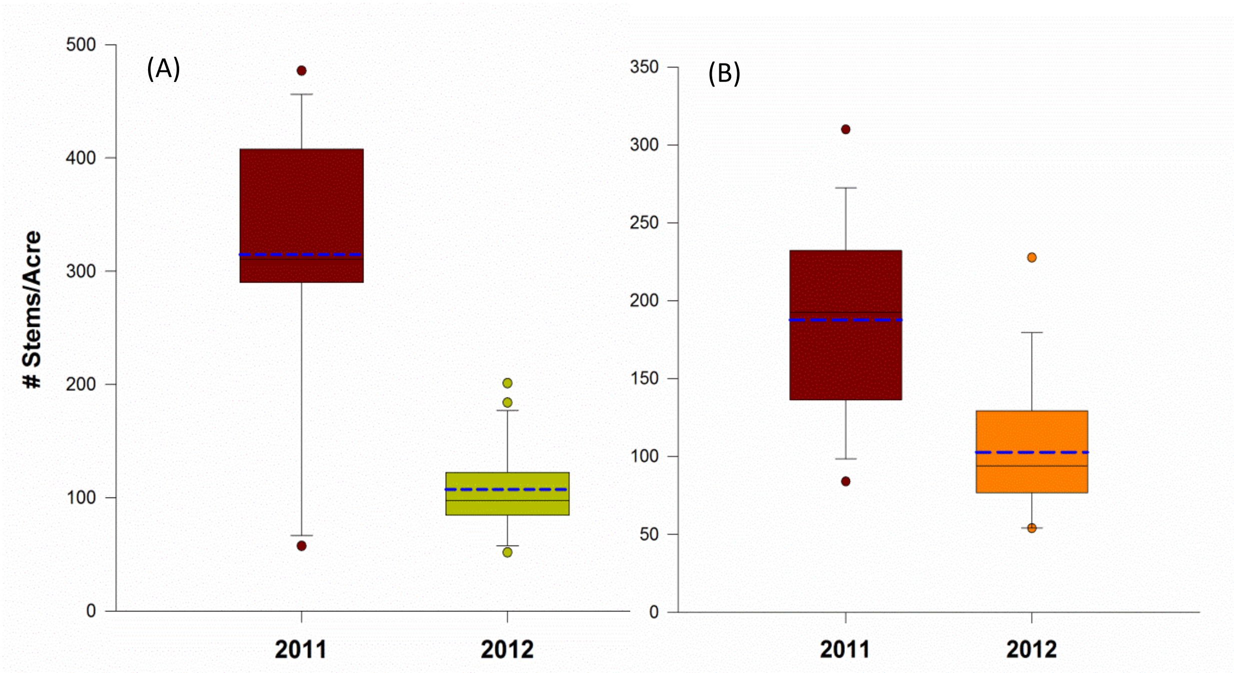

Figure 10. Stems per acre for Fixed Radius Plots (A) and Transects (B) in 2011 and 2012.

The density of stems for each species was also reduced during thinning operations with the largest percent decreases observed for PIPO and QUGA, a 40% and 65% reduction for each. Stem density was also reduced for JUSC and PSME, however the percent reduction was less than PIPO or QUGA, (26%, and <10%) (**Table 5, 6, Figure 11**).

Table 5. Stem density (trees/acre) by species for 2011 and 2012 for PCQ Transects.

Species	Average Density (stems/ac)		Total Number of Stems		Average Distance to Tree (ft.)	
Year	2011	**2012**	2011	**2012**	2011	**2012**
JUSC	300	**221**	43	**18**	23	**31**
PIPO	285	**173**	695	**655**	20	**26**
PSME	<1	**<1**	12	**8**	7	**8**
QUGA	2493	**881**	32	**16**	16	**24**

Table 6. Stem density (trees/acre) by species for 2011 and 2012 for fixed radius plots.

Species	Average Density (stems/ac)		Max Density (stems/ac)		Total Number of Stems	
Year	2011	**2012**	2011	**2012**	2011	**2012**
JUSC	7	**<1**	29	**6**	8	**1**
PIPO	274	**105**	453	**182**	605	**392**
PSME	6	**<1**	6	**<1**	4	**0**
QUGA	102	**35**	312	**88**	5	**3**

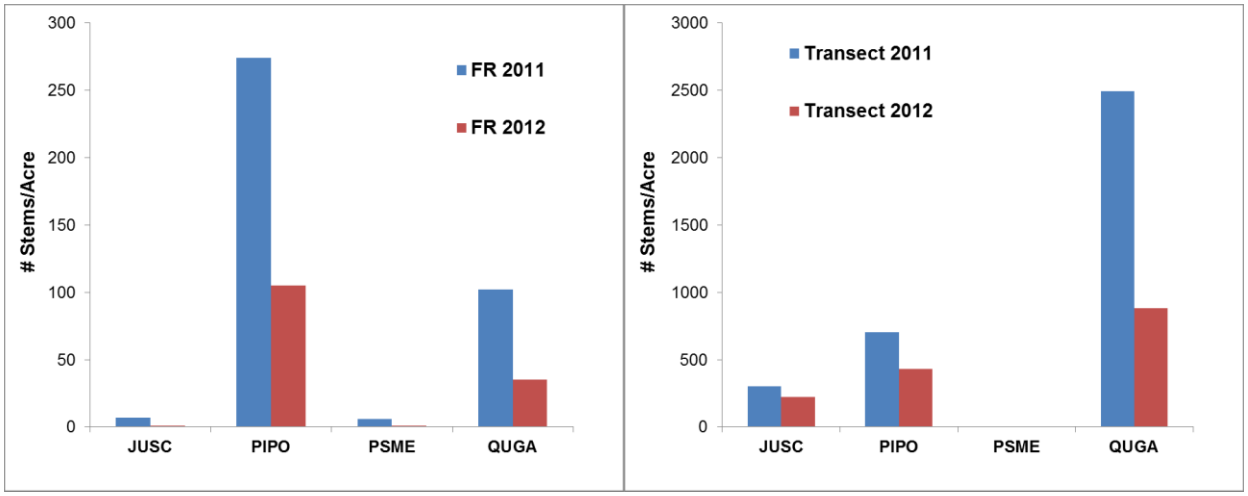

Figure 11. Stem density by species for Fixed Radius plots and Transects by year.

Tree Diameters

Evaluating tree diameters allows us to determine the general size and age estimates of the individual trees within a stand, when we compare tree diameters, tree height and age. Diameters were measured with a calibrated DBH tape, height was measured directly, and age was estimated using dendrochronology techniques on full cross-section slabs (Fritts, 1976; Stokes and Smiley, 1968).

The overall trend from 2011 to 2012 was increased average DBH, with the combined average DBH in 2011 of 10.6 inches to 14.0 inches (24% increase). We also observed this increasing trend in both transects (12.2 – 14.0, 12% increase), and fixed radius plots 8.9 – 13.9, 36% increase) (**Table 10, Fig 12**). The distribution of size classes also shifted to larger diameter trees (**Figure 13**). We also compared tree age to DBH, as well as height (**Figure 14, 15, 16**). Age was measured using full cross-section slabs (**Figure 17**). DBH classes were also compared for each year by species (**Figure 18**) where we generally found increases in sizes of trees across the four species sampled for the post-thinning period (2012).

Table 10. Average DBH and Number of Stems for Fixed Radius and Transects in 2011 and 2012

Year	Average DBH (in)		Total Number of stems	
	2011	**2012**	2011	**2012**
Transects	12.2	**14.0**	782	**697**
Fixed Radius Plots	8.9	**13.9**	712	**411**
Combined	10.6	**14.0**	1,491	**1,108**

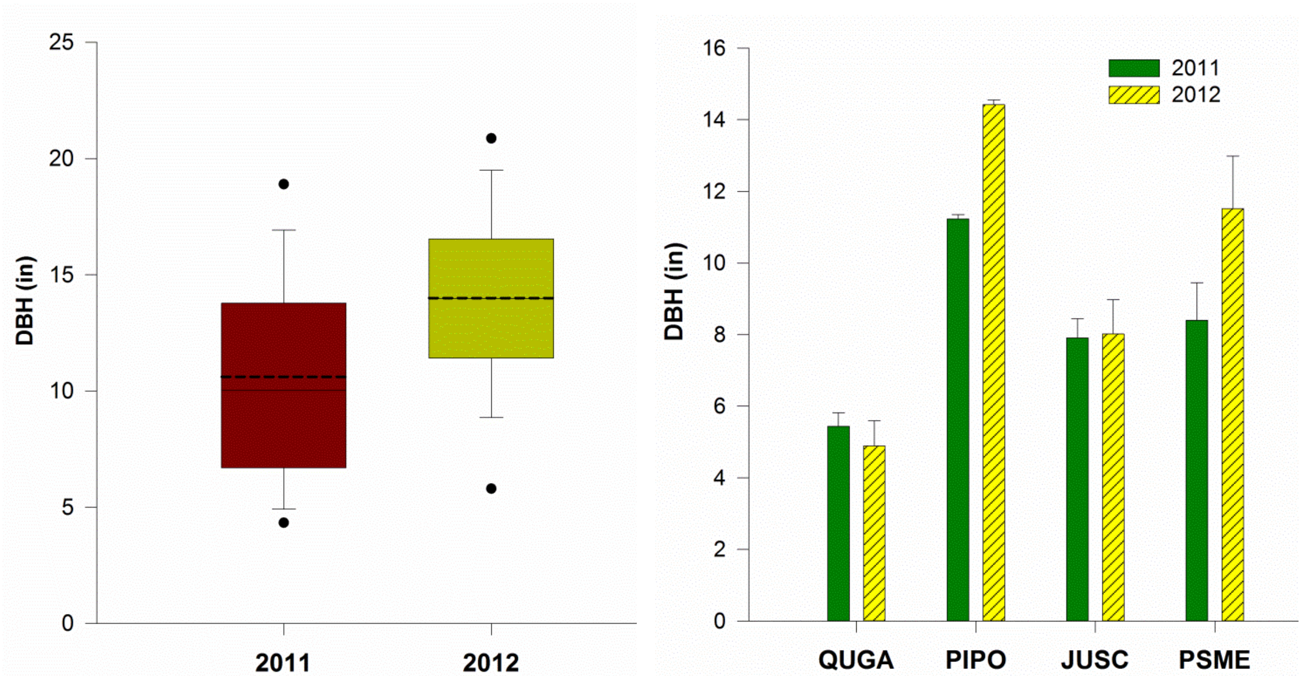

Figure 2. Size class distribution of all trees sampled. Left side is a boxplot with the solid line representing the median value, dashed line is mean value, grey box. Right side is a bar graph with 2011 values represented in green, and 2012 values represented in yellow, bars indicate 1 standard error of the mean.

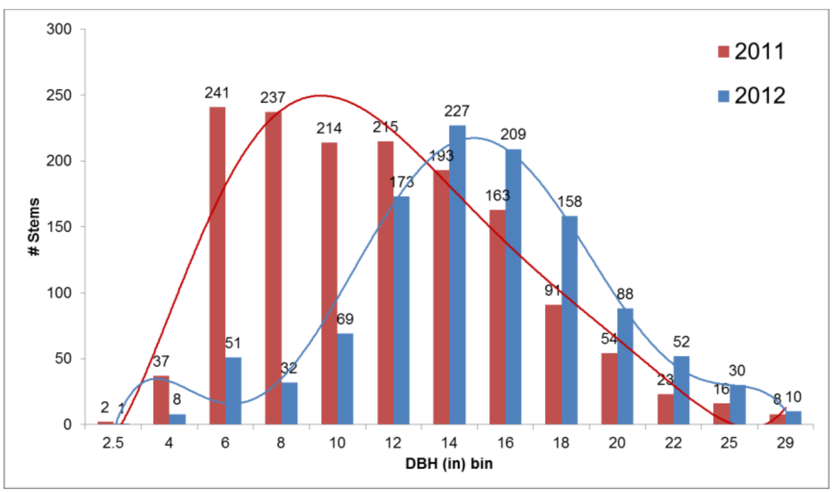

Figure 3. DBH size class distribution for 2011 (red) and 2012 (blue), bars indicate the number of stems (y axis) in each DBH class (x axis). Comparison indicates that the distribution of tree sizes shifted from being heavily weighted towards lower DBH sizes in 2011 to large and more evenly distributed tree sizes in 2012.

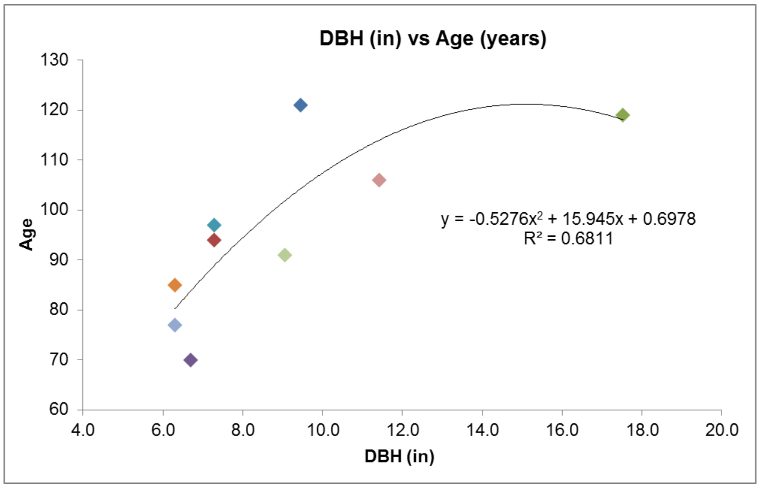

Figure 4. Age of trees compared to diameter (inches). Trees were aged using standard dendrochronology techniques on full slabs with age being confirmed by two evaluators.

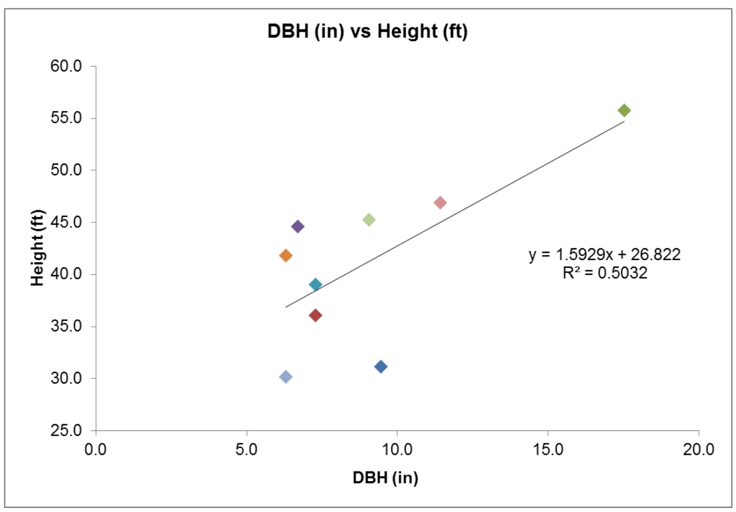

Figure 15. Height(ft.) of trees compared to diameter (in). Trees were measured directly from harvested samples with measurements taken from the ground to the top of the crown.

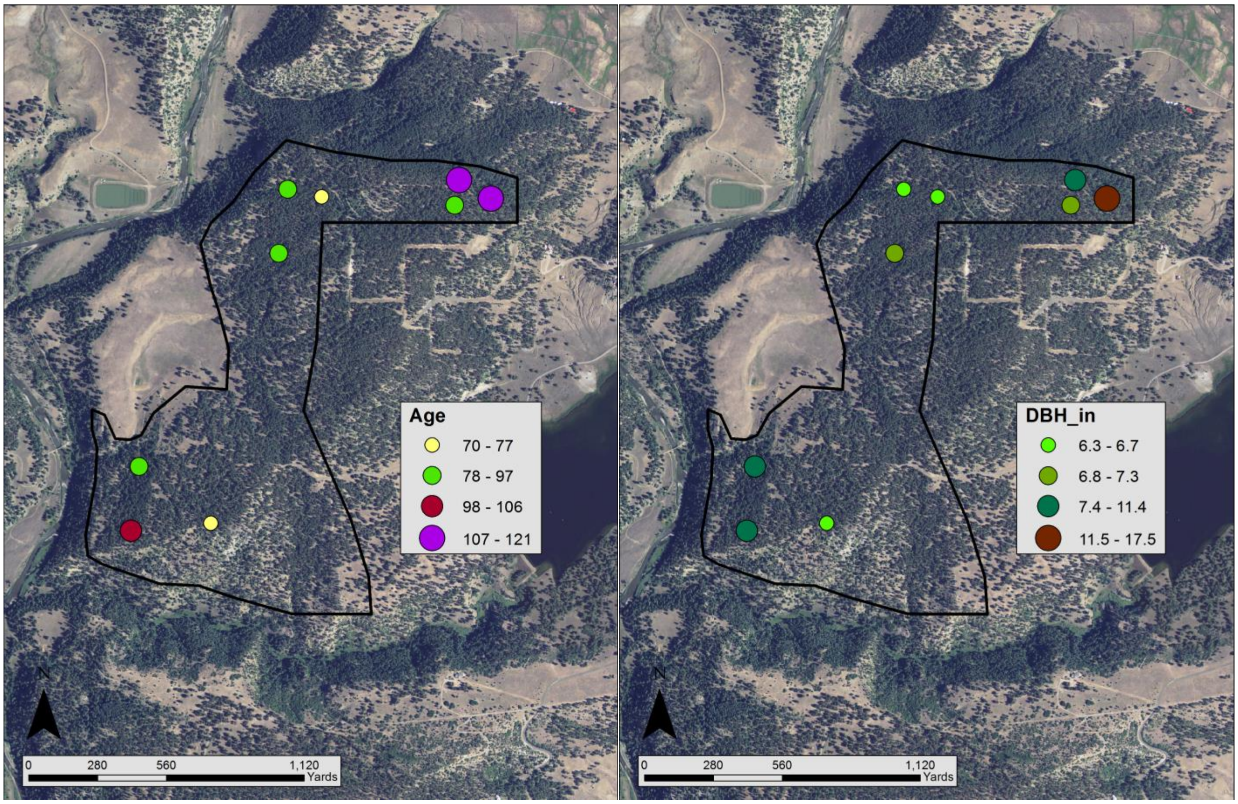

Figure 16. Locations of trees selected for dendrochronology analysis.

Figure 5. Example of a tree slab being analyzed for age and growth rates.

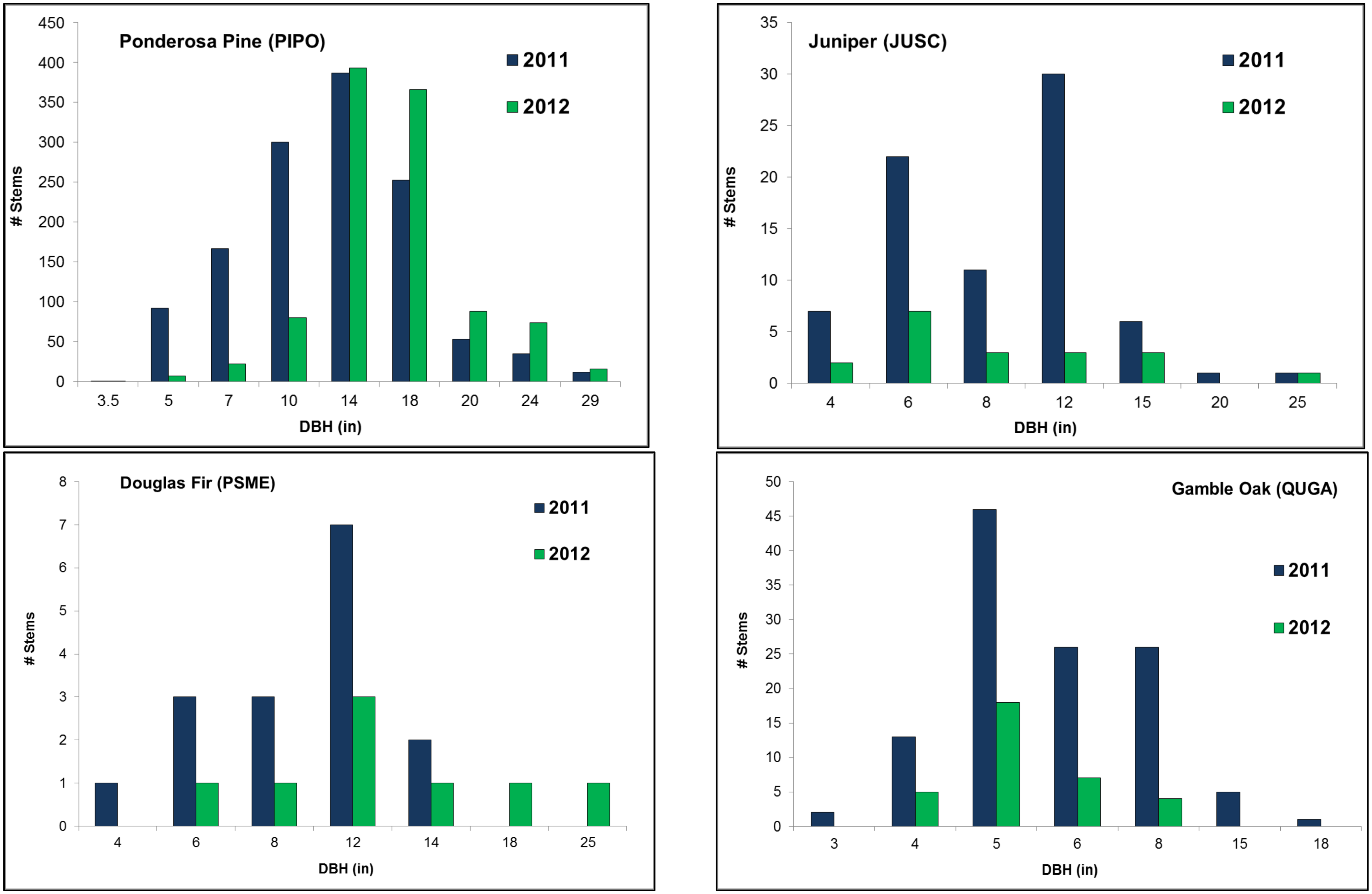

Figure 18. Size distribution for each species sampled.

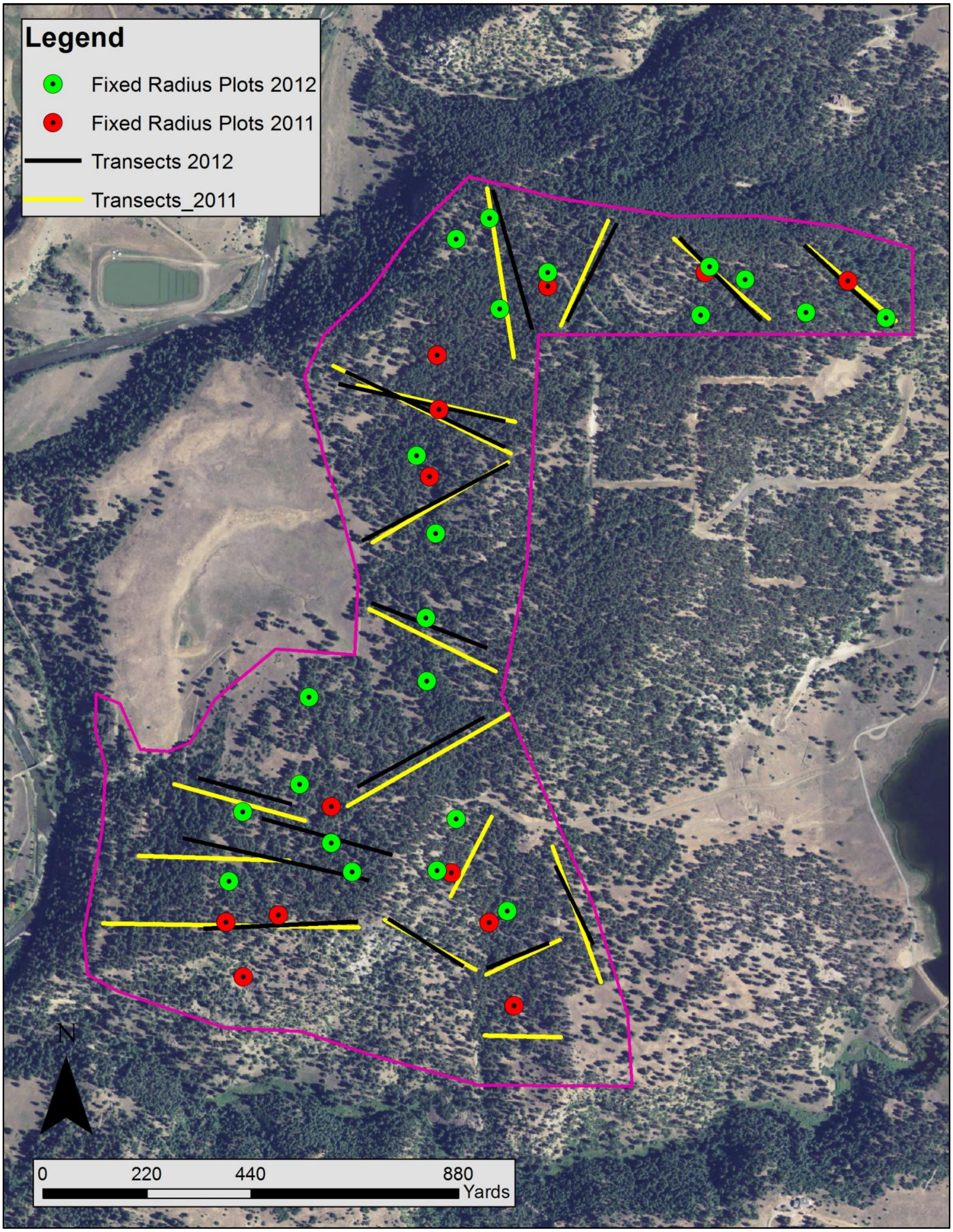

Figure 19. Orthographic photo (2009 NAIP) with transects and fixed radius for 2011 and 2012.

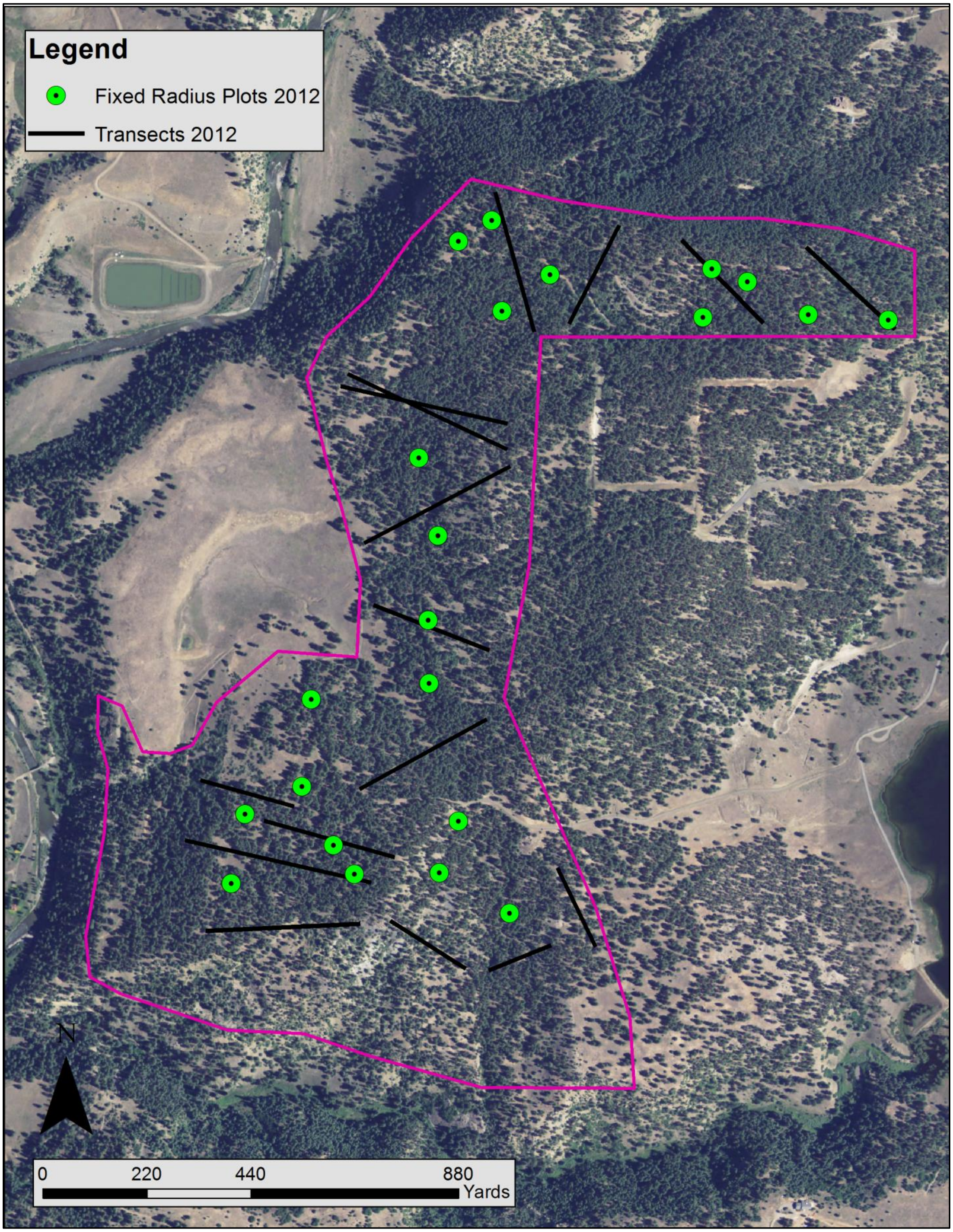

Figure 206. Location of transects and fixed radius plots 2012.

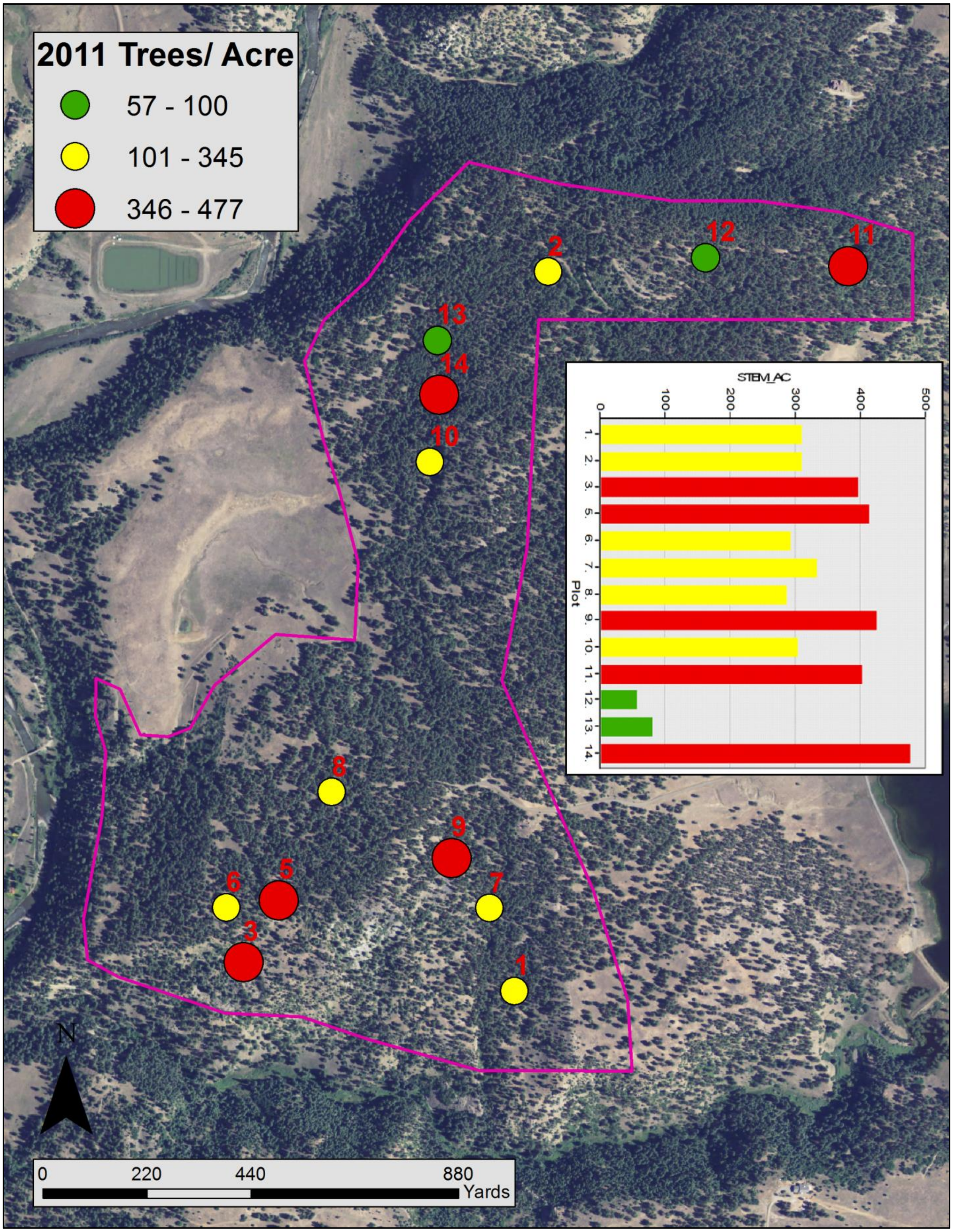

Figure 21. 2011 Stems per acre for Fixed Radius plots.

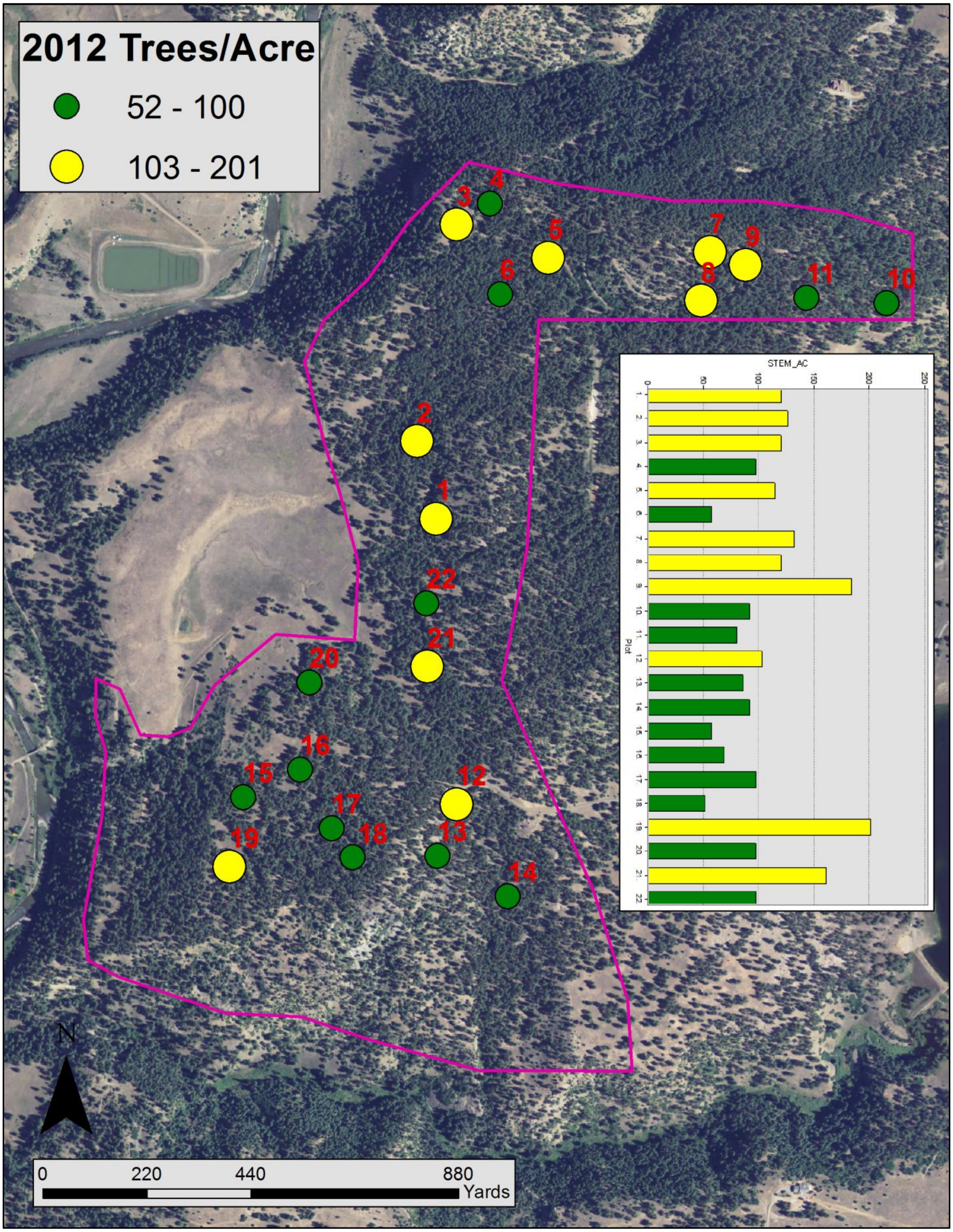

Figure 22. 2012 Stems per acre for the fixed radius plots.

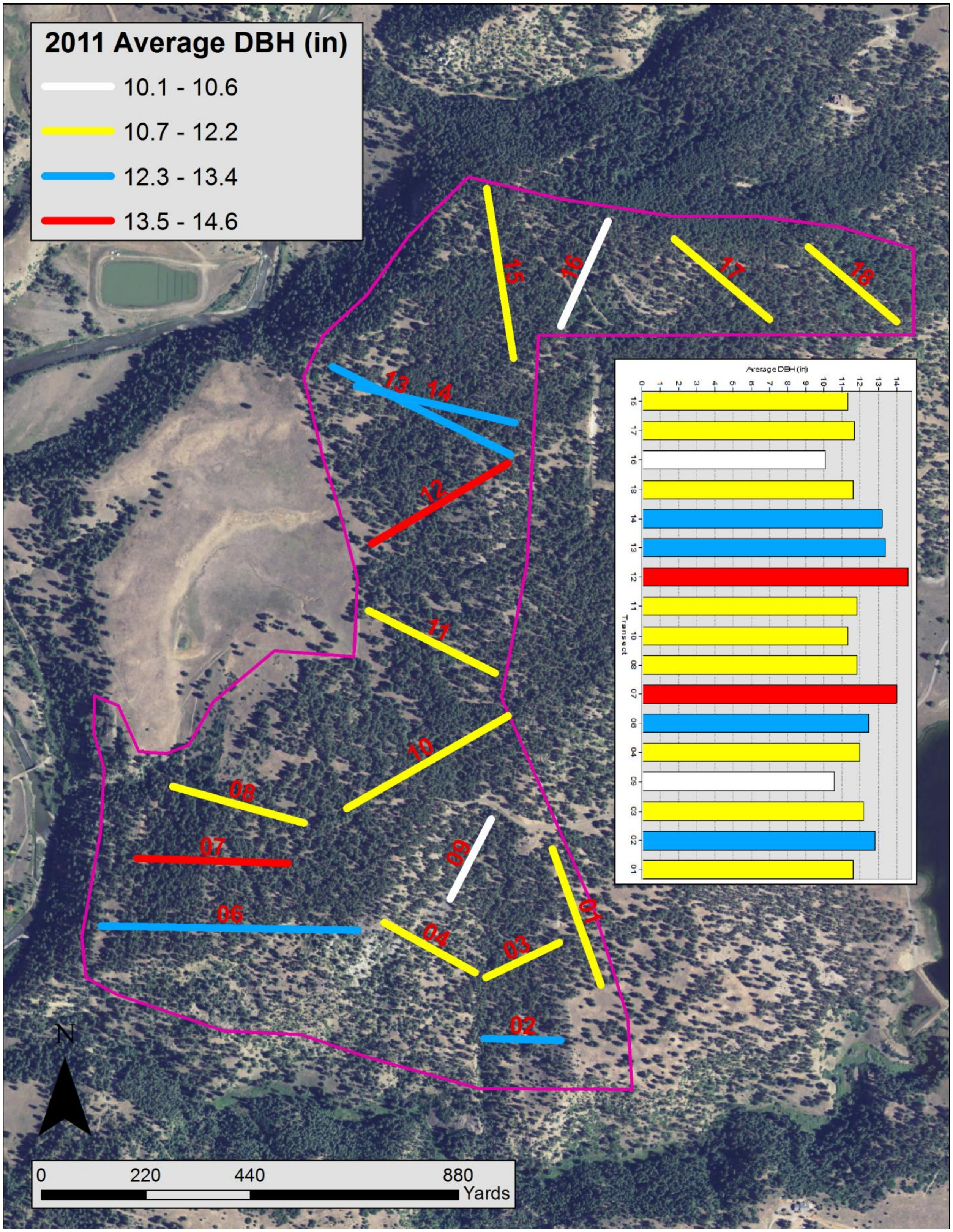

Figure 23. 2011 Average DBH for each sampled transect.

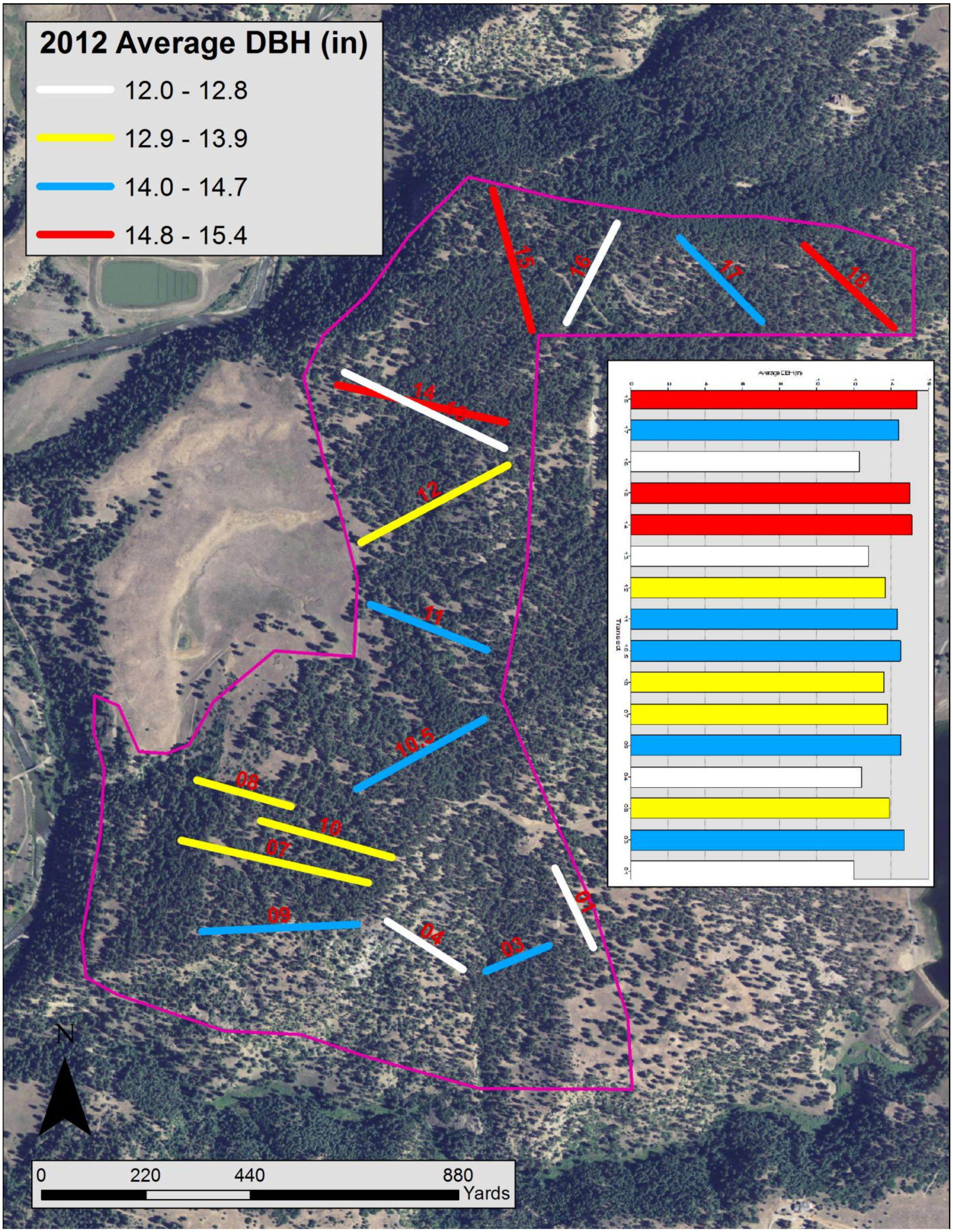

Figure 24. 2012 Average DBH for transects.

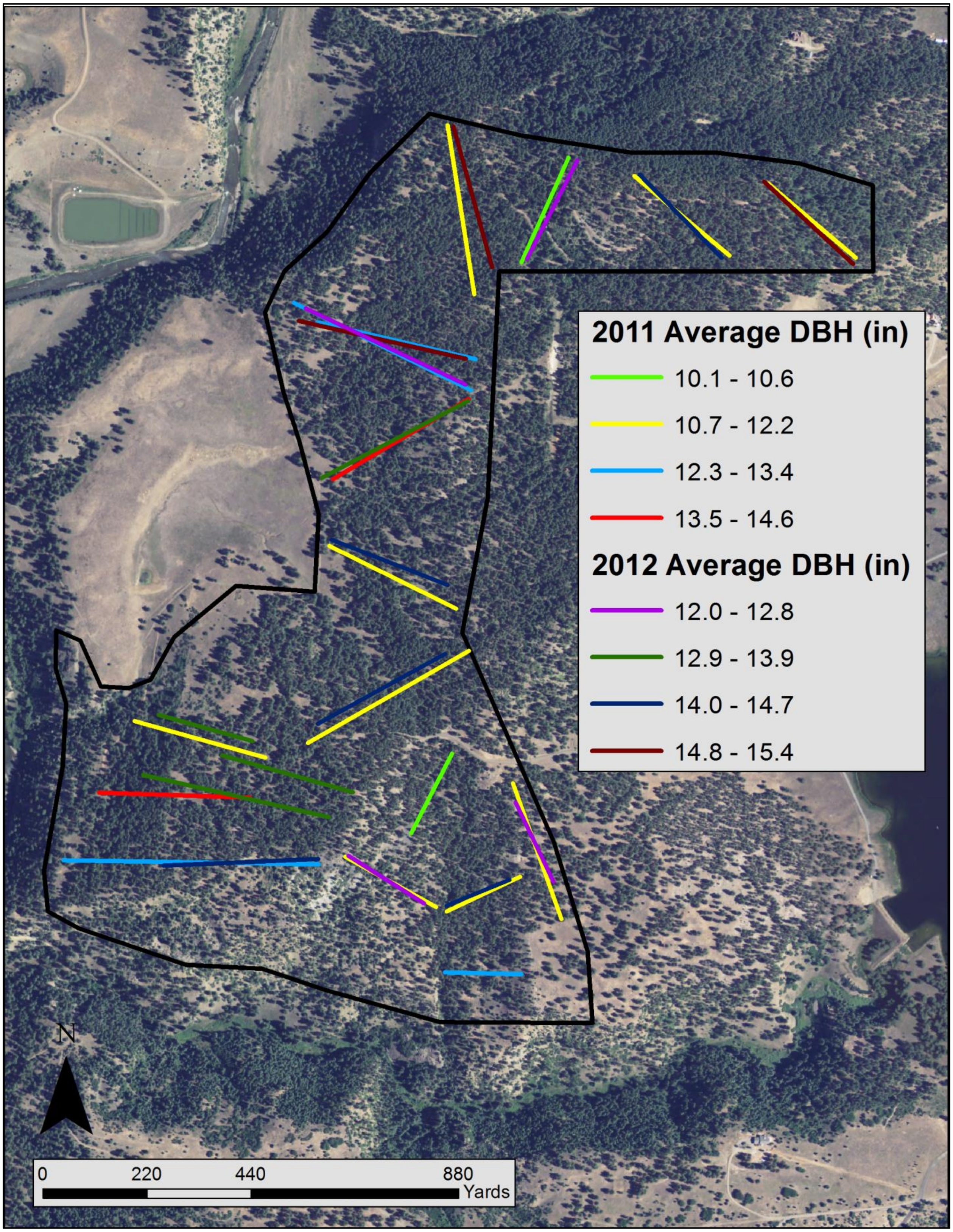

Figure 25. Mean density (stems/acre) for each sampled transect.

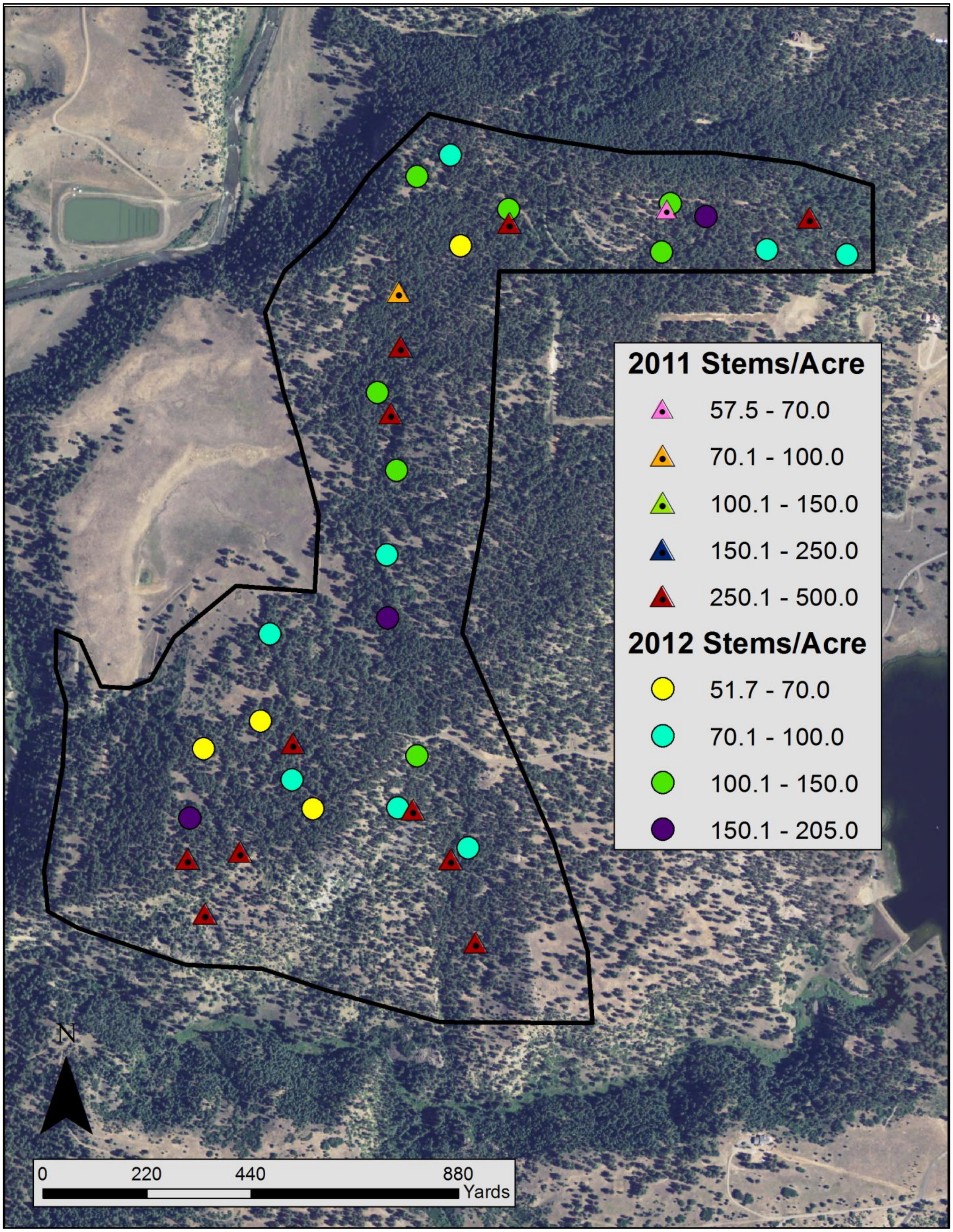

Figure 26. Stems per acre for 2011 and 2012.

Figure 27. Measuring diameter at breast height (1.3 m) DBH.

Figure 28. Example of Ponderosa in the larger size class (> 30 DBH)

Figure 29. Examples of overstocked lower diameter ponderosa (<20 DBH) among an older age class (<40 DBH)

Figure 30. Examples of post-thinning forest densities.

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