

A GIS Approach to Identifying the Distribution and Structure of Coast Redwood Across its Range¹

Peter Cowan,² Emily E. Burns,² and Richard Campbell²

To better understand the distribution and current structure of coast redwood (*Sequoia sempervirens* (D. Don) Endl.) forests throughout the range and how it varies by land ownerships, the Save the Redwoods League has conducted a redwood specific analysis of a high resolution forest structure database encompassing the entire natural coast redwood range. Using this analysis, we are able to identify those areas most likely to contain coast redwood and the probable stature of those forests. Previous League databases were built by expert evaluation of aerial photographs, requiring substantial time and monetary resources, limiting the frequency of updates. In this extended abstract we discuss approaches for using satellite based remote sensing tools to estimate forest composition and structure throughout the coast redwood range. We further explore some of the structure of redwood forests by region and ownership.

Database requirements include the ability to identify areas dominated by redwood consistently throughout the range from northern San Luis Obispo County, California to Curry County in Oregon. To aid in differentiating forest with restoration potential, the League also requires delineation of forest structure characteristics such as basal area, quadratic mean diameter (QMD), and trees per acre (TPA). The Oregon State University Landscape Ecology, Modeling, Mapping, and Analysis (LEMMA) team's Gradient Nearest Neighbors (GNN) structure geodatabase, fulfills these requirements (<http://lemma.forestry.oregonstate.edu/data/structure-maps>.; Ohmann and Gregory 2002).

Our project area was defined as any Hydrologic Unit Code (HUC) 12 watershed, the smallest hydrological units comprehensively mapped by the U.S. Geological Survey, within 1.6 km (1 mile) of known existing natural redwoods (CALVEG 2004; Save the Redwoods League, unpublished data). When clipped to this region the Landscape Ecology, Modeling, Mapping and Analysis Gradient Nearest Neighbor (LEMMA GNN) structure map (hereafter LEMMA) contained 3,867 pixel classes, with each pixel corresponding to a 30 m x 30 m LANDSAT pixel (Ohmann and Gregory 2002). These pixel classes were classified into 24 species and structure classes. Forest species was biased toward redwood by first categorizing any pixel with > 10 percent of basal area of redwood as redwood, likewise any remaining pixels with > 70 percent of basal area douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), with > 50 percent of basal area tanoak (*Notholithocarpus densiflorus* (Hook. & Arn.) P.S. Manos, C.H. Cannon, & S.H. Oh) were classified as those species and the remaining pixels as mixed conifer-hardwood.

Structure classification was based on the LEMMA data for TPA and dominant QMD. Structural classes are based on Spies and Franklin (1991), with the biomass accumulation stage subdivided into three classes and old growth replaced by 'large complex forest'. Large complex forests (LCF) are forests which have structural complexity similar to old growth forest, but may actually consist of largely second growth trees. This distinction is important, in part, because remote sensing is unreliable at determining forest age. To improve the identification of LCF, we first compared the pixel classes to the Save the Redwoods League old growth database (unpublished data) identifying those classes that accounted for a significant proportion of the area in the database (> 1 percent) and were specific to those areas (more than 12 percent of that class found within the old growth database). Other forest structures classes were defined as follows: canopy closure, 50 percent of stems < 20.3 cm (8 inches);

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² Save the Redwoods League, 111 Sutter Street, 11th Floor, San Francisco, CA 94104.

early biomass accumulation (ba), QMD < 40.6 cm (16 inches) or 300 TPA and QMD < 81.3 cm (32 inches); mid ba, QMD < 61 cm (24 inches) or 200 TPA and QMD < 81.3 cm (32 inches); late ba, QMD < 81.3 cm (32 inches); and maturation, 50 percent of stems < 122 cm (48 inches). Figure 1 shows the classification results for the Redwood National and State Parks region of the range.

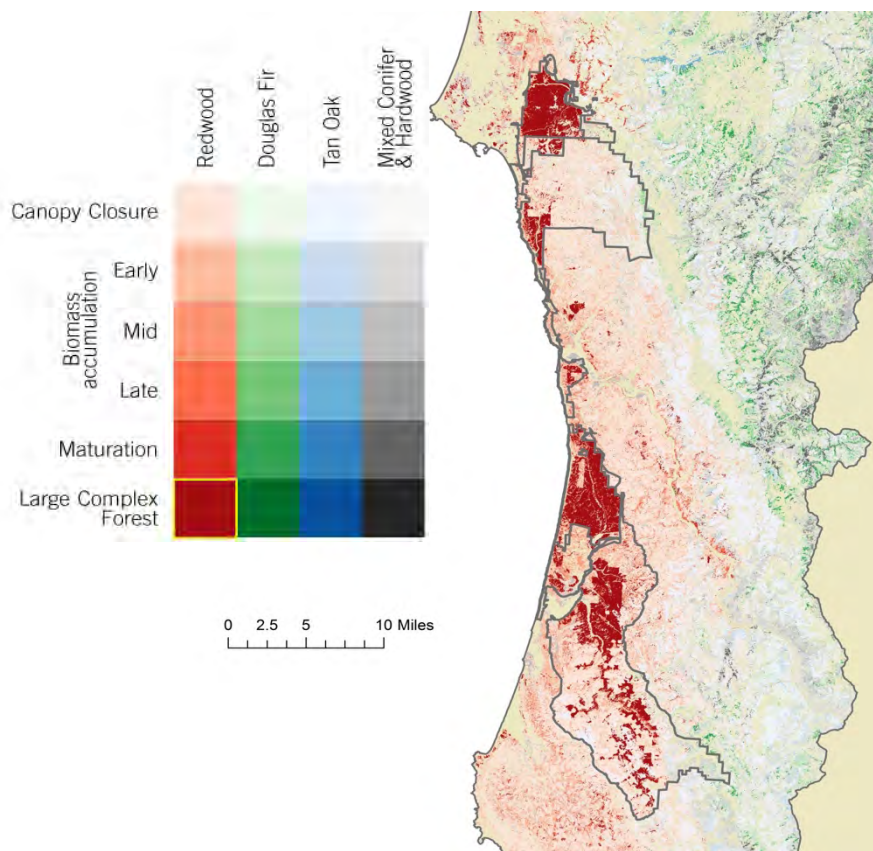


Figure 1—Example classification of the LEMMA species and structure map. The key describes four classes of species dominance and six structural classes. See text for classification details.

The resulting project boundary encompasses approximately 3.2 million ha (8 million ac), of which LEMMA identifies 2.1 million ha (5.1 million ac) as forested. As classified above 0.6 million ha (1.6 million ac) of the project area have redwood comprising greater than 10 percent of basal area, with 45, 729 ha (113,000 ac) being large complex redwood forest. Interestingly, nearly half of the LCF acres are aggregated into 14 complexes of 404.7 ha (1000 ac) or more. Furthermore over 75 percent of existing LCF is found in Del Norte, Humboldt, and Mendocino counties and more than 20 percent in the Bay Area counties, with comparatively little LCF south of Santa Cruz County.

We also explored the ownership of redwood forests throughout the range (fig. 2). Protected areas were identified as having “park type” protection in the California Protected Areas Database (CPAD (2015) database; we also identified state and national forests, tribal forests, as well as industrial and other private ownership types (unpublished data). While the majority of LCF exists in protected lands, large proportions are under industrial and other private ownerships, primarily as small isolated patches. Conversely, smaller structure redwood forests are widely distributed across the major ownership types within the coast redwood range, namely protected areas, industrial timberlands and other private landowners (fig. 2).

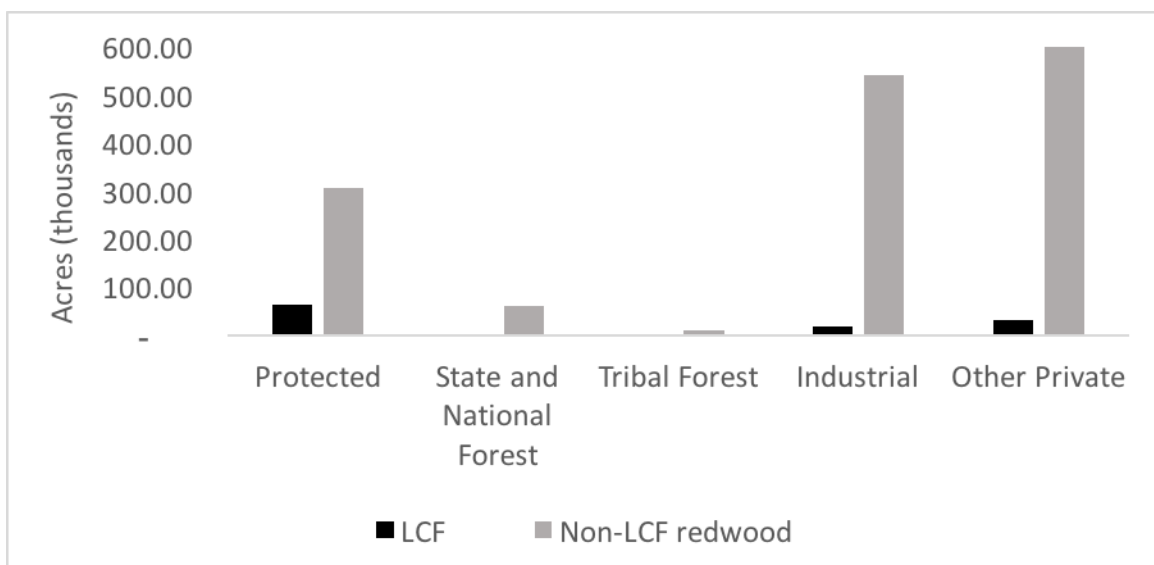


Figure 2—Acres of large complex forest (LCF) redwood forest and smaller stature redwood forests by ownership type throughout the coast redwood range.

Utilizing a high resolution species and structure map based on remote sensed data, we were able to identify the distribution of redwood forests and their structure throughout the range. The largest most complex redwood forest structure class is highly aggregated into several large complexes, mostly in protected areas and the northern portion of the range. Unsurprising, the extent of smaller structure classes is much larger and comprised the majority of redwood forests across all ownership types, including protected areas.

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