Prioritizing Treatment of Second-Growth Forests Using LiDAR

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We used multi-return light detecting and ranging (LiDAR) to develop a cost-effective method for describing forest conditions and prioritizing stands for treatment in over 14,000 ha of second-growth forests (11 to 85 years old) in Del Norte Coast Redwoods State Park (DNCRSP). DNCRSP consists primarily of redwood and Douglas-fir dominated forests with scattered tanoak dominated stands. Our objectives were to inventory and prioritize 30+ year old stands for treatment to promote growth and the development of late-seral conditions in overly dense stands.

A stratified sampling design was implemented to establish plots throughout the range of age classes and vegetation types within the property in 2009. We compared summary data from fixed ground plots to first return LiDAR data from the same approximate location. A key step to building a model to predict forest metrics with LiDAR is to ensure that each fixed-radius ground plot was accurately represented by an extracted plot LiDAR point cloud cylinder. To accomplish this, we attempted to obtain sub-meter accuracy for all ground plot centers by using a Trimble XH with a Zepher antennae GPS system. A minimum of 300 points were averaged for each plot, and then the resulting positions were checked and occasionally adjusted to match stem mapped trees visible in the point cloud. We also established plots in locations that appeared to be relatively uniform so that any LiDAR point cloud cylinder extracted within two meters of the actual plot center would be similar.

We used Forest Vegetation Simulator (FVS) software to calculate current plot conditions and account for 2 to 3 years of growth, corresponding to the number of growing seasons between the LiDAR flight in 2007 and the plot installation in 2009. We could then back-calculate relative change in basal area and other metrics for each plot at the time of the flight.

Descriptive statistics of the cylinders of normalized LiDAR data for each extracted plot were developed using the USDA Forest Service Fusion/LTK tools. Statistics derived included: quantile values of vertical height (e.g., the 95th percentile height), metrics of percent cover in LiDAR returns (e.g., the percentage of pulses that reflected off vegetation above 3 m), and the proportion of returns absorbed in slices above the ground surface (e.g. of all returns from above 3 m, what percentage was above 6 m). To create two to four parameter multivariate regression relationships for each metric, we paired observed stand conditions and the statistical descriptions of the LiDAR data within each plot on a minimum of 60 plots. To date, we have developed models for four metrics: basal area (R^2 = 0.89), quadratic mean diameter

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(R^2 = 0.90), stand density index (SDI) (R^2 = 0.80), and tree density ($R^2 < 0.50$). We obtained an R^2 for tree density of 0.70 for second-growth that was at least 30 years old.

We delineated stands of relatively uniform conditions using the LiDAR derived canopy height model and then calculated stand-level forest metrics using our regression models. We then ranked stands independently based on both their SDI and the coefficient of variation of LiDAR first returns (CV). Stands with a high SDI and a low CV were ranked as having a greatest need of treatment. A high SDI indicates overcrowding where density management is most needed to promote growth. A low CV is an indication of less variability in tree heights (differentiation). Therefore a stand with a low CV is less able to self thin and progress rapidly towards late-seral conditions. A high CV could indicate a greater degree of differentiation or a stand where the canopy has not closed. CV was also useful in helping to identify uneven-aged stands (high CV). Since SDI cannot be readily calculated for uneven-aged stands, any stand with a high CV may have an inaccurate SDI. Stands will similarly be ranked by tree density as another indication of crowding. Standing volume could also be considered if timber extraction is used to offset the cost of implementation.

The North Coast Redwoods District of California State Parks is adopting this method to prioritize stands for forest restoration treatments but the methodology could be adopted for other objectives, such as thinning and harvesting schedules, habitat delineation or general inventories. We did not use this method for younger stands (<30 years-old) in part because this age class was already inventoried. Stem density may also be more critical for prioritizing young stands since their SDI is changing rapidly. Limitations of this method include the inability to describe species composition or diameter distribution.