# Aging of Large Giant Sequoia

Ariel C. Thomson and Robert A. York

## Introduction

Giant sequoia is one of the most well know species in the world. It is an iconic species known for its overwhelming size and assumed long-lived nature. Because of their massive size, however, accurate age estimates are elusive. Understanding the ages of these beautiful trees can be a very important piece of information to have when considering various areas of research and management.

This project had three primary objectives:

(1) gather general age information for all of the study trees. This was done to determine general differences, if any, in age within or between the various groves used in the study. Using a previously developed equation (Stephenson and Demetry 1995), age estimates were made to help understand the release potential of old trees.
(2) see if any methodology improvements could be made. These included measurements of wet and dry lengths of cores to improve accuracy. We specifically examine the potential for improvement to the "shrinkage-coefficient," which is related to the shrinking of cores that occurs following collection.
(3) we addressed the question: Do older trees actually look older? This was a subjective effort done by synthesizing age estimations, tree measurements, and pictures of each tree.

## Methods

### Study Area:

Our study areas were located on Giant Sequoia National Monument, managed by the US Forest Service. They were determined by harvest activities occurring in the 1980's that created structures with low canopy densities dominated by large, old giant sequoia. The structures were created by shelterwood regeneration harvests, which removed all trees other than the large giant sequoia and sometimes pine species, thus creating a "high severity mechanical disturbance." Once these areas were located, corresponding control areas that had not been harvested were located as well. In total 9 study areas were identified in 7 different sequoia groves. These groves being Redwood Mountain, Bearskin, Little Boulder, Lockwood, Black Mt, Long Meadow, and Starvation.

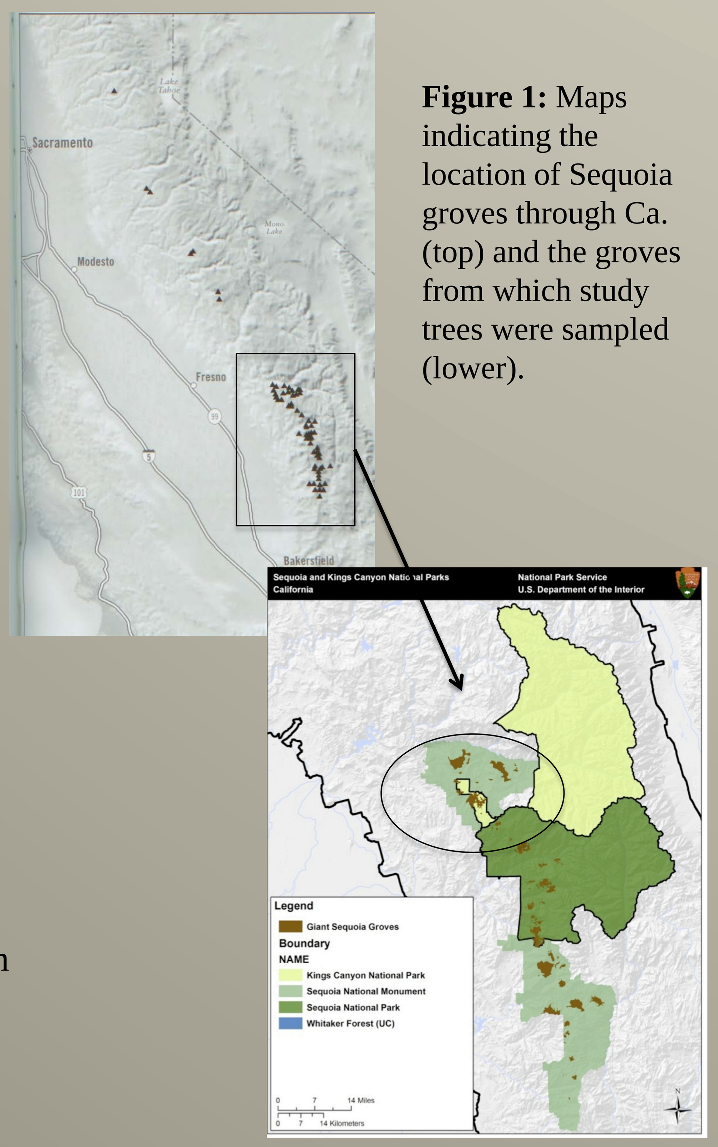



**Figure 1:** Maps indicating the location of Sequoia groves through Ca. (top) and the groves from which study trees were sampled (lower).

### Treatment and Study Design:

- Selection of trees was based on acquiring a sample of large trees from across the harvested areas.
- One to two 24 inch increment cores were taken from each tree.
- Cores were taken as close to 4.5 feet above ground as possible, when not possible diameter at core height was taken.
- Once the core was removed its full length (i.e. wet length) was measured immediately.
- Three random bark probes were taken to obtain an average measure of bark thickness, which was later subtracted from the bole diameter.
- In the lab the dry length of each core was measured. This dry length was then compared to the previously measured wet length to find the "shrinkage coefficient:"

  *Shrinkage Coefficient*=*Wet Length* / *Dry Length*

- Using the field and lab measurements, the age of each tree was estimated using an age estimation equation unique to giant sequoia developed by Stephenson and Demetry (1995).

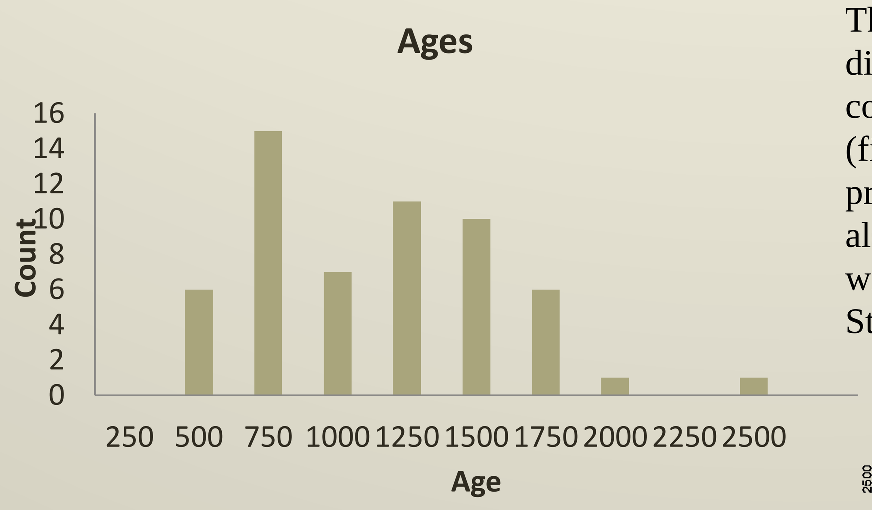
**Equation 1:** age estimation equation developed by Stephenson and Demetry (1995)

$$\frac{(c-100)+100r^{d}}{r^{d}-(r-g)^{4}}$$

- C=full ring count of a partial increment core
- g=length of the innermost 100 rings of the increment core
- r=the length g plus the length of the section of the bole radius not sampled.
- d indicates the direction and rate of ring width change with time.
  - d=.230+.759(100/g mm)+1.27r-.848r^2+.159r^3

## Results

### Age Estimates:




The mean age found was 1009 years, the maximum 2458 and the minimum 271 years. The age histogram (figure 2) did not show a distinct age distribution pattern, however, in conjunction with the age distribution by grove (figure 3) it shows the variability of ages present within and between groves. Figure 3 also shows the possibility for small age ranges within a grove, specifically Redwood Mt., Starvation and Black Mt.

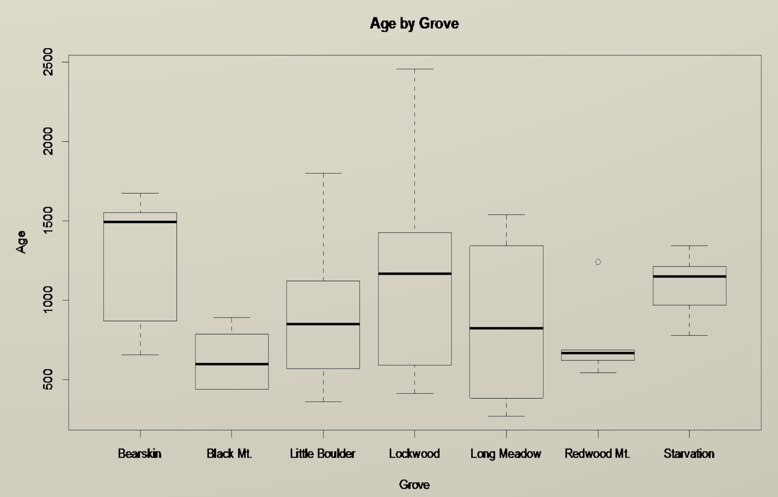



**Figure 2 (above)**: Histogram of tree ages from all 7 study groves (mean age, confidence interval not applied)
**Figure 3 (right)**: Box plot of ages by grove.

### Shrinkage Coefficient Results:

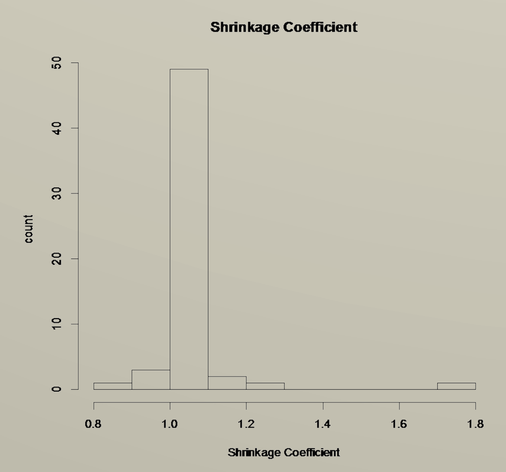



**Figure 4**: Histogram of shrinkage coefficient results (with outliers included)

We found that the average shrinkage coefficient was 1.04. As seen by figure 4 the majority of values fell between 1.0 and 1.1 . These calculations included 3 outliers with values less than 1. These values are likely due to measurement error and the the mean value without outliers was 1.05. This compares to the value of 1.02 used as a constant by Stephenson, 2000.

### Do They Look Older?

**A Case Study:**
The two trees shown at right both have somewhat irregular shaped crowns, however Lockwood 6 has a much more distorted crown and larger limbs. There characteristics would generally lead to the assumption that Lockwood Tree 6 is older, however, it is the younger by 800 years.

**Little Boulder Tree 2:** Total Age 1800, Diameter at Core Height:15.6 ft

**Lockwood Tree 6:** Total age 1071, Diameter at Core height 13.3 ft.

Through the synthesis of age estimations, tree measurements, and tree pictures we subjectively found that basing relative tree age estimates off physical attributes does not always give good results and certain characteristics are better predictors than others.
**Conical Crown Shape**: Generally canopies with well-defined conical shapes are considered to be younger than those with less defined canopies. While we found this to be the most reliable predictor, there were many instances of similar crown shapes having ages differing by over 500 years.
**Branch Form**: In general, larger branches and greater reiterations (a branch turning up into a secondary main stem) are a signs of age. We found this to be a highly variable and unreliable predictor.
**Diameter Size:** Diameter is often considered an indictor of age, however we found that this was not always the case. In multiple instances the diameter differed by 3-6 ft yet ages were no greater than 100 years apart.

## Discussion

**Age Estimates**: While our estimates are nowhere near exact we were able to find valuable age data that has never existed before for multiple groves. These ages were found as a component of a larger research project looking at the release potential of old giant sequoia post high disturbance activity. Studies of this nature have been done in the past, but never with age estimations in conjunction. These ages will be able a valuable component of this research project (York et at. 2010 and York unpublished data). We did not find a distinct age distribution between groves, but instead found great variability within and between groves. In some instances we found groves with small age ranges, which may be a predictor of regeneration post high severity disturbance.
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**Shrinkage Coefficient:** In attempting to improve the current aging methodology we examined the possibility of improvements to the shrinkage coefficient. This figure is necessary as counting the inner 100 rings and measuring them in the field while still wet is impractical. We found that while the coefficients tended towards 1.04-1.05 they had the ability to be highly variable. Not only can they be variable, but our average ratio is much larger than the 1.02 figure used by Stephenson and Demetry (1995). 1.02 is a reasonable figure, but shows the importance of obtaining core-specific measurements when possible. When core-specific measurements are not taken there is a chance to over or underestimate the age of trees.

**Do They Look Older?** Few people have spent large amounts of time examining both the ages and physical appearance of these large trees. While the synthesis of information in this area is highly subjective it may have implications for future discussions of the definition of "old growth". Due to the highly variable physical characteristics of trees in relation to age common ideas of an "old growth" tree being defined by a certain age could be questioned.

## Conclusions

### Our Trees Versus the Famous Ones

| Tree | Diameter (m) | Age |
|---|---|---|
| CBR26 | 5.8 | 3266 |
| General Sherman | 7.325 | 2150 |
| Grant Tree | 8.8 | 1700 |
| Grizzly Giant | 7.8 | 1780 |
| Lockwood Tree 12 | 5.48 | 2458 |
| Lockwood Tree 13 | 4.5 | 1745 |
| Bearskin East 1 | 4.253 | 1677 |

**Table 1:** shows the ages of various samples trees against the few known and estimates ages of famous living trees and stumps. Indicates the great increase in available age data.

Giant Sequoia is perhaps the most recognizable and most visited species in the Sierra. It is renowned for its size, and for its longevity, often assumed to be one of the most long lived species. Before this project little data existed to confirm this assumption. While the ages that we found were not found with great accuracy, as logistically this is near impossible, they greatly increased our current knowledge of sequoia ages and will be valuable for future research and to feed the public's curiosity.

## References and Acknowledgments

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