An Individual-Based Model of Chaparral Vegetation Response to Frequent Wildfires

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Introduction
Global climate change continues to impact natural ecosystems around the world. The hot and dry climate of Southern California serves as a likely environment for wildfires, affecting residential communities as well as the Mediterranean-like plant community structure composed primarily of chaparral.\(^1\) Nonsproutering chaparral species (NS) are completely killed by fire and reproduce only by seeds that germinate post-fire. Facultative sprouters both resprout after a wildfire and release seeds that germinate in response to fire cues. Facultative sprouters both resprout and reproduce by seeds that germinate post-fire.\(^1\) The average fire return interval (FRI) in the Santa Monica Mountains is 32 years, but in a biological preserve adjacent to Pepperdine University this has recently decreased to 7.5 years. Severe drought conditions coupled with frequent wildfires are threatening the survival of some chaparral species. Short fire return intervals prevent the establishment of a proper seed bank. At the same time, lack of rainfall stunts the growth of resprouts and seedlings. This is concerning because chaparral provide natural vegetative cover and preserve the structure of the steep mountain slopes.\(^1\) Therefore, a model of post-fire recovery of chaparral is pertinent due to the costs of repairing space for resources, seedlings recruitment, and resprouting behavior of individual shrubs in order to make predictions about the ecological impact of varying levels of rainfall and fire.

Life-History Models
Non-Sprouter Model
Mature plants release seeds annually at a constant rate.

Facultative Sprouter Model
Facultative sprouters both resprout and reproduce by seeds that germinate post-fire.

Data Collection - Point Quarter Sampling
Our study site has been marked and annual data has been collected from 1986-2014.

32 x 20 plots are arranged in a 4 x 8 grid and spaced 10m apart.

At each pole we establish axes along N-S, E-W lines to create 4 quadrants.

We locate the closest plant of interest and record the distance to the pole, the species, height, crown diameter, and basal diameter.

Simulation
Growth Models
The plots to the right show the effect of low rainfall on seedling and resprout growth. Below is the model of how plant height depends on rainfall \(v\) and time \(t\) since the previous fire. We estimated the parameters using plant heights from 1985-1993 and then compared our model by projecting the average heights from 1996-2007. The best model for resprout height is far growth to be proportional to rainfall and inversely proportional to time.

\[h(t, v) = \frac{\alpha(v) t}{1 + \beta(v) t}\]

The crown growth models are similar.

Results
Cantholus Simulation
Below are simulations of two Cantholus species with annual rainfall of 12 inches and fire return intervals of 6 and 12 years.

Fire Return Interval (FRI)

12 Years

Time 6

Time 12

Time 30

An average fire return interval of 6 years leads to the localized extinction of Cm and a fairly sparse landscape. In contrast the Cm continue to persist with a twenty year average.

All Species Simulations
Below are the results of simulations with four species of chaparral with varying rainfall and 12 year fire return intervals.

Validation and Prediction
Simulation Validation 1985-2014

60 Year Prediction for Species Densities

Frequent versus Infrequent Burn Sites (60 year simulation)

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