The Effects of Insect Herbivory on *Quercus buckleyi* Regeneration

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TREE

Abstract

Many *Quercus* (oak) populations are displaying signs of recruitment failure, defined as the inability of juveniles to reach maturity. Recruitment failure in *Quercus* communities could have a significant effect on forest trophic systems. Herbivory has been hypothesized to be a major limiting factor in the maturation of *Quercus* species. Specifically insect herbivores such as *Curculio occidentis* (Filbert Weevil) could play a large role in the recruitment failure, as they attack the oak at its most fragile state, the acorn. *Quercus buckleyi* acorns to be studied were collected from the Kerr Wildlife Management Area west of Kerrville, TX in the fall of 2012. Acorns were stratified for approximately 3000 hours prior to pericarp removal and insect damage classification. Acorns were then germinated to determine the effect of varying amount of damage. A major conservation and management need is to better understand patterns and variations in tree recruitment, and also the processes that affect the timing and success of regeneration. Determining and monitoring distribution patterns of local herbivore communities and their impact on *Quercus* demographics may lead to a better understanding of the potential interactions between herbivores and vegetative communities.

Introduction

Quercus buckleyi (Texas Red Oak, Spanish Oak, or Buckley's Oak) is a keystone species in the southern Great Plains of the United States. Many species of the *Quercus* genus appear to be undergoing recruitment failure, which is defined as the failure of germinated seedlings to reach mature adulthood (Branco, 2002). The Red oaks, along with all oaks, produce thousands of acorns every year that many birds, mammals, and insects are contingent on as a major part of their diet. The tree itself serves as a miniature ecosystem, on which many species of birds, reptiles, small mammals, and insects depend for shelter. Not to mention that the wood from *Quercus* species is used in construction, furniture, and has many other economic properties in our society. The impact of recruitment failure, therefore, will cascade through all trophic systems.

The acorns to be studied were collected from the Kerr Wildlife Management Area (KWMA), west of Kerrville, TX. The KWMA, like the rest of the Southern Great Plains, experienced an extreme drought since 2010. Since this drought began, KWMA has been subject to a steep decline in mature Oak species (Martinez, 2012) which include *Quercus laceyi* (Lacey Oak), *Quercus fusiformis* (Texas Live Oak) and most prevalently *Quercus buckleyi* (Texas Red Oak). This decline in contrast has been met with a great expansion of other woody species of plant, such as *Juniper ashei* (Ash Juniper, commonly referred to as Mountain Cedar) which is known to be drought-tolerant, whereas Quercus species require a substantial amount of water for a great period of time to grow to maturity (Macdougall, 2010). As these other trees displace the oaks, they may produce effects such as enhanced shading or water uptake that can negatively affect the growth of Red Oaks.

The Kerrville Wildlife Management Area has adopted strict practices to help recover the *Q. buckleyi* population, but regeneration failure still presents itself. This has led to much research in other factors that may be influencing this diminution. Light intensity, fire suppression, and climate change have all been suggested as probable causes of recruitment failure (Martinez, 2012). However, the major factor aside from the drought appears to be increased presence of herbivores in the plant communities.

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Failed *Quercus* regeneration is geographically widespread and appears to be independent of species. Recruitment failure is generally due to many factors which impact the many stages of the plants life. Most factors are assigned as pre-germination or post-germination, however, juveniles are very numerous compared to adults; so lack of recruitment appears to not occur at pre-germination stage, but later after juveniles establish, or post-germination (Purohit, 2009). This shows that the lack of adults is not due to lack of acorns germinating but is more likely due to some factor that kills the juvenile plant. pH of soil, nutrient availability, temperature, growth hormones, presence of pollution/litter, and herbivory are known to affect permanent establishment of *Quercus* for the duration of its post-germination life.

The main herbivores that impact *Quercus* include large mammals such as the white-tailed deer (*Odocoileus virginianus*) and insects like the Filbert weevil (*Curculio occidentis*). Herbivores obviously impact the growth of juveniles into adults through direct browsing, but can also indirectly modify vegetative patterns (Russell, 2002). Not only do insects eat the acorns, some use them as nurseries for larvae. Weevils, such as the Filbert Weevil (*Curculio occidentis*) deposit eggs into acorns of red and white oak using their long proboscis. The larvae that hatch from these eggs feed on the acorn until fully grown, then cut exit holes to emerge from their nursery. This form of pre-germination herbivory usually kills the acorn before it gets a chance to germinate. There can be at least four weevil larvae inside one acorn; the more weevils there are, the less likely the acorn will germinate.

Figure 1. (left). *C. occidentis* (Filbert Weevil) larvae inside of *Q. buckleyi* acorn. (right) Mature *C. occidentis*, the long proboscis is used to insert larvae into acorn.

Methods

- Acorns were collected from the Kerr Wildlife Management Area in Kerrville, TX.
- Acorns were kept in refrigerator for ~4 months to simulate winter.
- Acorns were then removed and weighed individually.
- Pericarp of Acorns were removed with X-acto knife
- Insect damage was categorized from 1 to 4
  - 1 = 0% of seed is damaged by insects
  - 2 = ≤10% of seed is damaged by insects
  - 3 = 10%-25% of seed is damaged by insects
  - 4 = ≥25% of seed is damaged by insects
- Acorns were then re-weighed without pericarp
- All weighed acorns were placed in a numbered bag
- All acorns measured were then planted into Styrofoam cups in a UTSA greenhouse and left to germinate

Results

I. Pre-planting Examination

Most pericarps were easily separated from the inner seed coat, but this step proved to be difficult with variation between infested acorns and un-infested. Acorns without larva ("un-infested") had harder pericarps which would fragment into large pieces allowing for easy removal. The acorns that contained larva ("infested"), however, tended to have flimsy shells that fragmented into small pieces and were very difficult to remove. Average overall mass decreased by approximately 30% when the pericarp was removed. It should be noted however that in acorns with more than two weevils, the inner seed usually fell apart into dust after the pericarp and weevils were removed, resulting in the pericarp representing a much larger percentage in these individuals.

Contrary to initial expectations, the percentage of infested acorns was relatively low. Acorns classified as ones by the quantification system represented 80% of the entire sample. There were 28 "twos", 20 "threes", and 36 "fours"; 6.5%, 4.7%, and 8.5% of the sample, respectively. Following pericarp removal and data collection, all acorns were placed into an individual bag labeled with a sample number

II. Planting

- Prepared acorns (pericarp removed) were planted in 8 ounce Styrofoam cups , with a equal parts mixture of topsoil, sphagnum moss, and sand.
- As planting continued, evidence of herbivory within the greenhouse was observed. Sample bags were disturbed and planted acorns appeared to be missing.
- These acorns were still accounted for by numbering the cup with the number on the bag and placing an 'X' below it, to indicate that there was no acorn in the cup.
- Herbivory disturbance was also noted when acorns were still present, cups were labeled with the corresponding numbers and an 'A' for apparent animal disturbance.

In total, 500 acorns were planted to determine germination rates. Thirty acorns were determined to have been lost or damaged by herbivory disturbance. To supplement for the acorns lost, additional acorns were weighed, pericarp removed, weighed again and planted in new cups labeled with corresponding numbers.

An exclusion "cage" was set up to deter herbivore pressure, and all cups were placed in the cage, including the cups determined to have no acorn (X) and observed damage (A) (Fig. 2).

Figure 2. (left) observed herbivore disturbance. (right) Exclusion "cage" used to protect remaining acorns.

In addition, a motion-sensing camera was set up to monitor the project set-up and attempt to identify the herbivore pressure.

The exclusion set-up was successful and no further herbivore damage was observed.

The camera was also useful in determining the source of the disturbance, *Otospermophilus variegatus* (Ground Squirrel) (Fig. 3).

III. Germination Results

After 4 weeks, no germination had occurred. Failed germination may be due to poor drainage, greater small mammal herbivory than expected, or a host of other variables. Unfortunately the experiment was halted due to no apparent germination, and will be re-started with corrective measures..

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Figure 3. *Otospermophilus variegatus* (Ground Squirrel).

Conclusions

- As the objective of the experiment was to investigate the influence of insect herbivory on seed survival and seedling vigor, half of this experiment is inconclusive due to the failed germination.
- Acorns containing multiple weevil larvae tend to destroy most of the nut, so it is suspected that insect herbivory could impact seedling survival. However, as noted in the results of the classification data, the small percentage of infested acorns indicates that it is not likely the major cause of failed oak recruitment for this specific field location. However it should be noted that , insect herbivory (i.e., weevil damage) will undoubtedly vary considerably between site locations.
- The process of pre-planting data collection was time consuming, and the extended length of time that the first acorns were kept in plastic bags. Without the protective pericarp, this could also represent a major variable that could affect germination rates.
- The drainage holes used proved to be somewhat ineffective, and as the seeds were routinely watered, they may have become hypotonic, and lost function.
- With all of these divergences from the expected, it is almost impossible to determine, if there is one single flaw in the experiment. It is probable that a combination of these and other unidentified factors proved to be limiting factors.

Continued Studies

To continue the study, the number of uncontrolled variables must be reduced.

- Mammalian herbivory must be prevented. This will be achieved by using an exclusion set-up ("cage") as well as better securing the greenhouse facility.
- More efficient drainage must be accomplished.
- Seeds will be prepared in a more timely fashion, or seeds will be planted periodically while others are still being weighed and characterized for insect damage. This will remove the variable that the seeds might become unviable by staying in a plastic bag for an extended time.
- Future studies will increase the sample size to 2,000 acorns analyzed

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