Masting trees

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1 Introduction

Increasing temperature and changing precipitation patterns are influencing most of the plant species. These environmental changes can significantly affect their growth and reproductive activities. In particular, they might shifts how plants are going to invest their resources through growth-reproduction trade-offs. Highly variability across years in reproduction is often associated with mast seeding, an important reproductive strategy. Mast seeding is the phenomenon of synchronized and variable seed production within plant populations. Even though there are several hypotheses explaining the potential mechanism of mast seeding (e.g., predator satiation, resource matching, etc.), the exact factors triggering this phenomenon in different species and ecosystems are not fully understood, but appear related to specific climatic conditions that allow trees to build up enough resources to mast.

Together with the environmental factors, knowledge of how masting events might be related to the growth of tree species can be used to better predict future forest dynamics, since mast seeding can significantly affect seed dispersal, regeneration and the overall resilience of forest ecosystems. As we face increasingly unpredictable weather patterns, being able to predict how trees will respond to these changes is essential for maintaining healthy and sustainable forest ecosystems.

1.1 Thesis aims and research questions

2 Understanding the relationship between masting and growth

2.1 Research Objectives

What is the relationship between masting and growth in different tree species?

1. **Assess Growth Patterns:** Analyze the historical annual growth of selected tree species in relation to their masting events to determine if there exist a trade-off.

2. **Identify Environmental Influences:** Investigate how environmental factors (e.g., temperature, precipitation, etc.) affect the relationship between masting behavior and tree growth.

3. **Compare Species Responses:** Evaluate the differences in masting and growth responses among various tree species across different elevations with various resources allocation strategies.

4. **Examine Resource Allocation:** Determine how resource allocation for reproduction impacts growth of the year, whether there is a difference between mast years versus non-mast years (or even years before masting).

2.2 Methods

To study the relationship between masting and growth, we have to ensure there is long-term seed data available. Our collaborator, Janneke Hille Ris Lambers, has been collecting stand-level seed data using seed traps starting from 2008 around Mt. Rainier, Washington, USA. To assess the historical growth of individual trees, we will collect cores from targeted species listed above in each stand with long-term seed data. Within each stand, there are at least 2 targeted species, and each species appears in at least 4 stands. We plan to collect tree cores from 25 individuals per species per stand, covering a size gradient. To

Table 1: Targeted species

Tree species	Common name	Life history strategies
Abies amabilis	Pacific silver fir	Conservative
Pseudotsuga menziesii	Douglas fir	Flexible
Tsuga heterophylla	Western hemlock	
Tsuga mertensiana	Mountain hemlock	
Thuja plicata	Western redcedar	Conservative
Callitropsis nootkatensis	Yellow cedar	Conservative

make sure the trees we core were mature enough to reproduce at least 10 years ago, we will only collect from trees with DBH greater than 25cm. Additionally, we will prioritize individuals that are close to seed traps to better correlate with seed data. We will core trees at breast height using increment borers, taking two tree cores from the opposite sides of the tree while avoiding slopes. To account for at least 15 years of growth and for cross-dating purposes, we will collect long cores of 25 cm from larger trees with a DBH above 50 cm, while for smaller trees, we will core to the center if possible.

Collected tree cores will be sliced using microtome. We will use a high-resolution camera to capture images of the tree cores and then measure the ring width with CooRecorder.

By combining averaged ring width data with seed data, we will be able to analyze the relationship between growth and reproduction for different species at various elevations.

2.3 Significance

Understanding the relationship between masting and growth is important for predicting how tree species will respond to changing environmental factors, particularly in the context of extending growing season, how trees might allocate additional carbon. By examining how these processes interact, we can gain insights into the adaptive strategies of different species and their potential resilience or vulnerability to future climate changes. This knowledge allows us to make more informed predictions about future forest dynamics, including shifts in species composition, regeneration, and ecosystem health. As climate conditions continue to fluctuate, understanding the masting behavior and growth responses will be essential for effective forest management and conservation efforts, helping us to anticipate changes and make strategies that will support the sustainability and resilience of forest ecosystems.

3 Explore which seed traits are relevant to masting

3.1 Research Objectives

Which seed traits are related to masting, and what might cause masting in different species?

1. **Characterize Seed Traits:** Identify and categorize key seed traits in relation to masting behavior among different tree species.
2. **Investigate Trait Associations:** Analyze the relationships between specific seed traits and masting event and frequency to determine which traits maybe advantages in masting.
3. **Explore Ecological Contexts:** Investigate how environmental conditions and ecological interactions (seed predation), influence the seed traits linked to masting.
4. **Develop Predictive Models:** Create predictive models that link seed traits with masting behavior to better understand potential responses to changing environmental conditions.

3.2 Methods

There are many hypotheses regarding mast seeding, including predator satiation, pollination efficiency, environmental prediction, weather cues, and the resource budget model. The traits we selected aim to fit different hypotheses of masting.

For the predator satiation hypothesis, relevant traits include seed size, seed nutrient content, dispersal potential, seed dormancy, and seed longevity. These traits are closely related to interactions with seed predators. Regarding pollination efficiency, the relevant traits are type of reproduction (monoecious or dioecious), flowering duration, and the types of pollinators. For the resource matching hypothesis, selected traits include leaf longevity and determinacy. Additionally, we will consider biome, continentality, and critical environmental cues to examine how these factors may influence whether a species will mast.

We will explore various databases to gather this trait data, including Silvics of North America, MASTREE+, the Kew Seed Dataset, and the European Atlas of Forest Tree Species.

3.3 Significance

Studying the seed traits related to masting is significant for several reasons. First, it can help explain the potential mechanisms that drive this complex reproductive strategy, shedding light on why certain species mast while others do not. By examining traits such as seed size, nutrient content, dormancy, and longevity, researchers can gain insights into how these characteristics influence the success of seed production and dispersal during mast years, and how this is related to the seed predator's population dynamics. Additionally, understanding these relationships can help us to predict how environmental factors, such as climate change, may impact masting behavior in the future. For example, knowing which seed traits are most relavant to masting behaviour in specific ecological contexts can help us anticipate how shifts in temperature, precipitation, and other environmental cues might change masting patterns. By answering the question of what causes masting through looking at seed traits, we can better understand the dynamics of forest ecosystems.