The Nature Conservancy

COLORADO FOREST RESTORATION INSTITUTE
COLORADO STATE UNIVERSITY

Ponderosa Pine Cone and Seed Collection:

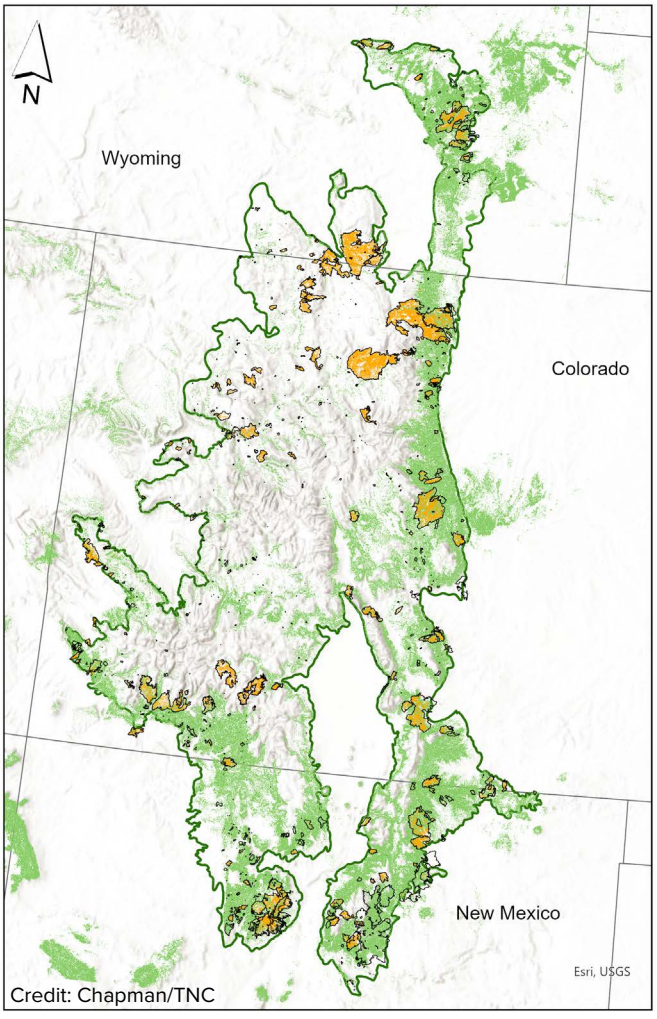
Frequently Asked Questions and Answers for the Colorado Front Range

INTRODUCTION

Ponderosa pine is a common forest type found at elevations between 6,000-9,000 feet on the Colorado Front Range. Fire is a natural component of ponderosa ecosystems; however, over the past 45 years, the frequency of large fires across the Southern Rockies, which includes the Front Range, has increased 274% (Schoennagel et al. 2017). Ponderosa pine have thick bark, a common adaptation to frequent fire, but changes in forest density, fire intensity, weather and a legacy of fire suppression have resulted in larger areas burned at high severity than in the past. Scientists predict that continued warming through mid-century will increase annual area burned (Lukas et al. 2014).

Ponderosa pine trees that survive wildfire produce cones, which provide a seed source for recovery, but these cones and large seeds do not travel far from the parent tree. Many burned areas are too far from a seed source to recover naturally and will require planting. The Nature Conservancy estimates that between 1985 and 2021, ~550,000 acres of ponderosa pine forest in the Southern Rocky Mountain Ecoregion, which covers Colorado, southern Wyoming, and northern New Mexico, have burned at high severity and may require reforestation with up to 83-138 million seedlings (estimate of 150-250 trees per acre) (Figure 1; Chapman, personal communication).

In this same analysis, The Nature Conservancy found that 83% of all trees planted in burn scars on U.S. Forest Service land are ponderosa pine (Chapman, personal communication). Given the limited recovery of ponderosa pine following high-severity wildfire, it is the focus of this document. There is a critical need to collect ponderosa pine seed to support forest recovery following wildfire. Seed stock is insufficient to address the 550,000 acres already burned at high severity nor meet the needs from future fires. According to nationwide estimates, the average seed stock per nursery would support only 3.8 years of conifer production for reforestation (Fargione et al. 2021).



Credit: Chapman/TNC

Figure 1. Reforestation opportunites for ponderosa pine in high-severity wildfires of Southern Rockies Ecoregion 1985-2021.

As efforts to collect ponderosa pine seed gain momentum, many are asking questions about the frequency of cone production, the timing of seed collection and insect pests and outbreaks. In this document, we review the scientific literature from Colorado's Front Range to provide a snapshot of what is known about the ecology and frequency of seed production, the viability of stored seeds, and the existing literature on insect pests. This document is not a how-to guide for ponderosa pine cone collection, but rather, aims to address commonly asked questions about ponderosa pine cone and seed collection.

COMMONLY QUESTIONS ASKED ABOUT PONDEROSA PINE SEED COLLECTION IN COLORADO

Ponderosa pine cone and seed ecology

How many months does it take a ponderosa pine tree to produce a cone?

It takes 26-27 months to produce a cone (Krannitz and Duralia 2004). Pollen and egg production occurs in mid-to-late summer of year zero (Mooney et al. 2011). In year one, pollination occurs between April and June with cone development by midsummer. Fertilization takes place in the spring of year two and cones mature by that fall. When mature, the scales of the cones open and release winged seeds.

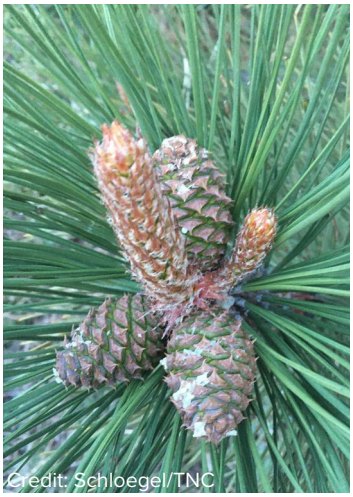


Figure 2. Ponderosa pine cones at different stages of development. Top left: male pollen cones, Top right: young female seed cones, Bottom Left: mature seed cone, and Bottom right: seed with wings.

How far do ponderosa pine seeds disperse from a parent tree?

Ponderosa pine seeds generally do not disperse farther than ~150 feet from parent trees (Johansen and Latta 2003). In high severity burn scars, distance from surviving forest edge and elevation are the best predictors of ponderosa pine recovery (Chambers et al. 2016). In areas burned at high severity with no surviving trees, regeneration declines significantly at distances greater than ~150 feet from surviving forest edges and below ~8000 feet in elevation (Chambers et al. 2016).

How often do ponderosa pine on the Colorado Front Range produce cones?

Ponderosa pine cones are produced intermittently and synchronously, in a process known as masting. Mast seeding years are when a heavy seed crop is produced. Masting is common among tree species and as explained below, it is thought to increase the potential for successful reproduction.

Long-term studies on Colorado's Front Range report that ponderosa pine usually masts at least once per decade. On the Southern Front Range, one study recorded four mast seeding years between 1981 and 2001 (Shepperd et al. 2006). In the Central Front Range in Boulder County, there were six masting years between 1979 and 2008 (Linhart et al. 2014). Although masting may occur over large areas, these records highlight the degree of localization.

Why do ponderosa pines mast?

Mast seeding is a way for trees to increase their potential for successful reproduction using an economy of scale. Reproductive synchrony in pollen production and female cone production increases the efficiency of pollination (Moreira et al. 2014). While some trees may produce pollen cones each year, heavy seed crops are only likely to be

Year	Central Front Range	Southern Front Range
1979		
1980		
1981	X	
1982		
1983		X
1984	X	
1985		
1986		X
1987		
1988		
1989		
1990		X
1991		
1992		
1993		
1994		X
1995		
1996		
1997	X	
1998		
1999		
2000		
2001	X	

Table 1: Mast years observed between 1979-2001 by Shepperd et al. (2006) and Linhart et al. (2014). "X" refers to a mast year.

pollinated during years when most trees at a given site invest in pollen production. Synchrony allows for better mixing of genes, or outcrossing, and lower rates of self-pollination.

Masting may also reduce seed predation by satiating seed predators, such as insects, birds and rodents (Linhart et al. 2014). When fewer cones are available, a greater proportion of cones are attacked by insects (Linhart et al. 2014). Seed predation in years with low cone production can range from 50 to 90%, while in mast years it drops to 6-12% (Linhart et al. 2014).

Do the male pollen cones and female seed cones occur on the same tree?

Yes. Male pollen cones are often found on low branches, while female seed cones frequently occur in the upper crown at branch tips.

At what age do ponderosa pine trees begin to produce cones with viable seeds?

Ponderosa pines begin to produce cones around 20 years old and can produce viable cones up to 350 years of age (Bonner and Karrfalt 2008). However, most viable seeds come from trees ages 60-160 years old (Bonner and Karrfalt 2008).

Because both pollen and seed cones occur on the same tree, younger trees may direct greater resources to producing less-energy intensive pollen cones, while older trees proportionally produce more seed cones (Wion et al. 2023)

Does the weather influence cone production?

The effects of weather on cone production vary by elevation and site. There is no observed relationship between masting and long-term climate (Wion et al. 2023). However, moisture availability likely influences cone production but differs by elevation. For example, at lower elevations with hotter and drier conditions, summer rain during year zero and year one are significant for cone production, but this effect diminishes with elevation (Wion et al. 2023).

Do trees with dwarf mistletoe (Arceuthobium spp.), the most widespread disease affecting ponderosa pine, reduce seed production and viability?

Yes, dwarf mistletoe reduces seed production and seed viability (Krannitz and Duralia 2004).

Which insects attack ponderosa pine cones?

Many types of insects damage ponderosa pine cones and seeds. Cone beetles (*Conophthorus ponderosae*), cone weevils (*Conotrachelus neomexicanus*), and cone moths (*Dioryctria spp. or Eucosma spp.*) are some of the most common, but cones may also be colonized by cone bugs (*Leptoglossus occidentalis*), seedworms (*Cydia piperana*), and parasitic wasps or chalcids (*Megastigmus albifrons*) (Keefover-Ring and Linhart 2010). These insects are endemic, or native, to ponderosa pine on the Colorado Front Range, and typically restrict their movements to only one or a few adjacent trees (Bodenham and Stevens 1981).

A useful dichotomous key in Bodenham and Stevens (1981) provides a description of the insects according to type of cone damage.


Credit: Titus/TNC


Credit: Titus/TNC

Figure 3: Examples of insect caused cone damage (top); Pinus cone maturation in incremental stages (bottom).

What do mature ponderosa pine cones look like?

By month 26, mature cones are 3-6 inches in length and green to brown in color. On the Colorado Front Range, mature cones are seen from late August through mid-October.

Do some trees consistently produce more cones than others?

Yes. "Super trees" likely produce many times more seed than average trees (Linhart and Mitton 1985, Shepperd et al. 2006, Linhart et al. 2014, Wion et al. 2023). In a 29-year-study in Boulder County, 12% of trees studied produced 50% of cones (Linhart et al. 2014). A recent study found that open grown trees and older trees produce more cones on average than on trees grown in dense patches (Wion et al. 2023). However, it is unknown if trees that produce more cones also produce a high percentage of viable seeds.

Should I collect from trees that appear to be "super trees" or multiple different trees?

To increase genetic diversity, collect fewer cones from many trees, rather than many cones from a few trees.

How many seeds are in a cone?

Typically, there are 50-70 seeds in a single cone, but temperature, disease, insect infestation and/or self-pollination can influence the number of fertilized seeds (Krannitz and Duralia 2004).

How many seeds are in a pound?

On average, there are ~12,000 seeds per cleaned pound (Burns and Honkala 1990).

How long will stored ponderosa pine seed retain its viability?

Seeds are living, but do not live forever. Ponderosa pine seeds remain dormant until the seed coat is broken in a process known as stratification. When dormant seeds are properly stored, they can be stored for 15 years or more without serious losses in viability (Bonner and Karrfalt 2008). Seeds are best stored by professionals in temperature-controlled warehouses. Proper seed storage first reduces the seeds' moisture content to 5 to 10% and then places seed in cool conditions.

Is it possible to collect cones every year?

There is minimal cone production between mast years. In a study in Boulder County, 76% of cones were produced during the six mast seeding years (Linhart et al. 2014). So, while it may be possible to collect cones when present, mast years are going to produce more seed per cone, more cones per tree, and seeds with higher viability.

Why should we collect ponderosa pine seeds with locally adapted traits?

The selection of an appropriate seed source for a planned planting project can influence the survival of outplanted seedlings, because although ponderosa pine is widely distributed between southern Canada and Mexico, genetic variation throughout its range ensures its cold and drought hardiness, dates for budburst, and overall tree health. For these reasons, it is important to record the location and elevation of each collection site.

Figure 4: Healthy, mature seed cones produced during a mast seeding year, which are ready for harvest.

In the past, U.S. Forest Service guidelines defined the areas in which seeds could be moved while still conserving locally adapted traits, known as seed zones and seed transfer guidelines. However, the warming climate presents new challenges, and trees may not be adapted to the area where they are found, but instead to a place with a cooler climate, such as higher elevations or different aspects (Aitken and Bemmels 2016). Colorado's projected increases in mean annual temperature urge the development of new seed transfer guidelines that incorporate these changing climatic conditions.

Is there a need to collect seeds from other tree species?

We need to increase seed collection for all tree species that we expect might be damaged by fire, flood, or insects.

How can I get involved?

There are many organizations across Colorado focused on seed collection. We suggest that you check with your local city and county open space and any local volunteer-based stewardship organizations, many of whom have active seed collection programs underway.

OTHER RESOURCES

- **Reforestation, Nurseries and Genetic Resources** (https://rngr.net/). RNGR is a leading source of technical information for nurseries and land managers regarding production and planting of trees and other native plants for reforestation, restoration, and conservation. Rngr.net is sponsored by the USDA Forest Service and Southern Regional Extension Forestry and is a collaborative effort between these two agencies.
- **Seed Lot Selection Tool** (https://seedlotselectiontool.org/sst/). The Seedlot Selection Tool (SST) is a web-based map designed to help forest managers match seeds with planting sites based on climatic information. The climates of the planting sites can be chosen to represent

current climates, or future climates based on selected climate change scenarios. The Seedlot Selection Tool is a collaboration between the US Forest Service, Oregon State University, and the Conservation Biology Institute.

- **Tree Planters Notes** (https://rngr.net/publications/tpn). Tree Planters' Notes (TPN) is a journal dedicated to technology transfer and publication of information relating to nursery production and outplanting of trees and shrubs for reforestation, restoration, and conservation. TPN is sponsored by the Cooperative Forestry Staff of the U.S. Department of Agriculture (USDA), Forest Service, State and Private Forestry Deputy Area, in Washington, DC.
- **USDA National Seed Lab** (https://www.fs.usda.gov/nsl/). This website provides seed testing services, training, and research.
- **National Nursery and Seed Directory** (https://rngr.net/resources/directory). This directory is an online source for finding businesses that support the propagation of forest and native plant materials in the US and Canada. It is possible to search the directory by name, state, product, or business type. The directory sponsored by the USDA Forest Service and Southern Regional Extension Forestry and is a collaborative effort between these two agencies.

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Contact: c.a.schloegel@tnc.org • https://www.nature.org/en-us/about-us/where-we-work/united-states/colorado