They Pulled Off a Drone Seeding — And Trees Grew!

A summary of lessons learned

Purpose

This brief provides recommendations for managers thinking about using an Unmanned Aerial Vehicle (drone) for post-fire seeding. This project was designed to test the technology, learn about the logistics associated with drone seeding, and share lessons learned to improve drone use in future projects. Partnerships made this project possible.

Maria Mircheva, Sugar Pine Foundation

BACKGROUND

In April 2021, a multidisciplinary group of Nevada-based organizations came together to solve a problem—how to conduct a post-fire seeding using a drone. This summary should provide a jumping off point for those thinking of using drones for revegetation.

Why Use Drones on Post-Fire Landscapes?

Drones are attractive tools for post-fire seeding, land stabilization, and soil rebuilding because:

- They involve very minimal environmental disturbance (it is limited to the staging location and boundary marking).
- They can be used to seed steep slopes or fragile landscapes where traditional ground seeding methods or hand-planting is costly or impossible.
- They can be used on sites where aerial seeding is cost prohibitive or logistically impossible due to altitude or approach limitations.
- They can direct seed placement to specific areas such as naturally occurring microsites, steep watersheds, and animal corridors.
- They provide safety for planting crews, who can access a large area from a single staging area.
- They track and map the areas (even microsites) where seed is deposited, which helps with data management and post-restoration monitoring.

The Players

Sugar Pine Foundation provided the seed, funding, and contracting

US Forest Service (USFS) Humboldt-Toiyabe National Forest provided the trial location and aided in planning and logistics

Flying Forests, a *WeRobotics* and *Beta Earth Venture Studio* partnership, developed the seed distribution hardware, experimental design, and drone flight paths, designed and manufactured the seed balls (Fig. 1), conducted the greenhouse control study, and contracted the drone pilots

Desert Research Institute provided the drone, drone pilots, and technical support

Figure 1. The seed balls. Photo credit: Desert Research Institute.

The Site

It was a steep, rocky slope on the Carson Ranger District of the Humboldt-Toiyabe NF. It had burned twice, once in the 1994 Cottonwood Fire and again in the Loyalton Fire in August 2020. The study location was 25 acres within the burn scar and was chosen for its following characteristics:

- Steep rocky slope for testing the technology
- Site supported trees before the fires and recieves a moderate amount of snow
- Legal and easy access to a road within 0.25 mile of the study area
- Space for the staging area needed for piloting and battery charging (Fig. 2)

HOW IT CAME TOGETHER

During the 2020 fire season Sugar Pine Foundation Executive Director, Maria Mircheva, was able to collect 30 lbs of Jeffrey pine (*Pinus jeffreyi*) seed (about 90,000 potential trees) with the help of concerned citizens and community members. Because suitable locations to plant seedlings after the Loyalton Fire were limited, she asked Annabelle Monti, Humboldt-Toiyabe National Forest Forester, "What about a drone seeding?" Monti wanted to test drone technology for post-disturbance restoration. On The Nature Conservancy's *Plant A Billion Trees* call, Mircheva learned of Dr. Lauren Fletcher, inventor of tree-planting drone technology and co-founder of Flying Forests, whose mission is to equip and empower local communities to restore ecosystems through better technology. Mircheva made the call, and the rest is below.

Figure 2. We have liftoff! Photo credit: Desert Research Institute.

PROJECT DETAILS

Seed Preparation

Jeffrey pine seeds were scarified on a 90-day cycle and hand-manufactured into 25,000 seed balls using a 60:40 clay-compost mix. This seed ball delivery mechanism provides nutrients to the seeds and protects them from the air drop. No seed predation deterrants were used. Although the seed balls were created by hand, the process is scalable. Controlled experiments showed that the germination rate of the seed balls (each containing ≤7 seeds) was 60-80%, which was slightly less than that of uncoated seed. Fully loaded drones weighed about 33 pounds and carried 500-700 seed balls.

Timing and Weather

The group planned a mid-spring seeding date to allow for some snowmelt and better site access, but this was delayed by about 3 weeks. Drone delivery of the seed balls occurred on April 22 (Earth Day), 2021. Persistent growing-season drought and heat dome conditions extended over much of western North America and were not conducive for seedling establishment and survival. However, the seed balls provided some cover and moisture to seeds, which bought time for conditions to improve. Seed balls escaping predation disintegrate within three months in the absence of precipitation. In late-spring, a handful of storms finally arrived, providing some critical moisture.

Drone Seeding

Drones dropped 25,000 seed balls from a height of 65-100 feet depending on the slope angle and presence of dead trees. About 1,000 seed balls/acre were distributed with 7-10 feet of separation for an approximate total of 75,000 seeds deposited on the 25-acre project area. Drones can carry up to 700 seed balls and were re-loaded about 3 times/acre (Fig. 3). A single load (from take-off to landing) took about 5-7 minutes. Batteries were swapped out every 3 flights, and re-load time was less than 5 minutes. Battery charging was done on-site using a generator. The single drone required a 2-person flight team, and the whole project area was seeded in just 1.5 days.

RESULTS

Field Trial

The project site (Figs. 4 and 5) was monitored four times following seeding. Data collection included seed ball distribution and final resting place condition (breakage, predation), germination, and seedling growth. Even with the harsh post-seeding conditions, the team located 10 seedlings in November 2021, suggesting establishment of maybe 100 seedlings. Although a low rate of establishment, it was better than expected and ultimately not the goal of this trial.

Greenhouse Study

A parallel study conducted at a Nevada Division of Forestry greenhouse evaluated germination and growth of loose seeds and seeds from seed balls.

- Germination of loose seeds averaged ~90% and those from seed balls of various compositions averaged 60-80%
- Germination of loose seeds occurred within 2 weeks; germination of seeds from seed balls took 3 weeks
- Seedling development of loose seeds was about a week ahead of those from seed balls

Figure 3. Reloading the drone with seed balls. Photo credit: Desert Research Institute.

Figure 4. The burned area and a drone in flight. Photo credit: Erica Hupp, USFS.

LESSONS LEARNED AND FUTURE IMPROVEMENTS

Site Selection

- Locate sites large enough to incorporate control plots and additional experiment plots
- Match the seed ball design to the moisture conditions of the site

Timing

- Seed earlier in the spring - on top of melting snow or following a precipitation event when temperatures are still conducive to germination
- Experiment with fall vs. spring seeding to test establishment with natural stratification

Figure 5. Piloting the drone in the burn scar study area. Photo credit: Desert Research Institute.

Seed Ball Development

- Fine tune the clay to compost ratio; seed balls delivered in this project were likely clay heavy
- Anticipate fluctuating seed availability
- Develop balls that can accomodate small seeds or a mix species without compromising emergence
- Test predation deterrents

Contracting and Permitting

- Drone permitting by the Federal Aviation Administration, Environmental Protection Agency, and USFS includes some disagreements and redundancies. Streamlining and coordination could reduce process hurdles
- Terminology and expectations for new technologies need updating in some contracts and proposals
- Utilizing a non-governmental organization like the Sugar Pine Foundation streamlined the contracting process and made the short timeline of this project possible

Expectations

- Temper stakeholders' expectations for immediate gratification while still encouraging a leap of faith in new technology
- Conduct more outreach to increase public awareness and excitement as a way to benefit fund-raising and cost sharing of future projects
- Share lessons learned and pitfalls to avoid

Design

- Begin the planning process early so that logistics of drone operations (Figs. 5 and 6) can be aligned with optimal ecological windows for the timing of seeding
- Experiment with planting prescriptions – grid vs. microsite
- Monitor for at least 5 years
- Involve researchers in the development of the exerimental design, monitoring process, and analysis of results

Figure 6. Drone contractor operating piloting controls. Photo credit: Erica Hupp, USFS.

Partners

- Partnerships (Figs. 7 and 8) in this drone seeding trial made it possible — the interested and motivated people, along with the important pieces of resources and skills that each brought to the table made this trial an operational success
- Making sure the team includes the necessary expertise related to experimental design, logistics, drone piloting and care, and post-treatment analysis is critical

FINAL THOUGHTS

In difficult to access or sensitive places, using drones for post-fire seeding has the potential to be a game changer, but drones are not for every situation. In many cases, drone seeding cannot replace hand-planting or traditional seeding, but it offers another option and will be valuable in the certain places. The cost of this experiment was more than hand-planting would have been, but with technological development and inreased use, the cost of drone seeding will come down and become more competitive with hand-planting.

More trials and controlled experiments, like this one, will help managers determine which situations are best suited for drone usage. And it is important to remember that the potential use of drones extends beyond post-fire seeding (to site scouting, monitoring, land stabilization, soil rebuilding, weed control, etc.).

Technological advancements (e.g., extended battery life, increases in the drone operational range, and improvements in seed ball development), will help to improve drone usage. The drone-seeding trial within the Loyalton fire area has contributed to the growing body of knowledge on how to best use drone technology in post-fire landscapes.

Figure 7. Some of the partners (Left to right: Matthew Zumstein, Carson District Ranger, USFS; Tressa Gibbard, Program Manager, Sugar Pine Foundation; Annabelle Monti, Forester, Humboldt-Toiyabe, USFS; Maria Mircheva, Director, Sugar Pine Foundation). Photo credit: Desert Research Institute.

Figure 8. Lauren Fletcher, Flying Forests, a WeRobotics and Beta Earth Venture Studio partnership. Photo credit: Desert Research Institute.

FOR MORE INFORMATION

Pioneer drone planting. 2021. Lake Tahoe Basin, NV and CA: Sugarpine Foundation. Available: https://sugarpine-foundation.org/pioneering-drone-planting

Partners test innovative reforestation method. 2021. Humboldt-Toiyabe National Forest, NV: U.S. Department of Agriculture, Forest Service. Available: https://storymaps.arcgis.com/stories/3b371501be6b43bc8892a354c58ef941

Restoration by drone. 2021. Reno, NV: Desert Research Institute. Available: https://www.dri.edu/restoration-by-drone/

Flying Forests. A holistic restoration company based in Reno, NV.