# Strategic Seed Management to Meet Reforestation Needs

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## Abstract

When land managers consider seed management for reforestation, they need to be deliberate so that efforts can be proactive to events on the ground. With increasing demand for reforestation, seed has become center stage. Strategic seed management is knowing when to bulk seed and when to keep seed lots separate as well as understanding where and how to use that seed. This approach allows land managers to confidently select available seed for reforestation projects and contributes to the production of high-quality nursery seedlings. Considering exact seed collection locations, managing the seed quality, and choosing the best stock type for the seed on hand can lead to efficiency and success with seed inventories. This paper was presented at The Reforestation Pipeline in the Western United States–Joint Annual Meeting of the Western Forest and Conservation Nursery Association, the Intertribal Nursery Council, and the Intermountain Container Seedling Growers Association (Missoula, MT, September 27–29, 2022).

## Introduction

Reforestation happens across the landscape for many reasons and in many ways. In most instances, reforestation starts with seed at a nursery (Dumroese et al. 2005). Selecting the appropriate seed is important for producing long-lived, healthy forest stands that can withstand the effects of climate or pests (Randall and Berrang 2002). Seed-use plans can be developed to inform land managers and help them be successful with reforestation efforts. These plans are also used to build annual cone-collection and seedling requests. A seed-use plan that is adaptive and includes as much information as possible is crucial for strategic seed management and deployment of that seed.

Seed management can be thought of much like the Target Plant Concept (TPC). The TPC guides users through a series of key considerations for choosing the best plant material for a given site (Dumroese et al. 2016, Landis et al. 2010). This same concept can be used for seed management and use, particularly with regard to limiting factors. When land managers consider objectives and constraints for seed, they often include risk analysis of seed movement. This risk analysis informs decisions for seed movement from a source environment to a planting environment (Randall and Berrang 2002). If the seed is difficult to acquire, one may be less likely to move it farther from the collection site for fear of limited survival results. Where predation could occur before germination, land managers may be unwilling to use seeds with limited supply for direct-seeding applications. If the seed is easy to acquire, one may be more willing to take those risks. Defining the available seed, seed needed, deployment locations, and planting need allows one to build a dynamic and effective seed-use plan (table 1).

## Seed Deployment

In seed planning and use, knowing the geographic source of the seed is important for understanding where deployment is appropriate. Often, the planting location is not the same as the collection location. To prevent maladaptation, seed should be used in a location climatically similar so that the future trees are adapted to the environment they are growing in and will have the greatest potential for success (Randall and Berrang 2002). Seed is identified from a collection area defined as a tree seed zone (figure 1), species-specific zone (figure 2), or breeding zone (figure 3). These zones are guides that have been developed to aid understanding

**Table 1.** The Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco) seed-use plan created for the U.S. Department of Agriculture, Forest Service, Mt. Hood National Forest shows all possible tree seed zones and breeding zones for this area, as well as the spatial overlaps that occur. This plan allows the user to input seed inventory according to how it was identified at collection, edit the columns with planting acres and planting density, and calculate the possible collection need.

| Identified collection zone | Spacial overlap with these zones | Corresponding elevation (ft) | Operational planting acres | Trees per acre | Seedlings required (thousands) | Seed needs[a] (lbs) | Inventory (lbs) | Other seed (lbs) |
|---|---|---|---|---|---|---|---|---|
| 042 | 042 | <1,000 | 0 | 200 | 0.0 | 0.00 | 0.00 | 0.00 |
| 042 | 042/06012 | 1,000–2,000 | 0 | 200 | 0.0 | 0.00 | 0.00 | 0.00 |
| 042 | 042/06013 | 2,000–3,000 | 0 | 200 | 0.0 | 0.00 | 0.00 | 0.00 |
| 042 | 042/06014 | 3,000–4,000 | 0 | 200 | 0.0 | 0.00 | 0.00 | 0.00 |
| 042 | 042/06015 | >4,000 | 0 | 200 | 0.0 | 0.00 | 0.00 | 0.00 |
| 451 | 451 | <1,000 | 0 | 200 | 0.0 | 0.00 | 1.46 | 0.00 |
| 451 | 451/06012 | 1,000–2,000 | 0 | 200 | 0.0 | 0.00 | 0.00 | 0.00 |
| 451 | 451/06013 | 2,000–3,000 | 265 | 76 | 20.1 | 1.72 | 1.71 | 0.00 |
| 451 | 451/06014/06024 | 3,000–4,000 | 0 | 200 | 0.0 | 0.00 | 0.00 | 0.00 |
| 451 | 451/06015/06025 | >4,000 | 0 | 200 | 0.0 | 0.00 | 0.00 | 0.00 |
| 452 | 452 | <1,000 | 0 | 200 | 0.0 | 0.00 | 0.00 | 0.00 |
| 452 | 452/06012 | 1,000–2,000 | 0 | 200 | 0.0 | 0.00 | 0.00 | 0.00 |
| 452 | 452/06013 | 2,000–3,000 | 0 | 200 | 0.0 | 0.00 | 0.00 | 0.00 |
| 452 | 452/06014/06024 | 3,000–4,000 | 0 | 200 | 0.0 | 0.00 | 0.00 | 0.00 |
| 452 | 452/06015/06025 | >4,000 | 0 | 200 | 0.0 | 0.00 | 0.00 | 0.00 |
| 462 | 462/06014 | 3,000–4,000 | 0 | 200 | 0.0 | 0.00 | 0.00 | 0.00 |
| 462 | 462/06015 | >4,000 | 0 | 200 | 0.0 | 0.00 | 0.00 | 0.00 |
| 463 | 463/06015 | >4,000 | 0 | 200 | 0.0 | 0.00 | 0.00 | 0.00 |
| 661 | 661/06012/06022 | 1,000–2,000 | 0 | 200 | 0.0 | 0.00 | 0.00 | 0.00 |
| 661 | 661/06013/06023 | 2,000–3,000 | 0 | 200 | 0.0 | 0.00 | 0.00 | 0.00 |
| 661 | 661/06014/06024 | 3,000–4,000 | 0 | 200 | 0.0 | 0.00 | 0.00 | 0.00 |
| 661 | 661/06015/06025 | >4,000 | 0 | 200 | 0.0 | 0.00 | 10.58 | 0.00 |
| 662 | 662/06015/06025 | >4,000 | 0 | 200 | 0.0 | 0.00 | 0.00 | 0.0 |
| 662 | 662/06022 | 1,000–2,000 | 0 | 200 | 0.0 | 0.00 | 0.00 | 0.0 |
| 662 | 662/06023 | 2,000–3,000 | 0 | 200 | 0.0 | 0.00 | 8.17 | 0.0 |
| 662 | 662/06014/06024 | 3,000–4,000 | 0 | 200 | 0.0 | 0.00 | 0.00 | 0.0 |
| 662 | 662 | >4,000 | 0 | 200 | 0.0 | 0.00 | 0.73 | 0.0 |
| 671 | 671/06023 | 2,000–3,000 | 0 | 200 | 0.0 | 0.00 | 0.00 | 0.0 |
| 671 | 671/06014/06024 | 3,000–4,000 | 0 | 200 | 0.0 | 0.00 | 0.00 | 0.0 |
| 671 | 671/06015 | >4,000 | 0 | 200 | 0.0 | 0.00 | 0.00 | 0.0 |
| 06012 | 06012/042/451/452/661 | 1,000–2,000 | 9,896 | 132 | 1,306.3 | 111.36 | 21.37 | 0.0 |
| 06013 | 06013/042/451/452/661 | 2,000–3,000 | 10,129 | 76 | 769.8 | 65.63 | 95.36 | 0.0 |
| 06014 | 06014/042/451/452/462/661 | 3,000–4,000 | 10,667 | 45 | 480.0 | 40.92 | 118.82 | 0.0 |
| 06015 | 06015/042/451/452/462/463/661 | >4,000 | 4,455 | 28 | 124.7 | 10.63 | 14.21 | 0.0 |
| 06022 | 06022/661/662 | 1,000–2,000 | 0 | 200 | 0.0 | 0.00 | 0.00 | 0.0 |
| 06023 | 06023/661/662 | 2,000–3,000 | 0 | 200 | 0.0 | 0.00 | 0.50 | 0.0 |
| 06024 | 06024/451/452/661/662/671 | 3,000–4,000 | 0 | 200 | 0.0 | 0.00 | 50.86 | 0.0 |
| 06025 | 06025/451/452/661 | >4,000 | 0 | 200 | 0.0 | 0.00 | 11.12 | 0.0 |
| **Totals** | | | **35,412** | | **2,701.0** | **230.26** | **334.89** | **0.00** |

[a] Estimated seedlings per pound of seed = 11,730.

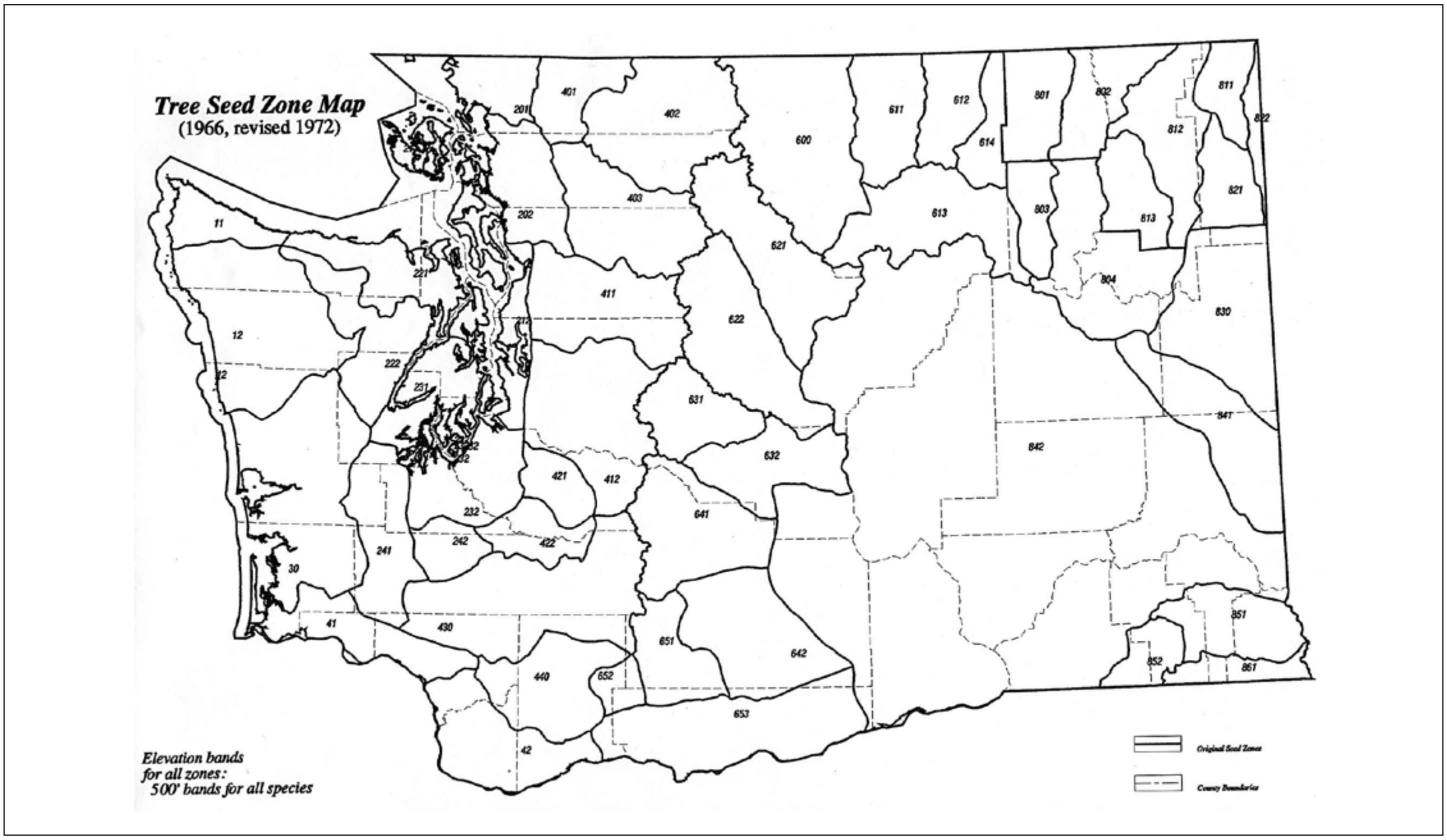


**Figure 1.** Generic tree seed-transfer zones were developed for Washington State and are used in conjunction with elevation bands to identify seed collections. (Source: Randall and Berrang 2002)

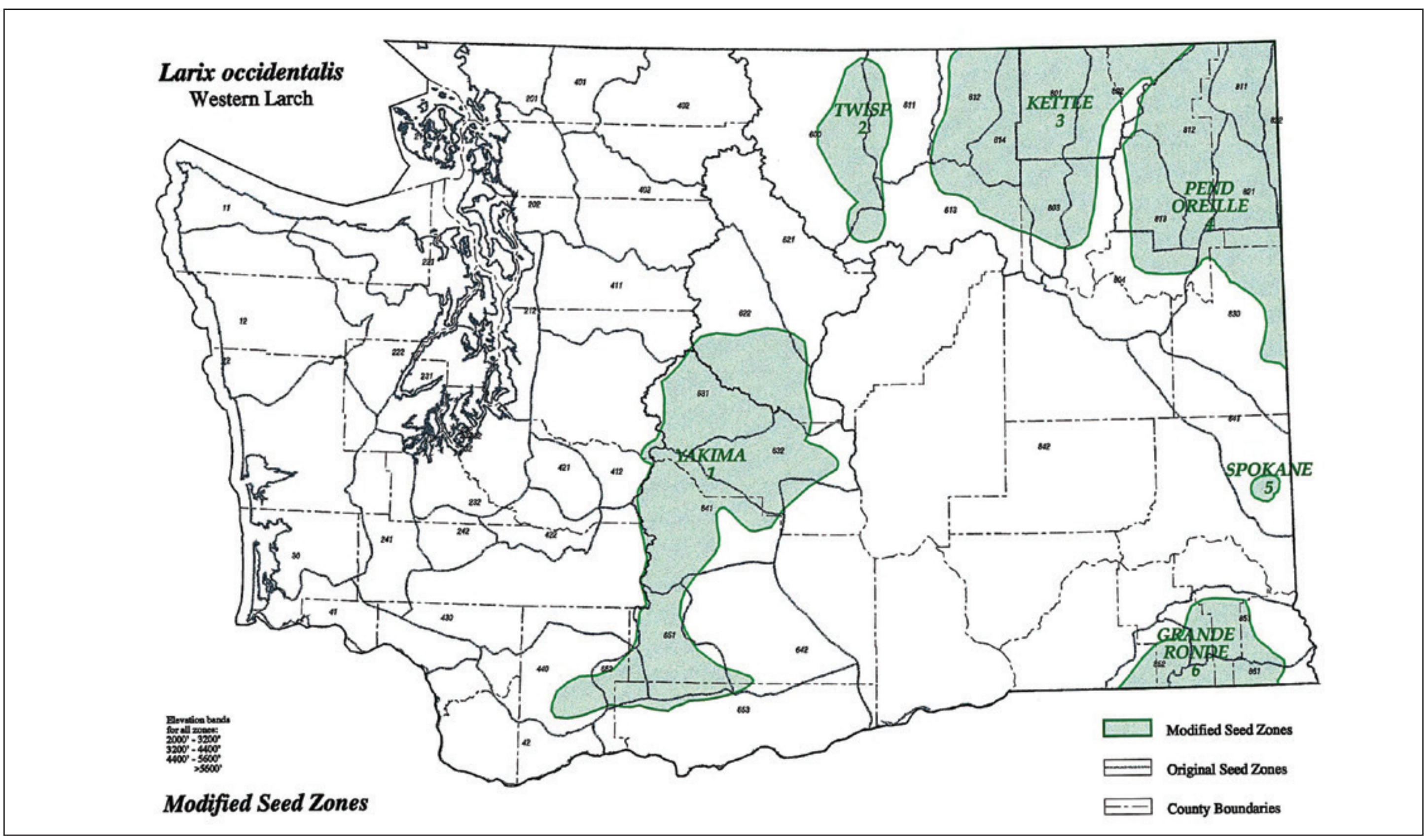


**Figure 2.** Species-specific zones, such as this one for western larch (*Larix occidentalis* Nutt.) within Washington State, have been developed for some locations. (Source: Randall and Berrang 2002)

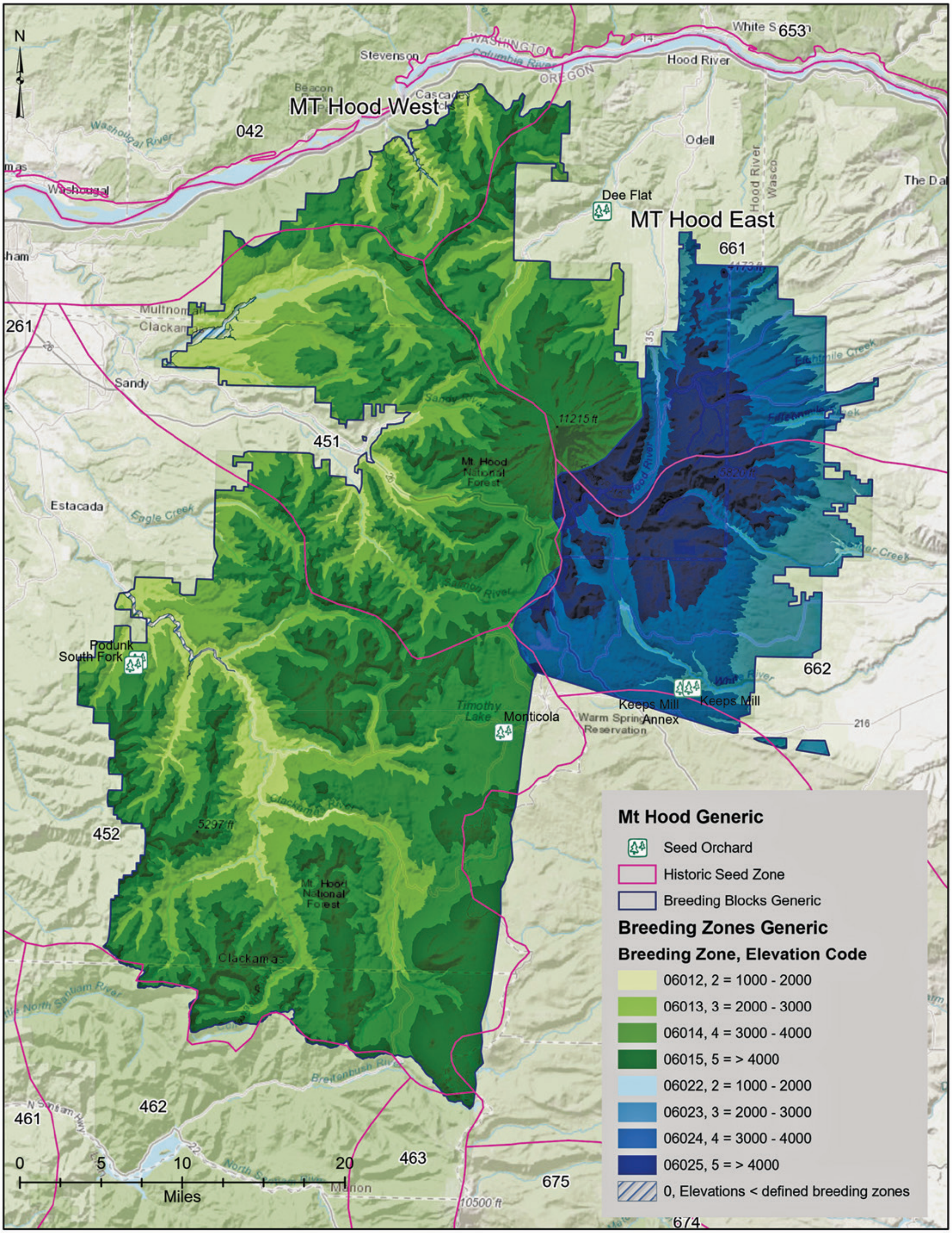


**Figure 3.** Overlaying a breeding zone map with tree seed zones allows users to better understand how to use older seed lots.

of seed sources and facilitate successful deployment (Buck et al. 1970, Randall and Berrang 2002). Common garden studies and assisted migration trials have resulted in increased understanding of seed-movement effects on plants (Schwinning et al. 2022, Silen and Mandel 1983). This work has also led to the development of tools, such as the Seedlot Selection Tool (St. Clair et al. 2022).

With the development of seed zones, collectors typically record only the zone and elevation information. Collecting exact geographic location, however, results in more flexibility for deployment. A seed zone is often a very large polygon across the landscape, thereby making it hard to pinpoint where seed came from if only the zone information is recorded. Depending on where the seed was collected from within the zone, it may or may not be able to cross into another zone. The edges of the zone could be quite far apart. For example, if seed is available from a zone that has a large geographic area, the north end and the south end may be very different. Seed can be moved within a zone with a high degree of confidence, but if the exact location is unknown, moving it outside of that zone could be risky. Exact geographic coordinates provide a better understanding of how far a given seed source can be deployed outside of that identified zone.

Strategic seed management examines where all possible zones overlap spatially. Breeding zones differ by species and forest and do not always match the seed zone polygons. Examining this overlap gives land managers the ability to better understand their seed on a map (figure 3) or in a tabular form (table 1). This examination identifies where the seed came from and where it could possibly be deployed, allowing for more dynamic management, flexibility of seed use, and the ability to use tools such as the Seedlot Selection Tool to guide deployment.

Deployment strategies and seed management are also affected by species characteristics such as genetic variation and adaptation capacity (Lu et al. 2014). As a result, modified zone maps for specific species have been developed (Randall and Berrang 2002). For example, a species like white spruce (*Picea glauca* [Moench] Voss) is tolerant of long-distance seed transfer and is predicted to cope well with climate change (Pike 2021). Thus, fewer seed lots are needed across the white spruce range. Red pine (*Pinus resinosa* Aiton), however, is projected to cope poorly with climate change (Peters et al. 2020) and has low genetic diversity (Pike 2022). Thus, more collection sites may be needed to capture red pine genetic diversity, but that would also allow for more options in seed deployment as the species can be moved large distances successfully (Pike 2022). When sharing seed across land ownership boundaries, labeling seed with the exact source location will be more important than ever to facilitate more deliberate seed movement.

## Seed-Collection Challenges

Logistically, acquiring seed and planning for cone crops that are worth the collection effort can be hard. Cone crops do not always occur annually, so being strategic with seed management and deployment is important. Removing seed from the seed bank due to low quality should be done only when there is replacement seed available. Land managers can use low-quality seed for direct seeding rather than in a greenhouse where poor germination cannot be tolerated within limited space resources. Planning for seed collections on a seed-use plan is an important component of seed management to ensure adequate seed inventory as much as possible.

## Seed Quality and Efficiency in the Nursery

Seed quality is another important aspect of seed management. Maintaining high-quality seed allows for nurseries to produce uniform, high-quality seedlings and helps to optimize efficiency of reforestation expenses (Barnett and McGilvray 2002). Seed-use efficiency has long been recognized as an important factor in nursery production (Landis and Karrfalt 1987). High seed efficiency minimizes oversowing or undersowing and potential seed waste (Barnett and McGilvray 2002). Nurseries continue to adapt and respond to increased demand for seedlings (Dumroese et al. 2005); in doing so, they are a resource to help land managers determine seed-collection needs and be efficient with available seed.

The economic impacts when using high-quality seed are often recognized, but creative ways to use the resource when quality has declined must also be considered. When seed germination is lower than desired, other strategies, such as supplemental direct seeding in addition to planting, can be considered (Godman and Mattson 1992).

## Conclusion

Strategic seed management is difficult and complex. A good seed plan includes key information to inform land managers and seed collectors to optimize seed quality, efficiency, and quantity in a cost-effective manner. Strategic seed management is critical for nurseries to produce high-quality seedlings and for land managers to be successful in restoration efforts.

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### Acknowledgments

This manuscript was developed from a presentation with input from colleagues at the U.S. Department of Agriculture, Forest Service (Nicole Balloffet, Sarah Garvin, Diane Haase, Matthew Horning, and Jason McNeal) and reviewed and revised with input from Maureen Crabtree at Washington Department of Natural Resources.

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