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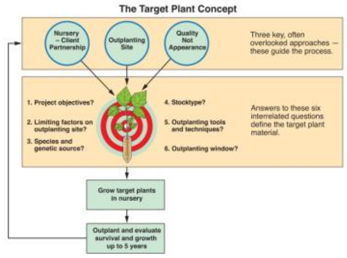


# Meeting forest restoration challenges: Using the Target Plant Concept

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## Abstract

Meeting forest restoration challenges relies on successful establishment of plant materials (e.g., seeds, cuttings, rooted cuttings, or seedlings, etc.; hereafter simply "seedlings"). The Target Plant Concept (TPC) provides a flexible framework that nursery managers and their clients can use to improve the survival and growth of these seedlings. The key tenets of the TPC are that (1) more emphasis is placed on how seedlings perform on the outplanting site rather than on nursery performance, (2) a partnership exists between the nursery manager and the client to determine the target plant based on site characteristics, and (3) that information gleaned from post-planting monitoring is used to improve subsequent plant materials. Through the nursery manager–client partnership, answers to a matrix of interrelated questions define a target plant to meet the reforestation or forest restoration objectives. These questions focus on project objectives; site characteristics, limiting factors, and possible mitigation efforts; species and genetic criteria; stocktype; outplanting tools and techniques; and outplanting window. We provide examples from the southeastern United States, Hawai'i, and Lebanon on how the TPC process has improved performance of seedlings deployed for reforestation and forest restoration.

## Keywords

Monitoring, Nursery, Outplanting, Reforestation, Seedling Quality, Stocktype

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# 1 Introduction

The art of growing tree seedlings as part of silviculture has been practiced for centuries (Evelyn 1664). The science of growing tree seedlings for reforestation, however, really began to develop in the early 20th century; the objective was to ensure that outplanted seedlings achieved high survival rates and good growth. This science used quantifiable seedling metrics to begin the process of determining what a “target” seedling might be.

The evolution of the term "Target Plant Concept” has gone through three distinct phases: (1) focus on morphological specifications; (2) physiological research led to seedling quality testing; and (3) expansion beyond trees for reforestation to all plant forms for restoration of degraded lands (Landis 2011). During the first half of the 20th century, science focused on relating seedling morphological characteristics to outplanting performance. Much of this work was pioneered by United States Forest Service scientists. In particular, Philip C. Wakeley, using southern pine as the model, pioneered a grading system based on morphology to identify targets for reforestation stock (Barnett 2013). Many of his recommendations and techniques (Wakeley 1954) were used for decades, and some of his research remains the standard (Barnett 2013). Wakeley (1949, 1954) realized, however, that there was more to seedling quality than just morphological attributes, and began researching physiological attributes as well. The second half of the 20th century saw an explosion of research on seedling physiology and nursery production techniques and a tremendous effort was expended to determine linkages among nursery practice, seedling morphology, seedling physiology, and outplanting performance (Grossnickle 2000, 2012). One of the first physiological metrics was root growth capacity (Stone 1955; Stone and Jenkinson 1971), followed by many more tests. By the mid-1980s the notion that a target seedling must have both desired morphological and physiological attributes—its “fitness for purpose” (Sutton 1980)—was widely accepted. Concurrent with this came various tests for assessing seedling fitness (quality) (Ritchie 1984; Ritchie et al. 2010). This idea of “fitness for purpose” means that the target plant’s quality is defined on the outplanting site and not in the nursery; this is a pillar of today’s Target Plant Concept.

Ensuring this “fitness for purpose” was cultured into seedlings during nursery production became a focus for bareroot (Duryea and Landis 1984; Ritchie 1984) and container (Tinus 1974; Tinus and McDonald 1979) systems, culminating in the first use of the term “Target Seedling Concept” (Rose et al. 1990b) at a 1990 Target Seedling Symposium (Rose et al. 1990a). The concept was envisioned as a method for improving nursery cultural practices to ensure high-quality seedlings were produced to meet targets set by land managers, in close cooperation with the nursery managers, to ensure plantation performance. This integrated the notion of Iverson (1984) that seedlings should be grown considering organizational objectives, genetic source, and seedling morphology and physiology, and that seedling characteristics should be matched with outplanting site conditions. The focus of the symposium was on how nurseries could deliver seedlings with target morphological and physiological characteristics. Rose and Haase (1995) subsequently provided guidance on implementing a target seedling program and Dumroese et al. (2007) further discussed the cooperative nature of seedling production between land managers and nursery managers (i.e., understanding production times, assessing seedling quality, monitoring outplanting performance, and revising target specifications).During the first decade of the 21st century, the Target Seedling Concept evolved and expanded, becoming inclusive of all types of plant materials (e.g., seeds, cuttings, seedlings; Landis and Dumroese 2006) and plant forms (e.g., grasses, shrubs, trees; Landis 2001), hence the Target “Plant” Concept (TPC).

Currently, the TPC has two components. The first component incorporates three simple, often overlooked ideas that, when considered together, guide the broad approach for defining and selecting the target plant materials for a specific site (Fig. 1). First, start at the outplanting site. What are the characteristics of the outplanting site and what is the required “fitness for purpose” of the materials needed for restoration? Second, forge a nursery-client partnership. The client and nursery manager must work together to define the ideal type of plant for the project, balancing economics and cultural feasibility. Once the plant material is grown, outplanted, and evaluated, they must work together to revise target plant characteristics to improve survival and growth of future crops. This partnership can lead to more realistic expectations by both parties throughout the plant material ordering, production, and outplanting process (Rose and Haase 1995; Landis 2001, 2003; Dumroese et al. 2007). This circular feedback mechanism is an important tenet of the TPC and notably different than the historic, linear approach where nurseries supplied seedlings and land managers had little influence about the types of seedlings produced. Third, put an emphasis on seedling quality, not just appearance. Recall that plant quality is not determined by how good a plant looks as it grows in the nursery, but by outplanting performance. A beautiful crop of plants in the nursery may perform miserably if the plants are inappropriate for the outplanting site conditions. Without the TPC, inexperienced clients may believe they can find cheap, all-purpose plants that will thrive nearly anywhere. Using the TPC, plant materials are produced in the nursery with a goal of thriving on the outplanting site and fulfilling project objectives.

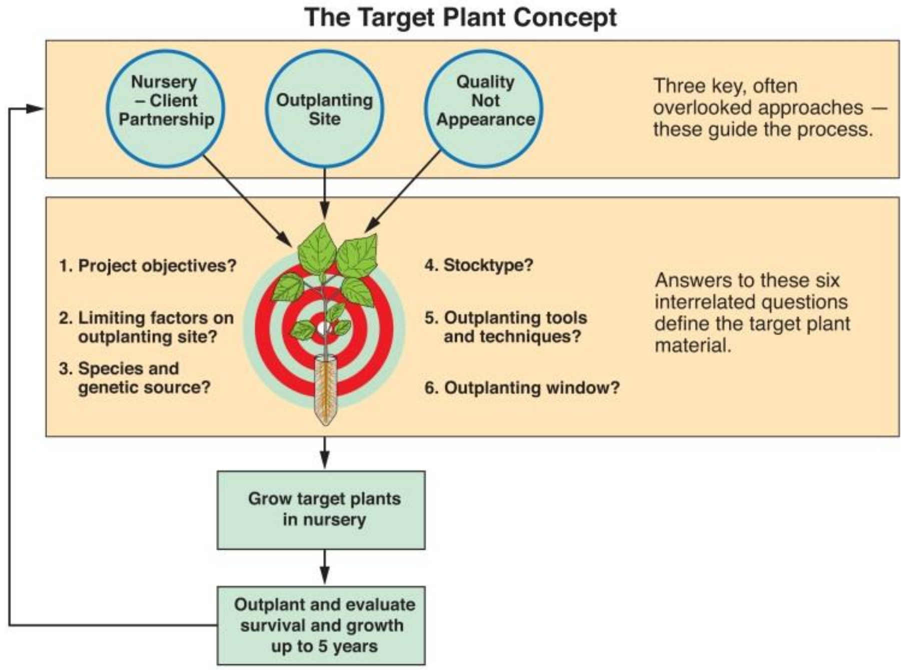


Figure 1. The Target Plant Concept starts with a partnership between the client and the nursery manager that focuses on putting the best plant materials on specific project sites. The partnerships answer important questions about the project and these define the target plant material needed to meet project objectives. The nursery produces the plant material. The client monitors outplanting performance and the client and nursery manager reassess successes and failures and use that information to improve future crops. Adapted from Landis (2011) and Landis and Wilkinson (2014).

The second component of the TPC is the process of defining target plant materials (Fig. 1). As mentioned earlier, the nursery manager and client use the characteristics of the outplanting site to systematically answer sequential, but interrelated questions to ultimately define the target plant material. Most published iterations of the TPC include six interrelated questions focused on project objectives; limiting factors on the site; appropriate species, genetics, and sexual diversity; potential stocktypes (the size and type of plant); the most efficient planting tool; and the outplanting window (Landis 2001, 2003, 2008; Landis and Dumroese 2006; Dumroese et al. 2007; Landis et al. 2010). The number of questions used, however, has been modified depending on the scope and objectives of particular projects, notably for harsh, severely-disturbed sites such as roadsides (Steinfeld et al. 2007; Landis 2011) and tropical systems (Landis and Wilkinson 2014; Wilkinson et al. 2016). This shows that the concept is fluid and can, and should, be adapted to unique circumstances or objectives; it provides a broad outline that can be implemented many ways. Such flexibility in applying the TPC will become increasingly important because, the often overlooked role of quality plant materials in the broader discussion of landscape forest restoration is now being acknowledged (Stanturf et al. 2014), forest restoration will be needed on harsher sites (Oliet and Jacobs 2012), and implementation of climate change mitigation measures, such as assisted migration, may be required (Williams and Dumroese 2013).

## 2 Defining the target plant

Let us briefly review the interrelated questions that define the target plant material for forest restoration. More exhaustive discussions can be found in Landis (2008), Landis et al. (2010), and Wilkinson and Landis (2014).

### 2.1 What are the project objectives?

Project objectives influence target plant characteristics. The type of plant material required may change as restoration activities move from forest rehabilitation (e.g., reforestation after timber harvest or wildfire) to reconstruction (e.g., afforestation on abandoned agriculture land) to reclamation (e.g., after mining) to replacement (e.g., replacing species in response to climate change) (Stanturf et al. 2014). Moreover, the type of plant material may also change within any of these four restoration scenarios. For example, if a harvest unit has upland and riparian sites, the target plant material for the upland portion might be a commercially valuable species grown as a bareroot seedling, whereas for the riparian zone the target plant might be long, non-rooted cutting inserted deeply into the soil to withstand flowing water. On the most degraded sites, such as those on mine spoils or in old quarries, the first target plant material may be seeds of grasses and forbs used to stabilize the site until woody vegetation can be established.

Sometimes project objectives, especially reforestation after harvest with anticipation of future harvest, are straightforward and target plants are easily defined. For complex, large, or specialized restoration projects, however, the approach may need to include finding reference sites, considering succession, and creating measurable goals (Steinfeld et al. 2007). Reference sites are natural or recovered areas with environmental conditions similar to the project site that serve as models for a desired future forest condition. Using reference sites of different ages can provide important information about succession. This approach helps land managers understand how a young, recovering forest may look and if the restoration trajectory is aligned with the future desired characteristics. Once objectives are set, then specific actions (e.g., site preparation) and measurable targets (e.g., 800 surviving trees per hectare after 3 years) can guide actions on the ground (Stanturf et al. 2014).

### 2.2 What are the limiting factors on the site?

Limiting factors are the elements that prevent or reduce plant material survival and growth. Whether for reforestation or forest restoration, the project site should be comprehensively evaluated early in the process. Some notable factors to include in the process are site history (e.g., recent harvests, wildfire, resource extraction), soil type, local climate, vegetation, comparison to known reference sites, access, adjacent ownership, and potential limiting factors (e.g., competing vegetation, browsing, frost, drought). The capacity of the organization, in terms of expertise, funding, and labor to complete the outplanting and maintain the project could also be included. Limiting site factors may also include socio-economic issues, such as localized deforestation for cooking or communal land ownership. After site information is compiled and evaluated, the next step is to determine which factors are most limiting to plant establishment and growth. Although a whole array of atmospheric and edaphic factors can be limiting, soil moisture and temperature are usually the most common factors to consider. In general, multiple limiting factors are involved and they should be ranked in order of severity. Limiting factors are cumulative and sequential (akin to Leibig's law of the minimum), that is, once one factor is overcome, another will typically become limiting. Once identified and ranked, the best and most cost effective way to mitigate limiting factors must be determined.

### 2.3 What species and genetic sources meet project objectives?

Species are generally selected based on project objectives, reference sites, project site conditions, and limiting factors as previously described. Once species are identified, genetic factors need to be considered when producing the plant materials: local adaptation, genetic diversity, changing climate, and for dioecious species, sexual diversity.

Plants are genetically adapted to local environmental conditions and for that reason propagules should always be collected within the same geographic area where the nursery plants will be outplanted (unless data shows otherwise). This local adaptation can be essential for long-term viability and habitat value of restoration plantings. A variety of terms (e.g., seed zone, seed source, seed lot, provenance) are used to specify source-identified propagule collections. Sometimes, especially for commercially important trees, empirical transfer guidelines have been defined by geneticists to help land managers determine how far collections can be moved without risking maladaptation; in mountainous regions this may include elevational or moisture (windward and leeward) constraints as well. For many other plant species, empirical transfer guidelines are lacking, but provisional guidelines, generally based on broad climatic data, can be employed in the interim (Bower et al. 2014). Traditionally, transfer guidelines are static in nature (i.e., set geographic distances and elevations) but with climate change, they may need to be more dynamic. This flexibility may help species move across the landscape in response to changing climate (Williams and Dumroese 2013).

The level of genetic diversity required will depend on project objectives. If an objective is forest products, then propagules that have been selected for specific traits (e.g., growth rate, form, disease resistance) may be desired. If, however, the objective is to restore a more natural ecosystem, then a broader collection aimed at representing the full complement of genetics may be desired. For the former, propagules may originate from established seed orchards or stooling beds. For the later, propagules should be collected from at least 50 to 100 parent plants (Guinan 1993). If a restoration objective is to establish plants that can naturally reproduce, care should be taken when dioecious species or clonally propagated species are used to ensure both sexes are represented. Moreover, both sexes should be outplanted in a mixed pattern to promote seed production (Landis et al. 2003).

### 2.4 What type of plant material will meet project objectives?

A variety of plant materials can be used for reforestation and forest restoration. Common plant materials include traditional nursery stocktypes, such as container seedlings, bareroot seedlings, and rooted cuttings, as well as non-rooted cuttings (stakes and poles), and seeds. The characteristics of a particular species, along with limiting factors on the site and desired genetics, will help determine the appropriate stocktype.

Direct seeding is usually most successful for grasses, forbs, and some woody shrubs. Seeding is often used after wildfire or on severely degraded sites to prevent erosion. Trees with large seeds (e.g., *Quercus* L.) may also be established through direct seeding. On one hand, direct seeding is often more economical than other restoration methods because seeds can be easy to handle and deploy, and broadcast seeds develop plants with more "natural" root systems and spatial pattern on the outplanting site. On the other hand, efficacy of direct seeding is often reduced by bird and rodent predation, vegetative competition, and unpredictable weather (Bean et al. 2004). With direct seeding, it is difficult to control species composition and plant spacing across the project area (Landis et al. 1992).

Bareroot (open root) plants are propagated from seeds or cuttings (from roots or shoots) in the ground or in raised beds, and are harvested without soil around their roots. The same propagules are used to grow container plants. Some nurseries grow plants in containers for a short period of time and then transplant them to bareroot beds to finish them. High quality plants can be grown with any of these production methods. Because containers come in many shapes and sizes, a greater diversity of plant materials can be produced compared to bareroot production, which may provide more options for project objectives and site conditions (Fig. 2). Generally container stock is more tolerant and durable during handling, shipping, and outplanting because roots are more protected.

Short, non-rooted cuttings (< 30 cm or so) can be used to start plantations, especially those for biomass production. Long, non-rooted cuttings (1.5 to 5 m) might be used for specialty projects, such as riparian restoration or plantation establishment without supplemental irrigation, where they can be inserted deep enough into the soil such that the proximal ends are in contact with the water table.

Figure 2. Using the Target Plant Concept, nursery and land managers work together to specify what type of plant material would be best suited for the project. Left: Shown is a native reforestation project in Guam, where target plants included native trees such as *Intisa bijuga* (Colebr.) Kuntze grown in large, 4-liter root-training square containers. Right: The native seedlings were planted using a mattock in soft clay soil. Photos by J.B. Friday

## 2.5 What are the best outplanting tools and techniques?

Often reforestation and forest restoration occurs on sites with less than optimum soil conditions (e.g., rocky, eroded). Stocktypes for restoration may be quite different than those used for typical reforestation on harvested sites. Specialty tools and innovative techniques may be required depending on the stocktype and the site conditions and may mean the difference between plant survival and death, and completing the project within budget (Kloetzel 2004). A wide variety of hand tools, ranging from shovels to dibbles to planting bars as well as power tools and self-propelled machines have been used successfully to outplant nursery stock (Fig. 2). Hand tools provide optimum flexibility in plant placement (within the planting hole and across the site) and microsite utilization (Kloetzel 2004). Hand-held power tools offer some of the same benefits as hand tools in terms of plant placement, and may be essential for large or specialized plant materials. Self-propelled equipment or equipment pulled behind tractors (e.g., seed drills or planting machines) can be an efficient means of planting when topography and soil conditions allow (Fig. 3). Often, planters develop a preference for a particular implement, but this implement may not work well for all stocktypes or for a specific stocktype on different sites. For example, dibbles may work well for planting container seedlings on sandy soils, but they can create a compacted soil layer that inhibits root egress in clay soils (Landis et al. 2010). The pattern and spacing of outplanted material is also a reflection of project objectives. For example, if the objective is timber production, then outplant the optimum number of trees per area to maximize growth and form and in a regularly spaced pattern to facilitate maintenance and future mechanical harvesting. If the objective is restoration of a more natural forest, then outplant materials in a random pattern, or in random groups that more represent natural patterns (Landis and Dumroese 2006).


Figure 3. Self-propelled planting machines in Scandinavia can efficiently plant container seedlings on forest sites. The seedlings and machine were designed in concert, and in response to a dwindling, more expensive labor force. Photos by R. Kasten Dumroese

### 2.6 What is the best time for outplanting?

Although outplanting the project is the penultimate step in the reforestation or restoration process, it should be an early TPC consideration. Outplanting should be scheduled during the period of time (the outplanting window) when environmental conditions on the site most favor survival and growth of the plant material. Usually this means planting at the onset of a sustained period of ideal soil moisture and temperature. Knowing when plant materials will be deployed is necessary to ensure timely delivery of properly hardened stock from the nursery (Landis and Dumroese 2006). By "working backward" in time from outplanting, the nursery can properly schedule when particular production events (e.g., seed collection, seed treatment, sowing, growth phases, hardening, storage, shipping) must occur (Landis et al. 1998).

## 3 Learning and adapting: Field testing the target plant

At the start of any planting project, the client and the nursery manager need to evaluate and agree on certain morphological and physiological specifications based on answers to the questions that define a target plant. If time permits, a prototype target plant can be grown in the nursery and its suitability then verified by outplanting trials that monitor survival and growth. Clients with projects that must be planted all at once, however, will not be able to benefit from the target plant feedback cycle on prototype plants. In such cases, the best available information and experience is used to define the target plants to immediately serve the client's needs. When the project is complete, however, the nursery and other people involved can still learn from the outcomes and apply the lessons to future projects of a similar nature.

Monitoring survival and growth should be done during the first few months and one year after outplanting because problems with seedling quality, poor planting, or exposure to drought conditions are evident in the first several months after planting. Subsequent monitoring after 3 and 5 years provides a good assessment of plant growth rates. Many monitoring schemes can be used, including permanent circular plots or stake rows systematically located throughout the plantation (Landis et al. 2010). The number of plots is usually a function of available resources (time and money) and variability of the plants; a 1 to 2 percent sampling intensity is usually sufficient (Neumann and Landis 1995) unless high variability is observed.

Target plant evaluation may be part of an experiment. If the client and nursery manager decide to compare various stocktypes, species, genetics, or morphological characteristics as a way of defining the target plant, care must be taken in the design of the experiment to avoid confounding, bias, or unnecessary variation in the nursery as well as on the outplanting site to ensure meaningful results (Dumroese and Wenny 2003; Pinto et al. 2011; Haase 2014).

According to Pinto et al. (2011), key considerations to minimize confounding variables in the nursery when comparing stocktypes include: (1) isolate the variable being tested to reduce error; (2) grow all stocktypes with the same genetic source; (3) grow all stocktypes with similar edaphic, temperature, light, and vapor pressure deficit (unless you are comparing bareroot and container stocktypes, or different propagation environments, or cultural practices are an inherent part of the study); (4) ensure uniform seedling quality (including adequate mineral nutrition) across stocktypes; (5) adjust irrigation and fertilization regimes according to stocktype (see Dumroese et al. 2015); (6) use similar and sufficient hardening and storage regimes for all stocktypes; and (7) use a solid statistical design for appropriate analysis and interpretation.

On the outplanting site, key considerations to avoid confounding variables include: (1) plant all stocktypes concurrently and during the appropriate outplanting window; (2) avoid having a single planter responsible for planting a single stocktype or a single treatment (either one planter installs the whole trial or several planters equally share the planting of each stocktype and treatment); (3) use a solid statistical design for appropriate analysis and interpretation (Fig. 4; Owston and Stein 1974; Pinto et al. 2011; Haase 2014).

Figure 4. Installing a well-designed stocktype experiment requires minimizing confounding variables during nursery production as well as avoiding them on the outplanting site. When done properly, these studies can provide valuable information for defining target plant materials. Photo by R. Kasten Dumroese

## 4 The Target Plant Concept in practice

Here are three examples of how the TPC has been applied:

In the southeastern United States, *Pinus palustris* L. is a desired reforestation species because of its high-quality wood and its function as a keystone species in a highly diverse, but imperiled, ecosystem. Currently, an overall objective is to outplant more *P. palustris* to restore this plant community. Seedlings are the desired plant material. This species has very broad seed-transfer zones. The traditional outplanting window is winter (December to February), and seedlings are either hand or machine planted. The most limiting factor is not associated with site conditions, but with seedling quality. *Pinus palustris* has a grass stage; seedlings in the grass stage have a thick, “carrot-like” taproot, a rudimentary stem, and are characterized by needle growth that forms a clump resembling a bunch grass. Nurseries produced this species as 1+0 bareroot stock for decades. This stocktype, however, had variable success on the landscape; often survival was low and seedlings persisted in the grass stage for years. Combined, these issues caused *P. palustris* to be less favored by land managers for reforestation activities than faster growing southern pine species. More recently, researchers determined that container-grown *P. palustris* generally had better survival than bareroot, could be outplanted across a wider window, and spent less time in the grass stage (Fig. 5). In response to client demand, nurseries began producing container stock based on interim guidelines for quality attributes developed from field trials, leading to container seedlings now being the target plant when *P. palustris* is outplanted (see Jackson et al. 2012).

Figure 5. Research showed that *Pinus palustris* seedlings grown in containers generally have better survival than their bareroot cohorts and more promptly grow out of the grass stage. Photo by R. Kasten Dumroese

In Hawai‘i, *Acacia koa* A. Gray has an important place in Hawaiian culture, its valuable wood is renowned, and koa forests are crucial to existence of many endemic flora and fauna, many of which are threatened or endangered. Primarily, *A. koa* is desired for eventual harvest for specialty wood products, cultural uses, and to restore native forest to support endemic flora and fauna. Because *A. koa* is in the Fabaceae, its hard seeds can persist for decades in the seed bank, and with the correct site preparation, can be encouraged to germinate and grow. For sites lacking a viable seed bank, seedlings are the desired plant material. Using the most local seed source is recommended, but variability in elevation, soils, and precipitation can make collection difficult; seeds are not usually transferred among islands. If the objective is future forest products, then seeds should also be collected from trees with good form, whereas for restoring native forest and creating bird habitat, harvesting from a greater diversity of trees is encouraged to maintain genetic diversity. On most sites, competition from invasive grass, herbivory by cattle, and a lack of inoculant of *A. koa*’s symbiotic nitrogen-fixing bacteria (*Rhizobium*) in the soil are the main limiting factors. Competition can be reduced by scalping planting spots (either mechanically or with herbicides), temporary fencing may be needed to exclude cattle, and seedlings should be inoculated during nursery production. Outplanting coincides with the rainy season, generally March and April, and seedlings can be planted with a variety of hand tools, including augers, shovels, and planting bars. Thus, the current target seedling is grown for 12 to 18 weeks in a container (Fig. 6), inoculated with *Rhizobium*, and hand-planted during the rainy season onto sites where, if necessary, invasive grass have been controlled and grazing or browsing animals excluded (see Wilkinson and Elevitch 2003).

Figure 6. These *Acacia koa* seedlings are all the same age. The seedling on the left is the current stocktype widely outplanted, and performs well on sites where competition is controlled and herbivores are excluded. The seedling on the far right has been shown to thrive better than the small stocktype on highly competitive sites. Because the larger seedling grows faster, it may be desired when an objective is reducing time to canopy closure. Photo by R. Kasten Dumroese

Lebanon, a country with long-standing affinity for forests, in particular those of the Cedar of Lebanon (*Cedrus libani* A. Rich.), has undergone dramatic deforestation in its recent and extended past. Traditional reforestation practices were based on a linear model of procuring whatever plant materials were available and using local practices to outplant seedlings. Full payment for seedlings often did not occur until seedlings had survived for three years, resulting in both economic forfeit and failed-establishment scenarios. In 2011, the Lebanon Reforestation Initiative launched a multi-year project to introduce the TPC to growers and practitioners in the country. Beginning with source-identified seeds, growers now use a range of species, container volumes, and nursery cultural practices to provide seedlings with specific stem height and diameter tailored to varying field conditions. Maximum seedling height is now recognized as an important variable in limiting outplanting stress. This engagement of the TPC also shifted the outplanting season from the traditional post-winter window to an earlier fall season, allowing for better use of the rainy season. Finally, the traditional method of outplanting, which included large-scale mechanical site preparation (i.e., excavator), a pick to loosen rocks, and a hoe to make the final planting hole, has been shifted to a single-step process that utilizes a new combination hoe-and-pick tool (Fig. 7). The result is improved outplanting efficiency with reduced labor and site damage. Before application of the TPC, first-year survival was about 20 percent. After implementation (2011 to 2015), first-year survival rose to about 70 percent. Contributing to sustainability of this dramatic change, a newly formed cooperative of native plant nursery growers is regularly discussing needs and opportunities for improving seedling production. Additional research into field-irrigation for dry sites and vegetation control, as well as continued refinement of seedling parameters, should further improve plantation establishment.

Figure 7. Left: Two tools, a hoe and a pick, were traditionally used to plant seedlings in Lebanon's rocky soils. Right: Combining them into a new tool hasimproved outplanting efficiency with reduced labor, and along with target plants, is increasing seedling survival and growth. Photos by Darin Stringer

## 5 Summary

The TPC requires a nursery–client partnership; both parties must be involved in establishing objective sand defining target plant material through a series of interrelated questions: focus is on performance on the outplanting site and not on nursery performance. Although plant materials can be described by morphological and physiological characteristics, it is their performance on the outplanting site that matters; thus, immediate and long-term monitoring is crucial. This performance data is then used to refine the definition of the target plant material. Because it is a fluid concept and adaptable to any scenario, the TPC has been successfully used in a variety of forest restoration projects.

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