Nursery Cost-Estimating at the NRCS Bridger Plant Materials Center

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Abstract

The USDA Natural Resources Conservation Service Bridger Plant Materials Center (BPMC) at Bridger, Montana, has maintained cooperative agreements with Glacier and Yellowstone national parks for restoration research and native seed and plant production for nearly 15 years. Over time it became necessary to develop cost prediction tools to evaluate contractual obligations and allocate project resources. Since conventional nursery cost-estimating systems did not adequately address the increased expense of cleaning, inventorying, storing, and propagating wildland (uncultivated) seeds and plants, BPMC developed cost-estimate matrices based on production difficulty and the size of the seed production field, bareroot stock, or container unit. Production difficulty is determined by personal experience, the experience of other growers, or by numerical rating systems. Seed and plant values are based on Foundation seed prices or commercial and conservation nursery prices adjusted to reflect the additional inputs needed to grow wildland ecotypes for restoration projects. BPMC matrices can be used as templates for other cost-estimating systems and are easily modified as changing economic conditions, emerging propagation technologies, and unfavorable weather influence cost. It is recommended that contracting parties collaborate on the development of cost-estimate matrices, and that these matrices be used as evaluation and planning tools rather than accounting or budgetary systems.

Key Words

Matrix, matrices, restoration, ecotypes

Introduction

Since the late 1980s, the USDA Natural Resources Conservation Service Bridger Plant Materials Center (BPMC) has maintained cooperative agreements with the National Park Service (NPS), providing restoration research, technical support, and seed and plant production. This work involves the restoration of linear disturbances created by on-going highway reconstruction projects within Glacier and Yellowstone national parks. Funding for restoration activities has been provided by the Federal Highways Administration as part of the comprehensive effort to upgrade the road systems within each park.

Restoration policy within Glacier and Yellowstone national parks mandates the use of only plant species and propagules (seeds and cuttings) indigenous to each respective park. Relatively small, localized collections of propagules are made in the vicinity of each road project and used for seed and plant production. If environmental conditions or topographic features vary significantly over the length of a given construction project, multiple, separate collections of a single species may be necessary to assure adequate genetic sampling. Furthermore, in order to reduce the potential of genetic drift resulting from repeated off-site production, wildland seeds and cuttings are frequently used as production propagules in lieu of cultivated stock plants. Safeguards, such as the isolation of production fields and repeated cleaning of seed processing machinery (combines and cleaners), are necessary to guarantee the purity and genetic integrity of each lot during production. The additional expense of using non-cultivated propagules for production, and working with numerous, small collections, increases production costs relative to cultivated plants selected for vigor and productivity. The extrapolation of commercial production data, based on large-scale cultivation of superior selections, consistently under-estimates the cost of small-scale production of wildland ecotypes.

At BPMC, the need to estimate the value of restoration products arose from attempts to determine if contractual obligations to the NPS were being met. Additionally, the need to allocate resources for future projects dictated that the value of each product be estimated prior to project and contract development. This planning phase is particularly important in regards to seed and plant production, which often requires 3 to 4 years of lead time. In an attempt to estimate the true value of wildland ecotype production, BPMC developed cost-estimating matrices that assign values or costs to seeds and plants produced by BPMC for restoration projects (Scianna and others 2001). Although this system was conceived and designed for in-house use, the principles are broadly applicable and should be useful as a template for other projects involving ecotype-specific production for restoration and reforestation. Cost-estimating is not an accounting or budget management system. It represents an attempt to provide an approximation of the value of seeds and plants produced directly from native, wildland ecotypes.

Definitions

Cost-estimating, in the context of this paper, is defined as assigning monetary values to each product offered by a seed grower or nursery. In the case of BPMC, its purpose is to estimate the value of native, ecotype production for evaluating contractual obligations and allocating project resources. A matrix is a diagram or form consisting of a series of intersecting columns and rows. The intercept of each column and row is the value of a given product based on the difficulty of production and size of the seed production field, bareroot stock, or container plant. Large seed production fields of easy-to-grow species are least expensive, whereas small fields of hard-to-grow species are most expensive. Similarly, small, easy-to-grow plants are the least expensive to produce, whereas large, difficult-to-grow plants are the most expensive. Propagules are seeds and cuttings; wildland propagules are seeds and cuttings from uncultivated mother plants.

The High Cost of Restoration Production

The cost of producing seeds and plants of wildland ecotypes is higher than cultivated selections for several reasons. Restoration, by definition, implies some attempt to mimic the plant composition and natural diversity inherent to a particular site and geographic area (Majerus 1997). This is in contrast to mined land reclamation, revegetation, and reforestation projects that emphasize site stabilization or timber production with less emphasis on re-establishing plant communities, preserving population genetics, or maintaining species diversity. The goal of the restoration project and the constraints imposed by restoration policy influence the production costs associated with each project.

Restoration policy requiring the use of propagules taken only from local, native ecotypes increases the cost of production in several ways. Some of the additional expense of producing wildland ecotypes reflects propagule collection, which may or may not be the responsibility of the grower. Individual populations may be located in remote or inaccessible areas, resulting in high travel and collection costs. Seeds of many species ripen indeterminately, a situation exacerbated under non-cultivated conditions that may result in the need for multiple collection trips. In an attempt to adequately represent population genetics or species diversity, high numbers of individual plants may have to be sampled. Even if seeds and cuttings are provided to the grower, propagule production and viability are lower under wildland than cultivated conditions, requiring greater inputs of time and labor during all phases of production. Wildland seeds tend to have less fill and poorer germination rates than cultivated selections. As a result, stand establishment tends to be poor, with thin spots allowing weed establishment and driving up the cost of maintenance. In container production, empty cells require reseeding or culling. Individual plant populations, as defined by geographic, topographic, habitat-type, and climatic conditions, require scouting, sampling, storage, cleaning, production, inventorying, tracking, and shipping under isolated conditions. A lack of commercial incentive has resulted in less propagation research being conducted on uncultivated natives relative to ornamental selections. In many cases, a lack of established propagation and production protocols requires growers to resort to “trial and error” techniques that increase cost. In some cases, specialized harvesting and cleaning equipment are needed that further add to production expenses.

The small scale of production characteristic of many restoration projects also increases the cost of seed and plant production. Production inefficiencies resulting from the handling of multiple small lots or maintenance of small, isolated fields increases per unit cost as described later.

Cost Estimate Matrix

An example of a cost-estimate matrix appears in table 1. Column headings represent the level of production difficulty, whereas rows indicate the size of the seed production field, bareroot stock, or container plant. The point of intercept represents the estimated value or cost of the product.

Establishing Level of Difficulty

The amount of difficulty associated with producing a given species correlates closely with the final cost of production. Any production factor that increases time, labor, and material investment increases cost. These costs are not static over time, however, reflecting inflation, market supply and demand, emerging technologies, regulatory issues, and other factors that influence production costs. Costs also vary in response to weather conditions, insects, diseases, and other environmental factors. Production difficulty, as used here, reflects conditions during cultivation, but does not involve propagule collection. If growers are involved in the collection process, they should bill for collection services separately or integrate the cost of propagule collection into their products.

There are several methods of determining the level of production difficulty, including personal experience, the experience of other growers, inferences based on the commercial value of the same or a closely related species, and numerical rating systems. At BPMC, we subjectively assign a rating of “low,” “medium,” or “high” degree of difficulty based on our experiences growing a particular species. For species that we have not grown, we rely on our experience growing related plants, or gather information from other growers and references. In some cases, inferences can be made on the difficulty of production based on commercial prices for the same or closely related species. Systems that rate production difficulty based a numerical approach can also be used (table 2). Any number of production factors may be delineated based on their relative impact on production at a given nursery. Production factors are rated on a weighted scale and then tallied to determine if they fall within a numerical range indicating a low, medium, or high level of production difficulty. In the case of slenderbeak sedge (*Carex athrostachya*) in the example in table 2, increased inputs of time and materials are needed for several production factors that result in a “medium” difficulty rating.

For grass seed, production difficulty reflects seed dormancy characteristics, seedling emergence, rate and degree of stand establishment, cultural requirements, stand vigor, speed and degree of seed production, harvesting, and seed processing. Numerous secondary factors are also involved, such as weed management, stand longevity, predisposition to insects and disease, and other factors. Species such as slender wheatgrass (*Elymus trachycaulus* ssp. *trachycaulus*), mountain

Table 1. Cost estimate matrix based on production difficulty and unit size.

Type of Production	Production Difficulty: Low	Medium	High
I. Seed Production			
small field (≤ 0.1 ac [0.04 ha]) grass	$35/lb	$50/lb	$100/lb
medium field (> 0.1 to 0.25 ac [0.04 to 0.1 ha]) grass	$25/lb	$40/lb	$75/lb
large field (> 0.25 ac [0.1 ha]) grass	$15/lb	$30/lb	$60/lb
any size field (forbs)	$50-100/lb	$100-300/lb	$300+/lb
any size (shrubs and trees)	NA	NA	NA
II. Plant Production			
A. Bareroot Production (shrubs and trees)			
1+0	$1/plant	$2/plant	$3/plant
2+0	$1.25/plant	$2.25/plant	$3.50/plant
3+0	$1.50/plant	$2.50/plant	$4/plant
B. Container Production			
4 to 10 cubic inch (grass)	$1/plant	$2/plant	$4/plant
4 to 10 cubic inch (forb and shrub)	$2/plant	$3/plant	$5/plant
4 to 6 inch square pots (forb and shrub)	$3/plant	$5/plant	$7.50/plant
1 to 3 gal (3.8 to 11.3 l) (shrubs)	$5/plant	$7.50/plant	$10/plant
> 3 gal (11.3 l) priced separately (shrub)	NA	NA	NA
B&B priced separately (shrub)	NA	NA	NA

All costs in US$.

Table 2. Seed production difficulty of slenderbeak sedge (*Carex athrostachya*).

	Production Difficulty		
Production Factors	Low (0-33)	Medium (34-65)	High (66-100)
Wildland seed viability	0		
Wildland seed sowing			10
Wildland seed dormancy	0		
Cultural requirements		5	
Seedling vigor	0		
Stand productivity		5	
Stand longevity	0		
Time interval until final product		5	
Harvesting production seed			10
Cleaning production seed	0		
Subtotal:	0	15	20
Total:			35

brome (*Bromus marginatus*), streambank wheatgrass (*Elymus lanceolatus* ssp. *lanceolatus*), western wheatgrass (*Pascopyrum smithii*), and basin wildrye (*Leymus cinereus*) are "low" difficulty because they are easy-to-grow and prolific seed producers. Blue wildrye (*Elymus glaucus*), bluebunch wheatgrass (*Pseudoroegneria spicata*), sedges (*Carex* species), alpine timothy (*Phleum alpinum*), alpine bluegrass (*Poa alpina*), and tufted hairgrass (*Deschampsia cespitosa*) are "medium" difficulty because of one or more production challenges. Richardson's needlegrass (*Achnatherum richardsonii*), needleandthread (*Hesperostipa comata*), prairie junegrass (*Koeleria macrantha*), and pine grass (*Calamagrostis rubescens*) are considered "high" difficulty to produce, primarily because of stand establishment, seed processing, or seed production limitations. For bareroot and container plants, production difficulty often reflects seed dormancy, germination rate, seedling survival, cultural requirements, and rate of growth. Species such as chokecherry (*Prunus virginiana*), silverberry (*Elaeagnus commutata*), serviceberry (*Amelanchier alnifolia*), and Oregongrape (*Mahonia repens*) have high rates of germination and growth, and are considered "low" difficulty. In contrast, common snowberry (*Symphoricarpos albus*) and Rocky Mountain juniper (*Juniperus scopulorum*) have lengthy dormancy-breaking periods and erratic germination that makes them "medium" and "difficult," respectively. Although experienced growers know inherently which species are more difficult, and hence more expensive to grow, quantifying production difficulty helps justify cost during contract development and evaluation.

Production Unit Size

As noted earlier, the size of the seed production field, bareroot stock, or container plant is the second factor that has a direct bearing on the price of seeds and plants. The normal production efficiencies associated with economies of scale and large-scale production are not achieved with small lots of wildland ecotypes or cultivated selections. As an example, it may take as long to travel to a small production field and back as it does a large field. The cost of that travel is, therefore, greater per unit of product for a small field because it is distributed over fewer seeds or plants. Additional expenses may be inherent in the production of numerous small lots, such as production inefficiencies arising from the need to physically isolate the same or closely related species during production. In greenhouse production, media, irrigation, and nutritional requirements may vary widely by species. The need to custom culture numerous species often leads to increased manual labor, such as hand watering, that increases cost. Large and older nursery stock requires greater inputs (relative to small, young stock) of time, labor, and materials that drive up the cost of production. Even the temporary storage of container plants at the nursery requires additional inputs of water, fertilizers, pesticides, and labor that increase cost.

Establishing Unit Value

At BPMC, we use current Foundation seed prices as a baseline for determining the value of seed production. Foundation prices reflect the additional cost of isolation and purity mandated by federal and state seed laws. As an example, Montana standards for Certified basin wildrye allow a maximum of 0.5% of other grass species, whereas the Foundation class only allows 0.1%. Similarly, Certified basin wildrye can have a maximum of 0.5% weed seeds, whereas the Foundation class only allows 0.3% (Handbook of Standards 1995). In addition, Foundation seed prices remain relatively stable over time, whereas Certified and common seed prices tend to fluctuate in response to various market factors. If Foundation prices are unavailable, we base price on the Foundation value of a closely related species or estimate value based on actual time and materials. To determine the additional cost of wildland seed production above Foundation, we collect hourly maintenance and cultivation data for the production cycle of a given species and then adjust price. For plant production, BPMC uses commercial and conservation nursery price data as a baseline, and then adjusts upwards as previously described. Although only an approximation of value, this system allows BPMC to estimate the additional expense of producing plants for restoration projects.

Production Valuation

Based on production difficulty and unit size, the value of each species or lot can be determined and the entire value of production calculated (table 3). This calculation may be based on actual production that year or anticipated production based on historical data. Actual production value data can be used to determine if contract obligations were met for a given contract interval. Anticipated production data can be used to allocate funds for specific types of production based on restoration needs and project resources. Adjustments can be made to the product mix so that more seeds or plants of easy or moderately difficult species can be grown on a larger scale to meet target production. Adjustments to the product mix must consider the restoration goals of the project as they relate to species diversity and gene preservation factors that may reduce the amount of production possible for a fixed level of funding.

Cost Inflation Over Time

A frequently overlooked factor in determining the value of products and services, particularly with multi-year contracts, is cost inflation. Product costs typically increase over time as expenses such as labor, utilities, taxes, and materials increase. Budget and contract managers should develop a strategy to address inflation during contract negotiations. For multi-year contracts in which the same level of funding is available each year, the amount of production should decrease annually to account for inflation. Another option is to average production over the length of the contract to account for inflation, that is, provide a reduced but consistent level of production each year. If a fixed amount of production is needed annually, the cost of that production should increase each year.

The annual inflation rate may be projected from the Consumer Price Index or based on increases in actual expenses incurred over a given time period (Schaefer 2002). The future cost of a product for a given rate of inflation can be calculated by the formula, $X (1 + I)^N$, where "X" is the original amount of money, "I" is the

Table 3. Calculating entire production value.

Species	Field Size (acres)	Production Difficulty	Unit Value Per Pound	Amount of Seed Produced (pounds)	Species Value
BRMA	0.19	Low	$25	23.00	$575
BRMA	0.12	Low	$25	17.00	$425
BRMA	0.12	Low	$25	36.00	$900
BRMA	0.23	Low	$25	38.00	$950
ELTR	0.23	Low	$25	67.52	$1,688
ELTR	0.12	Low	$25	62.00	$1,550
LECI	0.15	Low	$25	27.00	$675
AGSC	0.12	Medium	$40	9.95	$398
AGSC	0.23	Medium	$40	22.00	$880
ELGL	0.23	Medium	$40	27.50	$1,100
FEID	0.23	Medium	$40	2.38	$95
PSSP	0.23	Medium	$25	27.00	$675
ELEL	0.23	High	$75	9.57	$718
HECO	0.27	High	$60	30.00	$1,800
				Subtotal:	$12,429

All costs in US$.

inflation rate in percent, and "N" is the number of years. At BPMC, we plan production for an annual inflation rate of 4%. For example, if US$ 10,000 were needed to produce 10,000 plants in Year 1, the cost of the same 10,000 plants would increase to US$ 11,698.58 by Year 5 (4 years of inflation) given a 4% annual inflation rate. Similarly, only 8548 plants could be produced in Year 5 if funding remained static with a 4% annual inflation rate. Fair compensation aside, it is only important that the contracting parties recognize the additional cost of doing business over time and then address the issue in some mutually agreeable fashion.

Summary

The cost-estimating system developed by BPMC and NPS represents an attempt to assign values to seeds and plants that more accurately reflect the additional cost of ecotype-specific production for restoration projects. Additionally, cost-estimate matrices provide information indicating why one species is more expensive to produce than another, and why it is more costly than commercial production of a cultivated selection of the same species. This up-front information allows restorationists and budget managers to select species mixes that meet both the biological and economic constraints of the project. The price of seeds and plants of some wildland species could potentially approach that of commercial selections as production protocols are refined and if the scale of production increased.

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