Photo by David E Steinfeld

Roadside revegetation of forest highways: new applications for native plants

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ABSTRACT

Road revegetation with native plants is both a challenge and an opportunity. A new partnership between the Western Federal Lands Highway Division of the Federal Highway Administration and the USDA Forest Service is focusing on the use of native plants for forest highway road revegetation and road obliteration projects. This emphasis is leading to new applications for many native plant species, as well as development of new stock types, innovative equipment, and monitoring techniques. The process of road planning and development has become more holistic and comprehensive, allowing engineers and biologists to work in partnerships to bring about desired results. Unique challenges of road revegetation projects include harsh conditions, high visibility, and a lack of available information and techniques. Road revegetation offers unique opportunities, including long lead times that facilitate advanced seed procurement and nursery development of native plants, as well as allowing time to evaluate different installation techniques. Two projects highlighting some innovative road revegetation strategies and native stock types are discussed: one along a scenic section of a river on steep mountainous terrain, another on a well-traveled, visually sensitive road near a ski area. Strategies included developing and testing hydroseeding mixes and application techniques with native shrub, forb, and grass species; developing seeded mats for establishing native grasses on severe sites such as gabion walls; and overcoming obstacles to obtaining and increasing high-quality local native plant seed. Because little information is available on revegetating roads with native plants, a new manual is being created to help meet the challenges ahead.

KEY WORDS
road, restoration, nursery, mulch

NOMENCLATURE
USDA NRCS (2004)

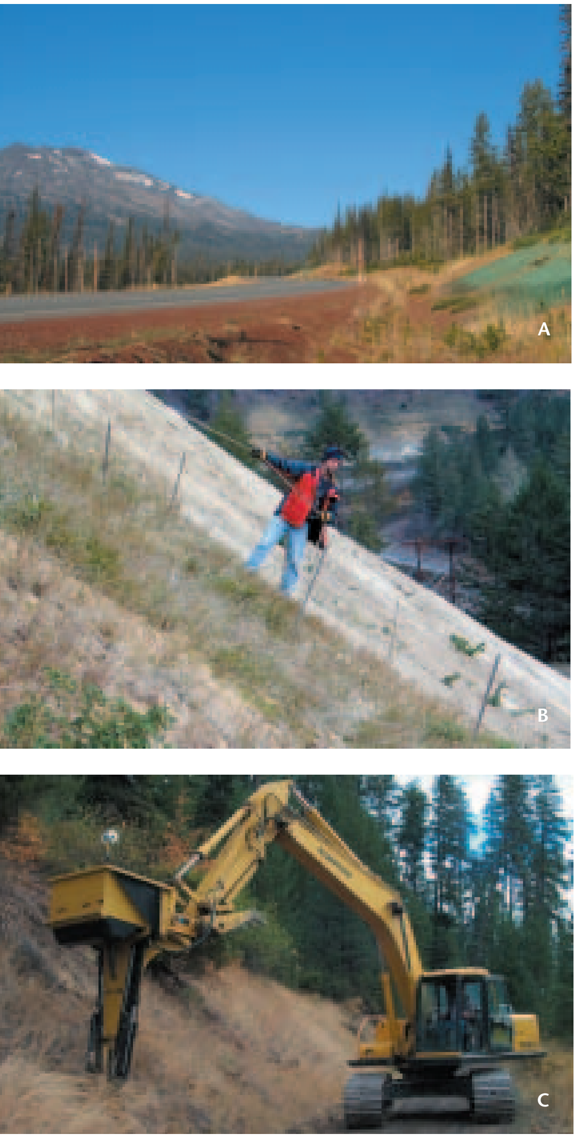


Figure 1. Forest highway revegetation is challenging because all aspects of a project are highly visible (A) and slopes can be in excess of 45 degrees (B). On the positive side, all projects are all-weather accessible by heavy equipment such as the Expandable Stinger (C).

Photos by: A, Christy Lowe; B, David E Steinfeld; C, Dan Cully

The Western Federal Lands Highway Division (WFLHD) of the Federal Highway Administration has been building roads on National Forest lands since the 1920s. At that time, little consideration was given to revegetation during or after road construction, and if it was, it merely involved seeding some introduced grass species. Today, the Federal Highway Administration and the USDA Forest Service have developed a partnership focusing on the use of native plants. This partnership has led to a more holistic and comprehensive process for road planning and development in order to facilitate the successful establishment of native species. Engineers and biologists working together from these 2 organizations have developed some new and exciting uses for a wide range of native plants including forbs, shrubs, and trees, in addition to grasses. The partnership has also led to the development of new stock types and innovative equipment.

CHALLENGES AND OPPORTUNITIES OF FOREST HIGHWAY REVEGETATION

Revegetating forest highways presents some unique challenges compared with typical restorations. Projects are highly visible to the public, often year-round (Figure 1A). The severely compacted soils are typically some mixture of subsoil and parent material, highly eroded by wind and water, and completely lacking beneficial microorganisms. Often, slopes can be very steep and some inaccessible on foot (Figure 1B). Engineering structures such as gabion walls make revegetation difficult, and invasive weeds rapidly take over the highly disturbed and compacted soils. Historically, highway revegetation projects were merely hydroseeded with nonnative grasses and so there is a lack of published research, case studies, or guidelines for using native plants. Because of the need to use source-identified natives, the cost of producing seeds or growing nursery stock is often considered excessive. Finally, roadside maintenance activities, such as mowing, can conflict with the use of many native plants.

These challenges are balanced by some interesting advantages and opportunities that are characteristic of forest highways. Revegetation units are long and narrow and, because they border paved roads, they remain accessible to heavy equipment in any weather (Figure 1C). Instead of being an afterthought, funding for revegetation is part of a comprehensive WFLHD project planning and development process. Federal highway projects often have a long lead time, typically a year or more, which allows for nursery stock production and seed increase. Revegetating with native plants supports the Native Plants Policy that was recently adopted by the Forest Service.

When it comes to using native plants, most engineers and even some restorationists have voiced serious reservations: “Native plants won’t hold up on harsh sites,” “Native species are too expensive,” “Native seeds and plants are hard to find,” or “Native seeds don’t store well.” But, as evidenced by the wide range of articles in this journal, the quality of native plant materials has increased exponentially in recent years, and seed producers and nurseries can be found throughout the country. In addition, new native plant stock types are continually being developed to fit special restoration needs.

MOVING AWAY FROM EXOTICS AND TOWARD NATIVES

Road revegetation has traditionally been accomplished with exotic plants because exotics were cheap, readily available, and easy to establish on disturbed sites. Using native plants along roadsides, however, is increasing in popularity. Way back in 1932, the Texas

Department of Transportation hired a landscape architect to encourage use of wildflowers and other natives along rights-of-way (Markwardt 2005). The Federal Highway Administration recently published a landmark book called *Roadside Use of Native Plants*, which has become a standard reference (Harper-Lore and Wilson 2000). In *Road Ecology: Science and Solutions*, an entire section is devoted to establishment and management of roadside vegetation (Forman 2003).

Using a variety of native plant species from grasses and forbs to woody shrubs and trees not only heals the disturbance of road construction but helps blend road rights-of-way back into the surrounding plant communities (Figure 2). In addition, revegetating with natives minimizes opportunities for noxious or invasive species to establish on road-

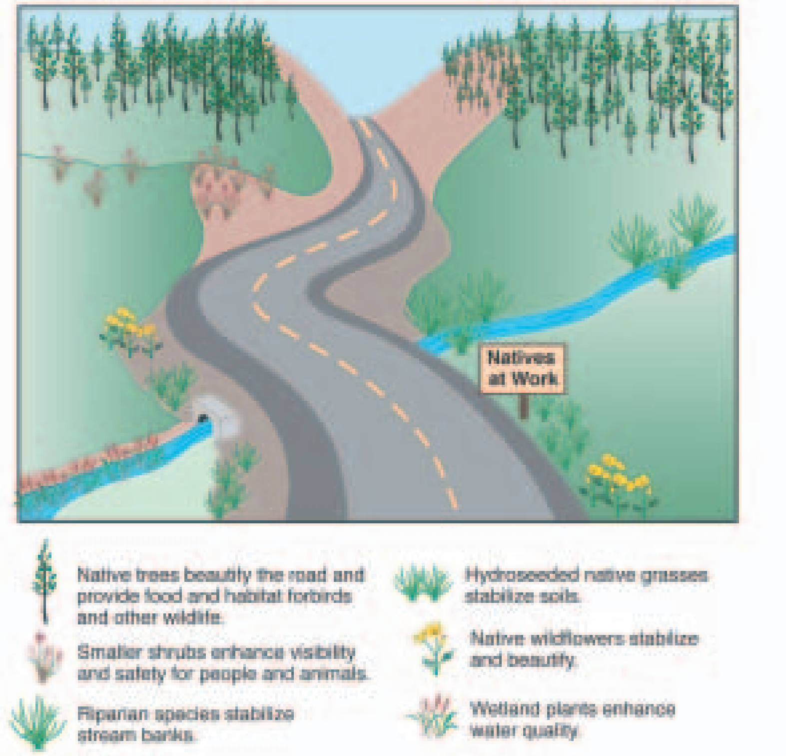
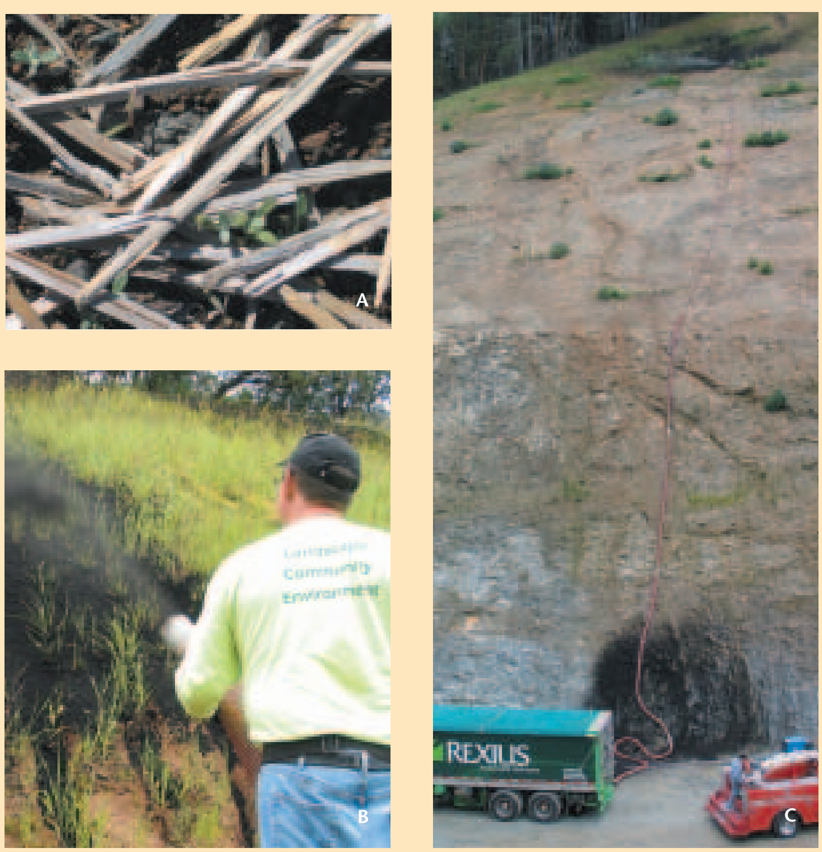


Figure 2. Using locally adapted native plants along forest highways not only fulfills restoration objectives but creates a visual transition to surrounding plant communities.

New Mulches for Extreme Sites

Photos by David E Steinfeld



Traditional hydroseeding has not always proved effective and durable on forest highway cuts and fills, so other mulches and application equipment are being tested. Besides the durability issue, many people have observed that seeds germinate better under a straw covering than under hydromulch. WoodStraw™ erosion control mulch is a new product developed by Forest Concepts LLC, consisting of long narrow strands of wood that are heavy enough to resist wind and water erosion yet can be applied with a straw blower. Like straw, WoodStraw™ mulch appears to moderate extreme surface temperatures and maintain high humidity, creating an ideal germination environment (*A*). In our initial trials, WoodStraw™ appears to persist better than grass straw that blows around in strong winds and often decomposes within a year. This longer durability benefits germination and establishment of native plants.

Rexius EcoBlanket® is another organic mulch that appears promising. This product consists of municipal compost that is effective in covering highly erosive soils on steep slopes and can even fill-in deep rills (*B*). Applying this mulch is relatively easy because it is transported in large trucks that can pump it to the top of very steep slopes—up to several hundred feet high (*C*).

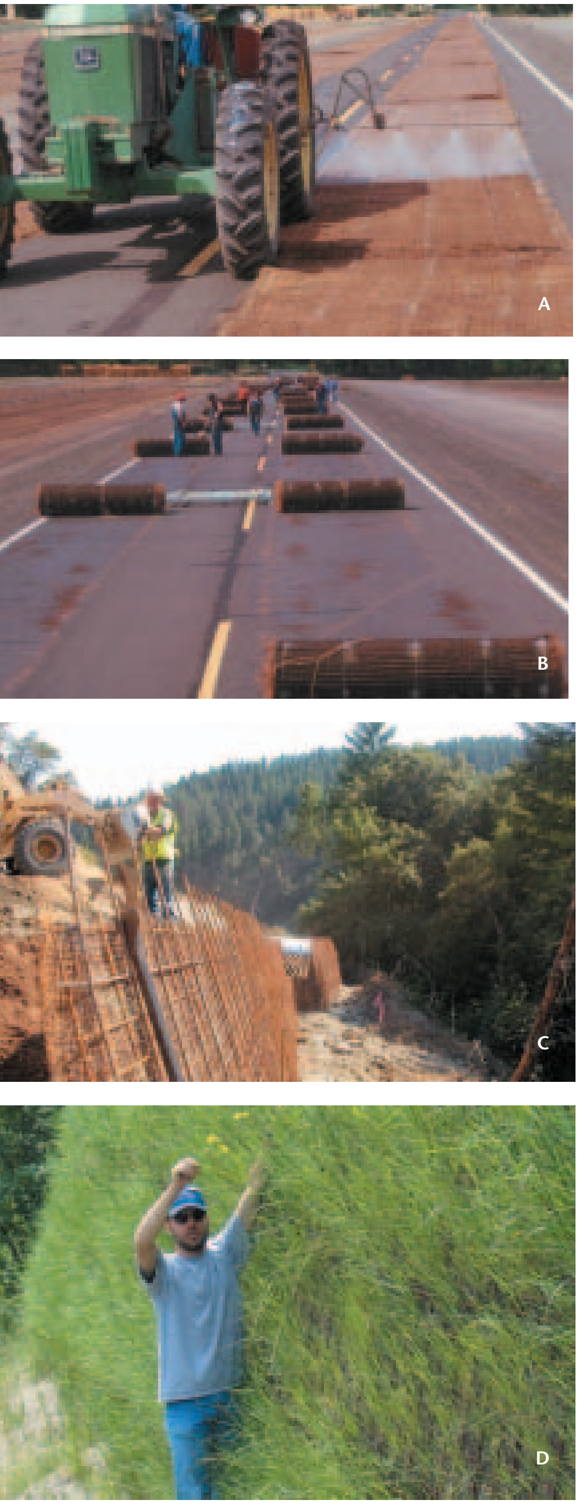


Figure 3. Gabion walls were used in road reconstruction in steep terrain along the Rogue River in Oregon. Revegetating them was a challenge. Native grass and forb seeds were glued to erosion control blankets (A), which were rolled up (B) and installed on the outside of the gabion walls (C). One year later, the walls were covered with a lush mat of native grasses and forbs (D). Photos by: A, B, D, David E Steinfeld; C, Scott Blower

TABLE 1

Native species meet the challenges of forest highway revegetation.

Revegetation objective	Function of native plants
Erosion control	Controlling surface erosion is a high priority on forest highway construction projects. Native grasses, forbs, and other herbaceous plants can help meet this challenge, particularly when their establishment is facilitated by good installation and management. Deep-rooted native trees and shrubs can also enhance stability of cut and fill slopes.
Visual enhancement	Vegetation is often used to enhance the aesthetic experience of the traveler. Wildflowers add beauty in spring and summer, deciduous trees change color in fall, and evergreen species stay green all winter long. Vegetation can also be used to hide structures such as gabion walls or slopes covered by riprap.
Weed control	Forest highways are corridors for transport and establishment of noxious or invasive species. Once established, weeds are hard to eradicate and become seed sources for further encroachment. Revegetating with desirable natives minimizes opportunities for problematic species to establish.
Wildlife protection	Some forest highways intercept corridors for animals. An understanding of forage preferences and a careful design that accounts for visibility and safety can guide animals to safe passageways for travel while minimizing dangerous interactions with vehicles. The presence of birds and small animals can be enhanced when appropriate plant species are reestablished.
Cost management	Native plants are up to the challenge of revegetating both road sides and obliterated roads. Advanced planning, some small-scale trials, and the use of appropriate stock types and equipment all facilitate successful and cost-effective revegetation with natives.

sides, thus preventing forest highways from becoming corridors for the transport of problematic species. A few of the ways that native plants can fulfill restoration objectives of forest highway projects are listed in Table 1.

Revegetating Gabion Walls

The Agness-Illahee Road is along the designated Wild and Scenic section of the Rogue River in western Oregon. The Rogue is a world famous fishing and rafting destination, and so, one of the primary revegetation objectives was to minimize the visual impact of the road reconstruction. Because of the steep mountainous terrain, design engineers had to make extensive use of gabion walls that would be visible to recreational users on the river. The area in front of the walls would be planted with shrubs and trees to screen the wall in the long term. The challenge was to reduce the visual impacts of the walls until this vegetative screen could establish.

Development of Seeded Erosion Blankets

The initial revegetation plan specified filling the face of the gabion baskets with a mixture of grass seeds and soil. Because we had a couple of years to test new techniques, we constructed gabion test walls at 2 different locations: the JH Herbert Stone Nursery (JHSN) in Central Point, Oregon, and the project site. In our first test, we filled gabion baskets with rocks in the back and a 30-cm-wide (1-ft) layer of soil mixed with seeds on the inside face. That did not work, apparently because many of the seeds were sown too deeply, so, for our second attempt, we glued seeds with a tackifier to several types of erosion control blankets. The use of vegetated erosion control blankets isn't new (van der Grinten and Gregory 2000), but we installed them just inside the wire mesh on the exposed face of the gabion. We tried seeds of several native grasses and learned that blue wildrye (*Elymus glaucus* Buckl. [Poaceae]) germinated but didn't persist well after the first year. Based on these initial trials, we selected a more persistent grass species, California fescue (*Festuca californica* Vasey [Poaceae]) and applied it to the best-performing erosion blanket.

Implementation

Using experience gained during these trials, we developed an operational way to mass produce seeded blankets. We laid long lengths of erosion fabric on the road at JHSN, applied seeds by hand, and glued them with a tackifier (Figure 3A). After the blankets were dry, we rolled them up (Figure 3B), and transported them to the project site. There, blankets were cut to the dimensions of the gabion baskets and installed on the outer surface (Figure 3C). Finally, baskets were back-filled with topsoil. Although the gabion walls were constructed during summer, the grass seeds did not germinate until fall rains began. One year later, the grass had bound the erosion fabric and soil into a well-established vegetated mat (Figure 3D). With this process, we created an effective way to revegetate severe sites such as gabion walls.

Hydroseeding a Greater Diversity of Native Plants

Hydroseeding has traditionally been used to stabilize soils on restoration projects using cultivars of exotic grasses (for example, Salkever 1994). In our federal highway projects, however, we use seeds of native forbs and small-seeded shrubs as well as native grasses. Some of our seed mixes have a 3:1 forb-to-grass ratio.

For example, the forest highway leading up to Mt Bachelor Ski Area in the central Oregon Cascades is well traveled year-round and therefore very visually sensitive (Figure 1A). The road traverses deep pumice soils with high infiltration rates and little surface runoff, and therefore, sedimentation was not an issue. On steep slopes, however, wind erosion and soil creep reduce plant establishment and therefore, we assumed that hydroseeding would be necessary to stabilize the cut slopes. Thus, our objective was to revegetate the highway right-of-way with a diversity of visually appealing plants that could survive on the unstable, droughty pumice (Figure 4A).

Testing Hydromulch Rates and Application Methods

During the planning stages, we anticipated the need for relatively high rates of hydromulch (up to 3363 kg/ha [3000 lb/ac]) for stabilization and to maintain moisture around the seeds on these droughty pumice soils. We established some trials in the fall to determine the proper hydromulch application rate as well as the best method of application. Should we mix seeds into the hydromulch and apply them together, or apply seeds first and then cover them with mulch? We established the following treatments along the forest highway (Figure 4B): 1) no mulch (control); 2) 1121 kg/ha (1000 lb/ac) of hydromulch/seed mix; 3) 2242 kg/ha (2000 lb/ac) of hydromulch/seed mix; 4) hydroseed first, followed by 2242 kg/ha (2000 lb/ac) of hydromulch; and 5) 3363 kg/ha (3000 lb/ac) of hydromulch/seed mix. This hydromulch rate with a cross-link tackifier creates what is known as a bonded fiber matrix (Figure 4C). All treatments included seeds, tackifier, fertilizer, mycorrhizal fungi, and biostimulant.

I-Buttons® were installed just under the soil surface in both the control and the 3363 kg/ha (3000 lb/ac) treatments. A field visit to the site the following spring revealed that most of the hydromulch was either gone or the tackifier had not held the fibers together. When we downloaded the temperature data from the I-Buttons®, it showed extreme temperatures during late winter and

Figure 4. Instead of hydroseeding highway cuts and fills with only grass seeds, we established trials testing hydromulch rates and application methods for the mixes (A). The highest application rate created a bonded fiber matrix (B). Monitoring the test plots proved difficult on the steep, unstable pumice soils (C).

Photos by David E Steinfeld

Figure 5. Hydroseeding is one of the best ways to revegetate highway cuts and fills and to retard soil erosion (left). On the Agness-Illahe project above the Rogue River in Oregon, we hydroseeded with a mixture of native grasses and forbs, which were well established by the following year (right). Photos by: left, David E Steinfeld; right, Steve Feigner.

early spring during periods of no snow cover. On some days, temperatures ranged from 40 °C (118 °F) during the day to –2 °C (28 °F) at night, causing frost heaving. We believe that successive freeze–thaw cycles for as long as 6 wks weaken the adhesion of the tackifier to the mulch particles. This, combined with the erosive effect of wind, severely decreased hydromulch effectiveness. These observations have made us question the use of hydromulch on these severe sites. Our initial observations confirmed that some seeds germinated, and we will continue to monitor these tests. This will be challenging, however, because we can't walk on pumice-cut slopes without damaging the sites (Figure 4D). So, the Forest Service and Federal Highway Administration are investigating innovative equipment to remotely monitor these sites.

Hydroseeding Successes

On the Agness-Illahee project, we also established hydroseeding trials with native grasses and forbs. Another primary revegetation objective was to keep sediment from reaching the river. This site receives up to 2540 mm (100 in) of annual rainfall, primarily during winter, and the runoff could carry sediment directly into the river. We found that hydromulch containing tackifier was effective in stopping soil erosion from steep cut and fill slopes (Figure 5, left). In most areas, the hydromulch was still intact the following spring facilitating the establishment of a diverse mix of grasses and forbs (Figure 5, right).

These hydroseeding trials on the Mt Bachelor and Agness-Illahee projects confirm that every site is different, and it is necessary to understand a site's unique soil and climate when developing a revegetation plan. Our trials also demonstrate the value of testing treatments before road construction actually begins.

OBTAINING LOCAL SOURCES OF NATIVE SEEDS AND PLANTS

On any revegetation project, one of the first obstacles is locating local sources of high-quality native plant seeds. The WFLHD project development process allows adequate time to collect seeds of native plants on-site, so that seeds or seedlings can be produced in time for the actual revegetation.

Using an example from the Mt Bachelor project, we noticed during the initial walk-through that the hardy native Pacific lupine (*Lupinus lepidus* Dougl. ex Lindl. [Fabaceae]) was thriving on these cinder gravels. In addition to nitrogen-fixing, the lupine's blue-purple flowers are very attractive against the red cinder background (Figure 6A). During the first year of the planning process, we collected seeds around the project area and then negotiated a seed increase contract with a local grower. Other "workhorse" native species that we collected for that project included common woolly sunflower (*Eriophyllum lanatum* (Pursh) Forbes [Asteraceae]) (Figure 6B) and silverleaf phacelia (*Phacelia hastata* Dougl. ex Lehm. [Hydrophyllaceae]). Seeds of these 2 species are also being grown through a seed increase contract. By the time actual construction begins, we will have a supply of locally adapted, source-identified seeds for hydroseeding. As another option, we can contract with a local nursery to grow plants for the project area.

Once a seed increase contract is in place, it is easy to procure a wide variety of native plant seeds or nursery stock rather than hope that nurseries or seed producers will have the species needed. The USDA Forest Service Regional Seed Increase Contract can be used to procure seeds for a variety of road and other revegetation projects. Because of the size and scope of this advance contract, local native plant seeds can be produced within a year at reasonable cost (Table 2). Species such as blue wildrye and California brome usually produce large

TABLE 2

Examples of actual cost (US$) and annual production from the USDA Forest Service Regional Seed Increase Contract in 2004.

SEEDS				
Common name	**Scientific name**	**Cost per kg (lb)**	**Production kg (lb)**	
Blue wildrye	*Elymus glaucus* Buckl (Poaceae)	$13.25 ($6)	3084 (6800)	
California brome	*Bromus carinatus* Hook. & Arn. (Poaceae)	$13.25 ($6)	2223 (4900)	
Idaho fescue	*Festuca idahoensis* Elmer (Poaceae)	$19.85 ($9)	1406 (3100)	
Squirreltail	*Elymus elymoides* Raf. Swezey (Poaceae)	$46.30 ($21)	725 (1600)	
Mountain goldenbanner	*Thermopsis rhombifolia* var. *montana* (Nutt.) Isely (Fabaceae)	$50.70 ($22)	45 (100)	
American bird's-foot trefoil	*Lotus unifoliolatus* (Hook.) Benth. (Fabaceae)	$160.90 ($73)	8 (18)	
PLANTS				
Common name	**Scientific name**	**1+0 Bareroot**	**Styroblock® Container**	
			246 cm³ (15 in³)	**328 cm³ (20 in³)**
Oceanspray	*Holodiscus discolor* (Pursh) Maxim. (Rosaceae)	$0.75	$0.85	$1.95
Serviceberry	*Amelanchier alnifolia* (Nutt.) Nutt. ex M. Roemer (Rosaceae)	$0.75	$0.85	$1.95

crops the first year, but Idaho fescue and squirreltail take 2 years for an appreciable harvest. To date, more than 40 grass, sedge, and forb species have been produced under this contract as well as 15 shrubs and trees. For specific details of the Regional Seed Increase Contract, contact Scott Riley.

CONCLUSIONS

In the past, forest highway revegetation was usually carried out in piecemeal fashion, often with inadequate communication among stakeholders, including engineers and biologists. A lack of available information regarding species, technologies, and strategies contributed to difficulties and may have perpetuated some of the myths that "natives don't work" on harsh sites. The partnership between the Federal Highway Administration and the USDA Forest Service was formed to meet the challenge of revegetating forest highways with native plants. This partnership facilitates a comprehensive, holistic process of plan-

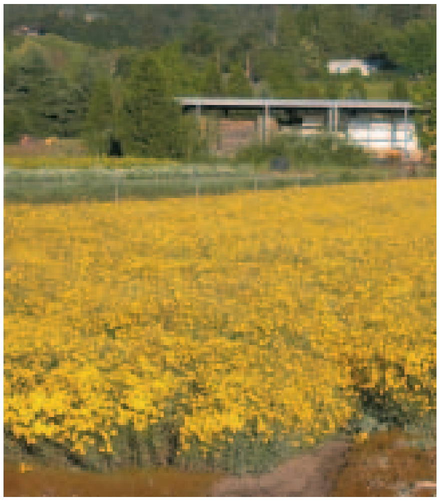


Figure 6. The WFLHD project development process allows adequate time so that seeds or cuttings of adapted plants can be collected on or near the project area (left) and seeds and plants produced by growers (right) before the actual revegetation begins. (left = *Lupinus lepidus*, right = *Eriophyllum lanatum*) Photos by: left, Scott Riley; right, David Davis

ning, implementation, and monitoring of roadside revegetation, involving numerous stakeholders to ensure successful establishment of a sustainable native plant community.

This article presents just a few examples of how native species can meet the challenges of forest highway revegetation. Engineers and biologists working together have pioneered technologies and innovations with native stock types and applications to strengthen and expand the use of native plants for forest highway projects. Each new project will provide unique opportunities and challenges, so there will be a continuing need to develop new establishment technologies and stock types. The Federal Highway Administration planning process allows several years to collect seeds and contract for source-identified, locally adapted plant materials. This lead time is also an opportunity to try out different installation strategies for improved results.

Native species can and do work on roadsides and other harsh sites. Because there is little published information on forest highway revegetation with native plants, we are working on a procedural manual, *Roadside Revegetation: A Practical Guide to Working with Native Species*. The user-friendly book will help fill current information and technology gaps, share successful strategies and techniques, and guide biologists, engineers, restorationists, and other stakeholders through the process of successful establishment of native species on roadsides.

Revegetating Obliterated or Decommissioned Road Sections

Woody shrubs and trees are needed to provide visual screening and prevent access on obliterated roads.
Photo by David Steinfeld

On some forest highway projects, sections of the old road are abandoned and these present unique challenges. The Federal Highway Administration calls these "obliterated" roads whereas the USDA Forest Service uses the term "decommissioned." As an example, an obliterated section of state highway near Chiloquin, Oregon, was successfully revegetated with native trees and shrubs. Locally collected seeds of Klamath plum (*Prunus subcordata* Benth. [Rosaceae]), chokecherry (*Prunus virginiana* L. [Rosaceae]), aspen (*Populus tremuloides* Michx. [Salicaceae]), ponderosa pine (*Pinus ponderosa* P.& C. Lawson [Pinaceae]), antelope bitterbrush (*Purshia tridentata* Pursh DC [Rosaceae]), and Saskatoon serviceberry (*Amelanchier alnifolia* (Nutt.) Nutt. ex M. Roemer [Rosaceae]) were grown in containers at the JH Stone Nursery. Containers included sections of PVC pipe called "longtubes" (46 cm [18 in] long with a volume of 4343 cm^3 [265 in^3]) and "Tall One" TreePots™ (36 cm [14 in] long with a volume of 2385 cm^3 [173 in^3]). On this site, the highway engineers removed the blacktop but no topsoil was available for amendment. To reduce compaction and improve water infiltration, the old roadbed was ripped to a depth of 76 cm (30 in) and a 10-cm (4-in) layer of wood mulch was applied to the surface. Trees and shrubs were outplanted by hand in March 2004 and, as of July 2005, most plants are alive and thriving, probably because the mulch maintained soil moisture near field capacity throughout summer on this normally dry site.

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