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A Manager's Guide to Roadside Revegetation Using Native Plants

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16. Abstract

This guide is intended to support managers in facilitating successful protection and/or establishment of native vegetation as an integral part of road design and construction. This report summarizes the concepts and approaches developed in Roadside Revegetation: An Integrated Approach to Establishing Native Plants, from a manager's perspective. While the full report is designed for field-level practitioners, it is this reference document that engineers and managers should use as a guide in project planning, design, and construction. This guide summarizes an integrated approach to effectively revegetating roadsides and other disturbance areas associated with road construction, modification, or obliteration. Management issues including scope, schedules, budgets, communication, and quality assurance are outlined as they relate to integrating revegetation practices.

By incorporating an integrated approach to revegetation into project management, the end product, the finished road, will be a better product. The driving public, partners, and other communities affected by road projects—including the plants, animals, and other forms of life—will be better served by this approach.

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Western Federal Lands Highway Division
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610 East 5th St.
Vancouver, WA 98661

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or “metric ton”)	Mg (or “t”)
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or “t”)	megagrams (or “metric ton”)	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

(Revised March 2003)

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Foreword

Establishing sustainable roadside vegetation is widely recognized as an essential and cost-effective practice to improve the safety, efficiency, and effectiveness of roads and associated environment. In recent years, the Federal Highway Administration (FHWA) has taken a leadership role in moving beyond regulation-driven mitigation approaches and into proactive environmental stewardship to promote healthy ecosystems. Native plants are a foundation of ecological health and function in natural environments. Revegetating roadsides with native plants is a key practice for managing environmental impacts and improving conditions for healthy ecosystems. In addition, native plants along roadsides offer economic, safety, and aesthetic advantages. Well-planned, sustainable native vegetation supports transportation goals for safety and efficiency by stabilizing slopes, reinforcing infrastructure, and improving the road user's experience by creating natural beauty and diversity along the roadside.

Reasons that many past attempts at native revegetation along roadsides have failed can be attributed either to a piecemeal approach or to lack of an integrated approach. Successful revegetation along roadsides using native plants requires forethought and planning. Revegetation planning must be an integral part of the process of designing and constructing roads.

This guide is intended to support managers in facilitating successful protection and/or establishment of native vegetation as an integral part of road design and construction. This report summarizes the concepts and approaches developed in *Roadside Revegetation: An Integrated Approach to Establishing Native Plants*, from a manager's perspective. While the full report is designed for field-level practitioners, it is this reference document that engineers and managers should use as a guide in project planning, design, and construction. This guide summarizes an integrated approach to effectively revegetating roadsides and other disturbance areas associated with road construction, modification, or obliteration. Management issues including scope, schedules, budgets, communication, and quality assurance are outlined as they relate to integrating revegetation practices.

By incorporating an integrated approach to revegetation into project management, the end product, the finished road, will be a better product. The driving public, partners, and other communities affected by road projects—including the plants, animals, and other forms of life—will be better served by this approach.

Figure 1 ~ Establishing desirable roadside vegetation is an essential and cost-effective practice to improve the safety, efficiency, and effectiveness of roads and associated management. (Glacier National Park, photo by Tara Luna.)

Road users require that road modifications not only improve safety and mobility but also preserve, protect, and, where possible, promote healthy natural environments. In recent years the Federal Highway Administration (FHWA) has taken a leadership role in moving beyond regulation-driven mitigation approaches and into proactive environmental stewardship to promote healthy ecosystems.

Native plants are a foundation of ecological health and function. Revegetating roadsides with native plants is a key practice for managing environmental impacts and improving conditions for healthy ecosystems. The ability to establish native plant communities on roadsides is central to determining whether the transportation corridor will be a healthy environment or a damaged one. However, past approaches to roadside revegetation often failed, despite policy initiatives, customer desires, good intentions, and widespread recognition of the many economic, aesthetic, and ecological benefits of native plants.

Overcoming the obstacles to successful establishment of native plants requires more than just technical information. A systematic, comprehensive approach is needed. With environmental stewardship as one of FHWA's "vital few" goals for road projects, native vegetation issues must be integrated with every phase of design and construction. Engineering and natural resource sciences must be brought together in a collaborative way.

Figure 2 ~ This debris slide took place two years after construction, when grasses were fully established. To preclude these kinds of problems, revegetation should have the establishment of long-term plant communities, not just quick cover, as a goal.

Benefits of Native Plants

Native plants along roadsides offer ecological, economic, safety, and aesthetic advantages. Ecologically, healthy native plant communities often are the best long-term defense against invasive and noxious weeds. Economically, maintenance costs for managing problematic vegetation are reduced, as are the concerns that sometimes result when weeds from roadsides invade neighboring lands or when pollution from herbicides occurs. The ineffectiveness of past roadside revegetation efforts has resulted in problems such as erosion and sediment loading, thereby affecting soil and water quality. Visually, when road disturbance is not healed properly, the aesthetic experience of the road user is diminished. In terms of efficiency and cost savings, poorly integrated natural processes can threaten the function and structural integrity of the road itself, leading to premature deterioration of the road's infrastructure.

The establishment of native plant communities supports transportation safety goals in a number of ways. One of the most important is by improving the function of roadside engineering. Appropriate

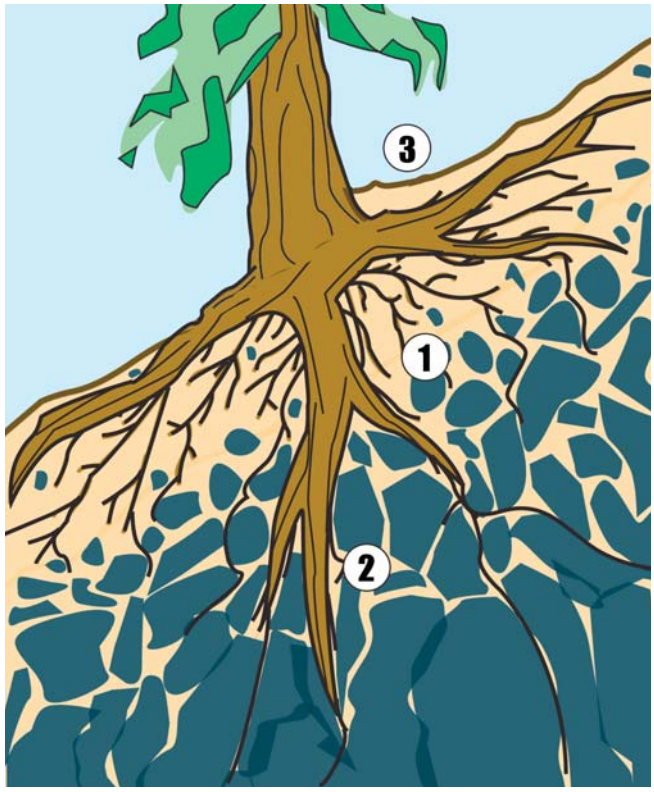

Figure 3 ~ Plant roots and stems increase slope stability by 1) reinforcing the surface horizon through a matrix of roots, 2) anchoring surface horizons to rock or subsoils, and 3) supporting the soil upslope.

vegetation can enhance visibility and support design features to help drivers recover if their vehicles leave the pavement. When native plant materials are incorporated into road design, they can improve long-term slope stability while softening visual experiences. For instance, hydroseeding with exotic grasses has been the conventional approach to stabilizing road cuts, but many grasses have shallow root systems and short lifespans. In contrast, hydroseeding with a mix of native forbs and grasses over a matrix of planted shrubs and small trees will increase slope stability and prevent slumps and debris flow onto the road.

Well-planned, desirable vegetation supports transportation goals for safety and efficiency by stabilizing slopes, reinforcing infrastructure, and improving the road user's experience by creating natural beauty and diversity along the roadside.

Collaboration, Integration, and Long-Term Goals

To be successful, an integrated and collaborative approach to roadside revegetation is needed. When protection or re-establishment of native vegetation is approached in a piecemeal fashion or as an afterthought, results are often not as desired. The process must be collaborative, focused on long-term goals for ecological health, and fully integrated with larger design and construction issues.

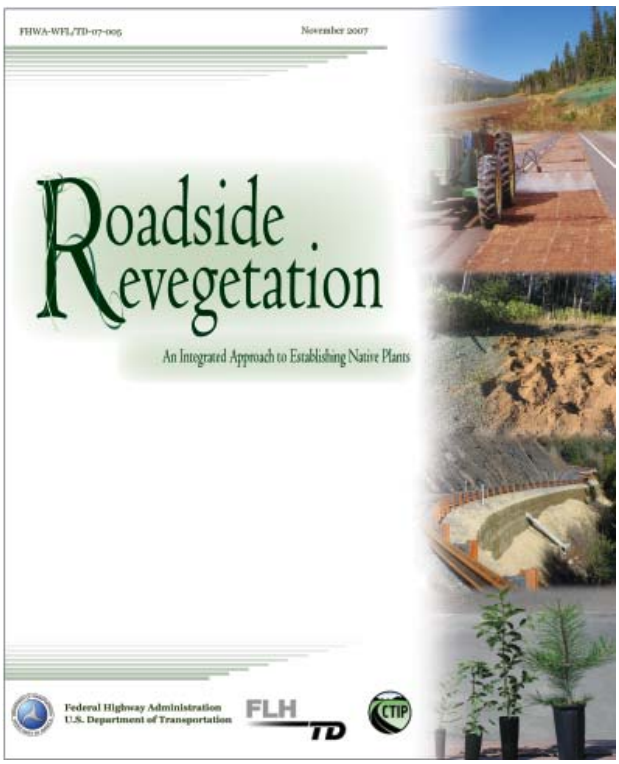

Figure 4 ~ This Guide for Managers *summarizes the approach that is detailed in the larger report,* Roadside Revegetation Using Native Plants: An Integrated Approach to Establishing Native Plants *(pictured). The larger report is intended for field-level practitioners and planners.*

This guide outlines an approach to roadside revegetation that is:

- *Goal-oriented:* Integrating long-term revegetation and ecological health objectives with larger transportation goals including safety, mobility, and cost effectiveness
- *Collaborative:* Incorporating the knowledge of engineering and natural sciences through collaborative processes and interagency cooperation
- *Context-sensitive:* Recognizing that each project has unique ecological characteristics and that source-identified, locally adapted plant materials ensure functional, long-term, self-sustaining plant communities, not just quick cover

A comprehensive report, *Roadside Revegetation: An Integrated Approach to Establishing Native Plants*, brings theoretical and practical information to bear on the challenge of revegetating roadsides with native plants. Intended for field-level practitioners and planners, the report is designed to help fill current information and technology gaps, share strategies and techniques, facilitate collaborative processes through interagency and interdisciplinary coordination, and help readers through the process of successfully establishing native plant communities on roadsides. This publication, *Roadside Revegetation Using Native Plants: A Summary Guide for Managers,* outlines the key points from the approach of supervisors and planners. The approach offered in these publications provides a goal-oriented, context-sensitive, collaborative approach to serve the needs of the customer for long-term ecological, economic, and aesthetic gains from establishing native plants on roadsides. In addition to necessary technical information, the process outlined shows how native vegetation concerns may be fully integrated into the larger processes of road design and construction.

Goal-Oriented

In past cases of failed revegetation efforts, the goal was often too shortsighted. Revegetation was considered important to improve the appearance of the roadside disturbance, but efforts emphasized seeding of exotic species because these were perceived as cheap, readily available, and quick to establish on disturbed sites. These exotics either spread to become problematic weeds, or failed to persist because they were not locally appropriate.

Figure 5 ~ Past approaches to revegetation often failed if the focus was on quick cover, not long-term goals. Integration of revegetation techniques into road planning and implementation increases chances of success.

Goals focused on long-term, functional communities of native plants, not just quick cover, are necessary.

In addition, the setting and meeting of revegetation goals should be integrated with larger transportation goals of safety and mobility. To achieve this, it is essential to integrate native plant considerations into all stages of road development. Whenever disturbance to soils and vegetation are planned, a revegetation specialist should be involved. A revegetation specialist's input serves to minimize the construction footprint and to plan to facilitate faster recovery of natural vegetation in the road corridor after disturbance. The revegetation approach is feasible technically and economically, and it is designed to produce long-term gains for native plants, ecological functions, soil and water protection, and other goals.

Collaborative

Collaborative approaches are a key to success. This guide illustrates timelines and processes for effective collaboration at any phase in the project. For example, the early stages of project development include key opportunities for integration. When disturbances to soils and vegetation are being discussed by the design engineers, the revegetation specialist can be involved in order to help determine what types of disturbances can be feasibly revegetated with native plants. Often small revisions can result in greatly improved conditions for native plant establishment. If a planned disturbance will not allow for revegetation, alternatives to that type of disturbance can be considered. The work of the revegetation specialist in developing the revegetation plan, as well as efforts to reduce the construction footprint and protect native vegetation on the project site, will become an integral part of the road construction plans.

Coordination of schedules, milestones, and budgets is summarized in this guide. Collaboration is emphasized so the appropriate people are involved at key times to preclude problems and optimize results. This guide illustrates a generic process and shows how and when engineering and natural science specialists should be collaborating. The approach employed recognizes that financial and personnel resources are limited.

Context-Sensitive

Given the unique ecological factors at play in each project, the approach is not prescriptive but rather provides principles and a step-by-step process for practitioners to take into the field to generate and implement their own locally appropriate, context-sensitive revegetation plan. Because the goal is plant communities that are functional in the long term, the approach is intended to facilitate the process of developing locally appropriate steps on a project-by-project basis. Top-down and ground-up information are integrated to meet the specific challenges at hand. For example, no 'one-size-fits-all' plant mix exists to apply under any circumstances and be successful. There are too many variables to make generic recommendations useful. Instead, the readers are guided through the conceptual aspects of every phase of a revegetation project. Steps are provided with examples so that personnel can identify unique site characteristics and how to best manage them. The process and tools needed are provided to arrive at appropriate solutions to revegetate any roadside project.

The Manager's Role

Establishing desirable vegetation is widely recognized as an essential and cost-effective step to improve the safety, efficiency, and effectiveness of roads and associated management. By incorporating an integrated approach to revegetation in the overall project vision, the end product, the finished road, will be a better product. The driving public, partners, and other communities affected by road projects—the plants, animals, and other forms of life—will be better served by this approach.

The manager's role is essential in widening project scope to fully include environmental stewardship, in

ensuring context-sensitive objectives are set and met, and in supervising effective processes to get the job done within budget and on schedule. Coordinating teamwork to meet challenges in a collaborative and integrated manner includes bringing people from different disciplines and organizations together and starting before any disturbance to soil or vegetation takes place. This guide is designed to support managers in facilitating successful protection and/or establishment of native vegetation as an integral part of road design and construction.

Management for Integrating Revegetation: Scope, Milestones, Budgets, and Communication

The manager's task is to ensure that the end product, the finished road, is completed efficiently, effectively, and to high standards of excellence, including that "customer" expectations are met. The protection and establishment of healthy communities of native plants along roadsides has become part of the scope of road construction projects. Native plants help satisfy client demands, federal mandates, public concerns, and environmental stewardship goals, as well as providing improved cost savings and safety.

To be effective, ecological thinking needs to be incorporated into all aspects of road design, construction, modification, and maintenance. One way this goal is being addressed is to fully integrate issues of native plant revegetation (including protection of existing soils and vegetation) into the larger design and construction processes of road projects. Considering revegetation in isolation from, or as an appendix to, the larger road project is a trend of the past that often resulted in failure. Instead, revegetation planning is an integral part of road planning.

To ensure successful integration of revegetation issues with the overall road project, managers need to understand how the revegetation process works and how scheduling, funding, team communication, and other management issues relate to the process. To optimize results, the revegetation specialist should be involved as early as possible after a project is programmed, integrated at the appropriate times, and coordinating with the appropriate people. In general, the revegetation specialist should be involved in planning and construction processes whenever soil and vegetation disturbances are planned. Revegetation efforts can be synchronized with schedules, milestones, and budgetary issues during road development and construction. Table 1 shows some key points for managers to consider as they work to integrate revegetation with the project as a whole.

Scope: What and Why

With environmental stewardship as one of FHWA's "vital few" goals, effective revegetation will be within the scope of any road construction, modification, or obliteration process. It is important for managers to consider revegetation as an integral part of the project.

In addition, the scope of revegetation efforts should be recognized. Goals and objectives often consider both short-term environmental protection and long-term ecological health. Real economic, ecological, and aesthetic gains are realized when the objective is the long-term establishment of healthy communities of native plants. These plant communities are resilient and largely self-sustaining, with the capacity to stabilize soil, improve water quality, and resist invasions of noxious plants. Managers can help to ensure that the scope of revegetation efforts includes true healing of the road scar, not just quick cover over the disturbance.

Statement of Work: Who and How

When assembling the project team, select a revegetation specialist and get her or him involved as early as possible in the planning process. A revegetation specialist should be a local resource person who knows the area and can generate context-appropriate solutions. A revegetation specialist may have a background in any number of natural sciences, including soil science, botany, ecology, or other fields. Good communication and organization skills, an ability to manage complex timelines and tasks, and a willingness to cooperate with other disciplines—engineering, hydrology, wildlife science, and so on—are important. A willingness and ability to learn engineering terminology and read construction plans is essential for effective communication. Involve the revegetation specialist before disturbances are planned. As the specialist begins work on the revegetation plan, consider the revegetation plan as an integral part of road construction plans—not as an appendix.

Milestones, Communication, and Funding

A key role of the project manager is to facilitate problem-solving in a collaborative and integrated manner. For revegetation and environmental stewardship, this means bringing people from different disciplines and organizations together and encouraging engineering and natural scientists to cooperate before any disturbance to soil or vegetation takes place. Team members should be oriented to larger processes in order to create key relationships and navigate the decision process effectively. This input helps to optimize results, save money and time, and ensure that any disturbances planned can be effectively revegetated with native plants.

In general, the revegetation specialist is usually involved just after the project is programmed, and

Table 1 ~ Managers should focus on the areas outlined in this table in order to successfully direct revegetation efforts and integrate them with construction processes.

Management Focus	Integrating Revegetation
Project Scope: What and Why	• Incorporate the establishment of healthy native plant communities on roadside as part of the project's goals—native plants are important to meet customer expectations, fulfill policy mandates, and improve the finished road. • Ensure all members of the team are aware of native plants and ecological concerns as integral to project, not an afterthought. • Set goals for long-term ecological health and self-perpetuating native plant communities, not just quick cover.
Statement of Work: Who and How	• Assemble team to include revegetation specialist *before* disturbances are planned. • Understand revegetation process and approach to support work. • Consider revegetation plan as an integral part of road construction plans, not an appendix.
Milestones: When	• Understand timelines for revegetation processes so they may be successfully integrated with other processes. • Ensure revegetation and construction activities will be complementary, not conflicting. • Be aware that revegetation tasks often begin 1-3 years before construction and continue after construction is complete.
Communication	• Ensure key opportunities for collaboration are utilized. • Encourage cooperation between engineering and natural sciences—optimal results often come from collaboration. • Involve revegetation specialist when disturbances to soil and vegetation are being planned or revised. • Allow special contract requirements to support context-sensitive revegetation needs.
Funding	• Plan funding as needed for revegetation schedule. • Know that revegetation tasks begin 1-3 years before construction and continue after road construction is complete.
Quality Assurance	• Ensure measurable goals are set and met for soil and vegetation. • Use context-sensitive goals, matched to unique site conditions. • Ensure a reasonable approach is followed to reach goals. • Know that measurements of success may be qualitative and/or quantitative. • Consider long-term ecological health and self-perpetuating native plant communities, not just quick cover.
Process Improvement	• Improve practice through sharing of lessons learned.

involvement continues through and following construction. It is important to note that the implementation phase of revegetation begins while the project development process is still underway. Waiting until construction begins is not feasible because locally-adapted native plant materials almost always have to be propagated in advance.

Essential points to coordinate revegetation efforts with road planning and construction are illustrated in Figure 6, including budgetary and scheduling issues.

Planning and Programming

A project is considered "programmed" once it has been determined that the project will take place, and funding and a schedule for a specific delivery year have been set for that project. A revegetation specialist will usually not be involved in a project until after it is programmed, although at times one might be called in to assess the feasibility of various alternatives.

Road Project Development

The road project development phase usually has three sub-phases. These involve developing, analyzing, and considering approaches and alternatives to the project until a strategy and specifications of how to best proceed are established in the final plan. The process usually involves:

- Preliminary (road construction plans 30% complete)
- Intermediate (road construction plans 50%-70% complete)
- Final (road construction plans 70-100% complete, hand off to construction)

Preliminary

The preliminary phase is a crucial one for revegetation. This phase represents the best opportunity for input regarding issues associated with revegetation, including disturbances planned for existing soil and vegetation on the site. Significant features of the preliminary revegetation plan should be incorporated during this road planning phase. By the time of environmental approvals, the vegetative concepts and the necessary commitments of resources and funds should be integrated with the plan, as revegetation will be an important aspect of environmental protection and mitigation. The appropriate level of detail for the revegetation plan during the preliminary phase depends on the project. For the revegetation specialist, some environmental guidelines may be predetermined by legislation that specifies goals for the project regarding issues of soil stabilization, percent native vegetative cover, and protection of water quality. The revegetation specialist must be aware of these guidelines, and design them into the final revegetation plan. Approvals are also key milestones for the revegetation specialist regarding availability of funds. This early release of funds is essential to carry out site assessments and revegetation planning work including, preliminary mapping and seed collections.

Intermediate

At the intermediate stage, the revegetation specialist should be far along in the development of the revegetation plan. Mitigating measures have been identified for impacted areas and contracts for seed and seedling production have begun. The intermediate set of road plans will include specifications for how the project will be carried out.

These specifications, particularly special contract requirements, are a key tool for successful revegetation. Special requirements address context-sensitive concerns for a particular project. Revegetation specialists should be encouraged and supported to adequately develop and describe special contract requirements to achieve the desired results in the field. These might range from issues of soil or plant salvage to soil amendments, construction of topographical features, temporary soil stabilization measures, and the like. Because they will be part of the contract, not an afterthought, special contract requirements are a valuable tool for integration. Without them, the risk is that construction and revegetation activities might conflict, instead of complementing each other.

Final

The final set of road plans will include the design elements of the revegetation plan, as well as the details for road construction. The work of the revegetation specialist in developing the revegetation plan, as well as input to reduce the construction footprint and protect native soils and vegetation on the project site, will be an integral part of the road construction plans, At this point, finalizing the revegetation plan will be necessary. It is also time to coordinate with contractors and agencies in order to time availability of plants with the proper time to establish plants in the field.

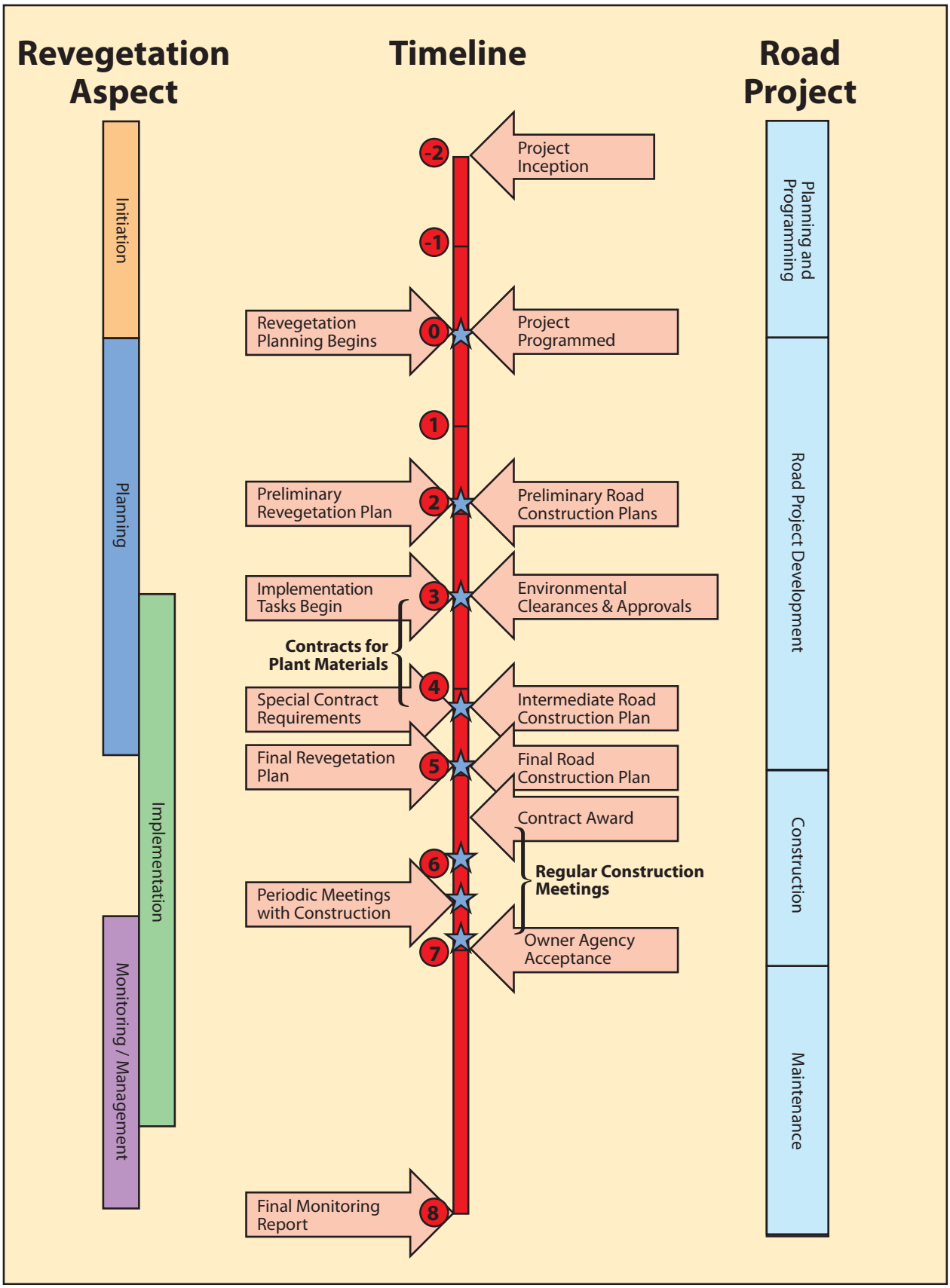

Figure 6 ~ Coordinating revegetation with the larger processes of road construction is essential. While the timelines and agencies involved will vary, this figure illustrates some of the key opportunities for communication and integration.

Road Construction

Following project development, the project is often handed off to construction personnel. As shown in Figures 6 and 7, the revegetation specialist will have begun many of their implementation tasks while the project is still in the development phase. In addition, many of the revegetation tasks will continue during and after road construction. For these reasons, the construction engineer is an essential contact for the revegetation specialist. The specialist may attend a number of the weekly meetings that take place during road construction to help coordinate efforts.

Road Maintenance

After construction is complete, the work of the revegetation specialist will usually continue for an additional year or more until the revegetation is fully implemented. Usually, the submission of a final monitoring report marks the end of the revegetation specialist's involvement with the project. Coordinating road maintenance activities with the road-owning agency is necessary to ensure that maintenance activities do not undo portions of the revegetation. For example, if blanket herbicide use is conventional practice, alternatives will need to be selected.

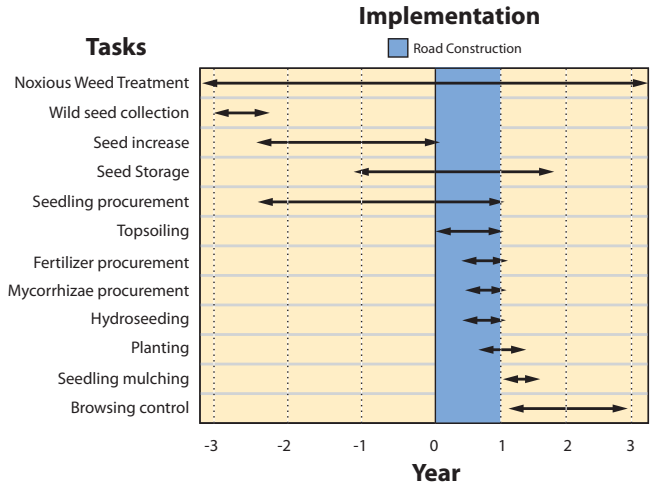

Figure 7 ~ Example revegetation timeline for implementation. Note that revegetation tasks may begin three years prior to road construction, and continue several years afterwards. Coordinating timelines and budgets is essential.

Summary of Revegetation Stages

Figure 6 illustrates how processes for revegetation can be coordinated with the larger design and construction processes for road projects. This sidebar provides an outline of the revegetation side of the process. The report, *Roadside Revegetation: An Integrated Approach to Establishing Native Plants,* provides in-depth information on each aspect of the approach.

Roadside Revegetation synthesizes an integrated approach that can be used for effective revegetation of roadsides and other disturbed areas associated with road construction, modification, or obliteration. The four stages of the revegetation process are: initiation, planning, implementation, and monitoring/management. The first stage, initiation, involves creating key relationships to navigate the decision process to initiate a project. There are essential steps to coordinate revegetation efforts with road planning and construction activities, including funding and scheduling issues. In addition, initiation involves creating bridges between nonengineers and engineers regarding terminology and technical concepts to improve communication.

The second stage is planning—the process of defining project objectives, assessing the site, overcoming limitations, strategizing revegetation procedures, and integrating the revegetation activities with the road project. This stage culminates in the creation of a Revegetation Plan for the project.

The third stage is implementation—executing the Revegetation Plan in the field, including coordinating contracts and managing budgets and schedules. Implementation involves carrying out site treatments, mitigation measures, and revegetation tactics. This includes tasks to stabilize soils, overcome limiting factors, improve site conditions, and establish communities of native plants.

Finally, the monitoring stage involves assessing the effectiveness of the revegetation project, correcting any shortcomings if goals were not yet met, and adding to future knowledge. Once vegetation has been established, long-term management dovetails with the practices outlined in Integrated Roadside Vegetation Management (IRVM) programs.

Quality Assurance

Another key role of the manager is to ensure that goals are set and met. This includes ensuring that a reasonable approach is being followed to both set and fulfill the goals. Because revegetation aspects will be dictated by the context and site conditions, no generic success criteria exist that apply to all revegetation projects. Instead, the revegetation specialist will develop revegetation objectives based on the site conditions. General goals of aesthetics, stability, function, and health can be provided in advance. Specific, measurable objectives, usually called Desired Future Conditions (DFCs), will be set by the revegetation specialist early in the planning phase. The manager can support this by ensuring that the revegetation specialist is following the approach outlined in the next section and detailed in the report, *Roadside Revegetation: An Integrated Approach to Establishing Native Plants*. Some measurements will be qualitative and some may be quantitative. Goals usually include some short-term needs, such as stabilizing soils, and long-term objectives for a healthy plant community.

Key Management Issues Regarding Roadside Revegetation

- Collaboration should begin before any disturbances to soil or vegetation take place and continue throughout the project.
- Many revegetation implementation tasks (such as seed collection and plant propagation) need to begin 1-3 years before road construction begins. Funds need to be available accordingly.
- There are no "one-size-fits-all" criteria for revegetation success. Revegetation specialists develop context-appropriate objectives and plans based on ecological science and an understanding of site conditions.
- Special contract requirements are a key tool for revegetation, essential for context-sensitive approaches.
- Revegetation objectives dovetail with larger project objectives.
- Often, optimal solutions are achieved through cooperation between engineering and natural science approaches. Communicating and sharing ideas and past experiences is essential to reaching a solution that benefits everyone.

Management Should Ensure the Revegetation Specialist:

- Understands overall project objectives
- Keeps good records
- Understands cooperator processes, timelines, and milestones
- Is collaborating with the right people at the right time
- Is involved when disturbances to soil and vegetation are planned

Process Improvement

Moving beyond piecemeal, mitigation-driven processes and into environmental stewardship is an ongoing challenge. In addition, restoration ecology is an evolving science and roadside revegetation is an evolving practice. Continual advances are being made on all these fronts. Lessons from revegetation practices, failures as well as successes, should be documented and shared. The revegetation specialist will document the technical aspects of their efforts. Managers can help improve the field of restoration by observing the overall process of road design and construction and by learning how to best facilitate and streamline to create improved results.

Summary of Integrated Approach to Roadside Revegetation

To supervise the successful establishment of native plants along roadsides, a general understanding of an effective approach to revegetation is useful to managers. A summary of the essential steps for revegetation planning is provided in this section. Table 2 provides an outline of the report, *Roadside Revegetation: An Integrated Approach to Establishing Native Plants*, so that managers can guide staff to consult this reference as necessary. Key concepts are highlighted to provide managers with an overview which they can use to support the setting and meeting of reasonable goals, the execution of an effective approach, and the coordination of collaborative processes.

Essential Steps

To be successful, roadside revegetation needs to be approached in a systematic and comprehensive way. The goal is not simply to establish quick cover; the goal is to establish long-term, functional communities of native plants. Ecologically, roadsides and other road-related disturbances often represent drastically disturbed environments, where soil may be severely compacted and consist of a mixture of subsoil and parent material. Beneficial microorganisms, nutrients, and organic matter necessary to sustain plant growth may be absent or severely depleted. Often, slopes can be steep or inaccessible, exposed to the erosive effects of wind and water. These environments represent a revegetation challenge of high intensity and magnitude. Soils, subsoils, and vegetation cannot be considered in isolation; they must be viewed collectively in order to successfully overcome limitations to establishing plants. Table 2 summarizes the essential steps for revegetation planning. Managers should note that some of the steps will be iterative, not linear. Key concepts associated with each step are summarized in the table.

Key Concepts in the Approach

Initiation

Effective roadside revegetation requires not only technical skills, but also an ability to cultivate

What are Native Plants?

"Native plants," as defined in this approach, are locally-adapted, genetically appropriate native plant materials (Withrow-Robinson and Johnson 2006). These plants are best suited evolutionarily to the local conditions, and generally require less maintenance and persist longer than non-local species. When properly established, they form plant communities with the potential to be self-sustaining and self-perpetuating over time, requiring little or no input from humans to continue and thrive. Recent policy mandates from many federal agencies that manage roads now require the use of native plant materials as the first choice in revegetation efforts.

Figure 8 ~ The establishment of locally-adapted native plant communities is a cornerstone of ecological restoration.

Table 2 ~ Overview of essential steps for roadside revegetation. Managers should note that some steps will be iterative. Key concepts associated with each step are summarized in the text. Links to the full report, Roadside Revegetation: An Integrated Approach to Establishing Native Plants, *are provided so managers can guide staff to consult this reference as necessary.*

Section	Chapter	Goal	Tasks
Initiation Part One	**Chapter 2**	***Understand cooperators and decision processes***	Set up recordkeeping
			Identify cooperators: Who is involved?
			Define cooperator processes, timelines, and milestones
			Define objectives: What is the project trying to accomplish?
Initiation Part Two	**Chapter 3**	***Understand road plans and terminology***	Read and interpret road construction plans
			Understand key concepts and terminology
Planning Phase One	**Chapter 4**	***Orient to the project***	Determine revegetation objectives
			Define revegetation units
			Select reference sites
			Define the desired future conditions
Planning Phase Two	**Chapter 5**	***Assess site***	Identify limiting factors
			Consider mitigating measures for limiting factors
			Assess site resources
Planning Phase Three	**Chapter 6**	***Analyze vegetation***	Complete vegetation assessment
			Create a comprehensive species list
			Define plant communities and successional processes
			Determine which species and groups of species will be used on the project
			Identify target plant requirements
			Create menu of potential stocktypes and plant establishment methods
Planning Phase Four	**Chapter 7**	***Integrate and strategize***	Finalize revegetation units and DFCs
			Integrate survey information and develop potential revegetation strategies
			Compare and select revegetation strategies
			Assemble revegetation plan
	Chapter 8	***Example plan***	Example revegetation plan
Implementation	**Chapters 9 and 10**	***Implement***	Review plans with construction engineer
			Review revegetation treatment details and timelines
			Develop contracts
			Install treatments
			Keep good records
			Carry out quality control
			Implement early maintenance and monitoring
Monitoring & Management	**Chapters 11 and 12**	***Monitor, evaluate, correct, improve***	Revisit project objectives and DFCs
			Develop monitoring strategy and protocols
			Record data and observations
			Evaluate data and apply any corrective measures
			Organize and file project results
			Share lessons learned

The Process of Succession: Change Over Time

Native species play an important role in ecosystem development over time. If native species can colonize and become established on a disturbance, the processes of succession, including soil genesis and nutrient cycling, are initiated. Effective revegetation of highly disturbed roadsides aims to initiate or accelerate processes of natural succession following disturbances. In most cases, native plants are established on roadsides through seeding or planting, although sometimes passive revegetation (natural colonization) is possible where native seed banks are nearby and limiting factors are mitigated. The establishment of native plant communities in order to re-initiate natural processes of succession is a cornerstone of most ecological restoration efforts.

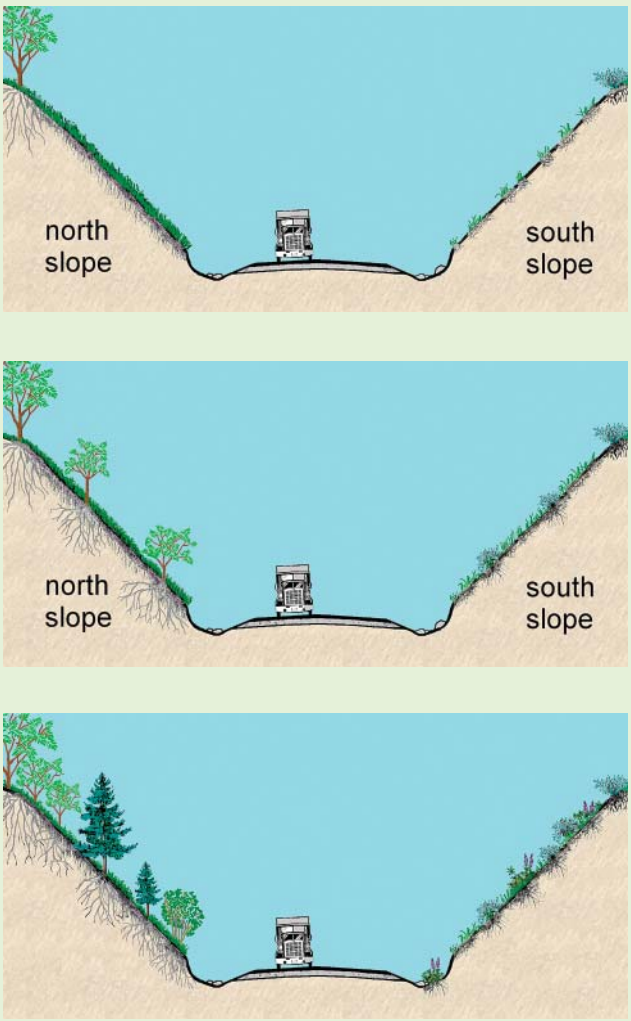

Figure 9 ~ Successional processes and plant communities vary considerably based on site conditions. In this example, plant communities developed differently over a ten-year period on north-facing and south-facing slopes.

relationships and navigate the decision processes so that a project will run smoothly. Road construction, alteration, or decommissioning involves a variety of land management agencies, programs, and regulations. Revegetation specialists need to learn about agency procedures for the organizations involved with road projects. Timelines, budgetary issues, and interface opportunities are considered to enable the revegetation specialist to integrate revegetation efforts with the overall process of road planning and construction. Attending meetings and coordinating with key contacts within agencies are important tasks in the early stages of the project.

In the initiation phase, the revegetation specialist needs to become familiar with reading and interpreting road plans and understanding terminology. This ability enables the specialist to communicate effectively about engineering plans, contribute fully to minimizing the adverse environmental impacts, and ensure that revegetation is an integral part of the efforts.

Construction plans provide information necessary to understand the current project site conditions, as well as to predict the future condition of the project site following road construction.

Planning

Planning forms the foundation of future work. The process of planning is organized into four phases.

Planning Phase One

Phase One involves defining four essential aspects of the project: 1) the revegetation objectives; 2) the management areas (revegetation units); 3) the natural models (reference sites); and 4) the specific goals for each revegetation unit (called desired future conditions, DFCs). Defining these steps requires a preliminary assessment of site characteristics, including vegetation, climate, and soil.

Determine Revegetation Objectives

Revegetation objectives are linked to larger project objectives for safety, mobility, and environmental protection. Most revegetation projects state several objectives to address both short-term and long-term outcomes. For example, short-term, immediate revegetation objectives on most projects include erosion control and water quality protection through mulch and vegetative cover. Long-term revegetation objectives might include the exclusion of invasive weeds, visual enhancement, and establishment of healthy native plant communities through soil restoration. While short-term objectives might rely on quick-growing ground covers such as grasses and forbs, long-term objectives are often broadened to include such revegetation treatments as planting deep-rooted tree and shrub seedlings to stabilize roadsides, creating visual screens, and/or supporting sustained plant community development. As the project evolves, objectives are translated into specific, measurable goals (DFCs). After the installation is complete, DFCs and revegetation objectives will be utilized in monitoring, evaluating, and managing the project.

Define Revegetation Units

Revegetation units are delineated on the project site. These are areas within the project site that are similar enough to be appropriate for similar strategies and treatments. Homogenous sites will have only a few units; sites with greater diversity (e.g., different soil types, microclimates, vegetation types, management needs) will have more revegetation units. Each unit is distinct in terms of ecology, management requirements, or both. Goals will be set appropriate to the conditions in each unit.

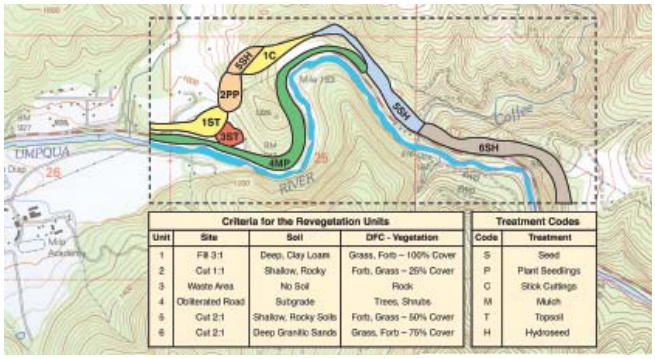

Figure 10 ~ Context-sensitive revegetation planning includes mapping revegetation units on the project site to account for variations in soils, climate, management considerations, and other factors. Goals will be set appropriate to the site conditions in each unit.

Select Reference Sites

Identifying and surveying reference sites or natural models for the desired recovery process is essential to setting attainable, site-appropriate goals regarding revegetation. Reference sites provide guidance about what species may be established and how their plant communities will change over time. Reference sites are natural or revegetated areas that serve as models for desirable recovery of native plant communities. One or more reference sites are identified for each revegetation unit in the project.

Define the Desired Future Conditions (DFCs)

DFCs are specific, measurable goals for each revegetation unit, usually defined in terms of the percentage of vegetative cover, ground cover, species composition, and so on. Once revegetation units and corresponding reference sites have been identified, mapped, and described, an appropriate desired future condition (DFC) can be defined for each unit. The DFC takes the overall revegetation objectives defined earlier and translates them into measurable goals tailored to each revegetation unit. The DFC specifies the desired or expected composition of vegetation at a defined point in time after the completion of the revegetation work. An example DFC would be, "two years after seeding, vegetative ground cover will be 50%; of this cover, 75% will be composed of perennial native species." Stating expectations in this manner will:

- Clarify how the site will appear after treatments;
- Narrow down the appropriate revegetation treatments;
- Define measurable criteria, or success thresholds, that can be used to manage activities and monitor project development.

Planning Phase Two

Phase Two defines site attributes and limiting factors. Factors critical for plant establishment, such as soil and climate, are assessed. Obstacles to revegetation, as well as available resources, are examined. A field investigation of each revegetation unit describes the site in depth and reveals how site characteristics will either support or limit achieving the DFCs. Based on the determination of limiting factors, a menu of possible mitigating measures for assuring plant establishment (short-term) and plant

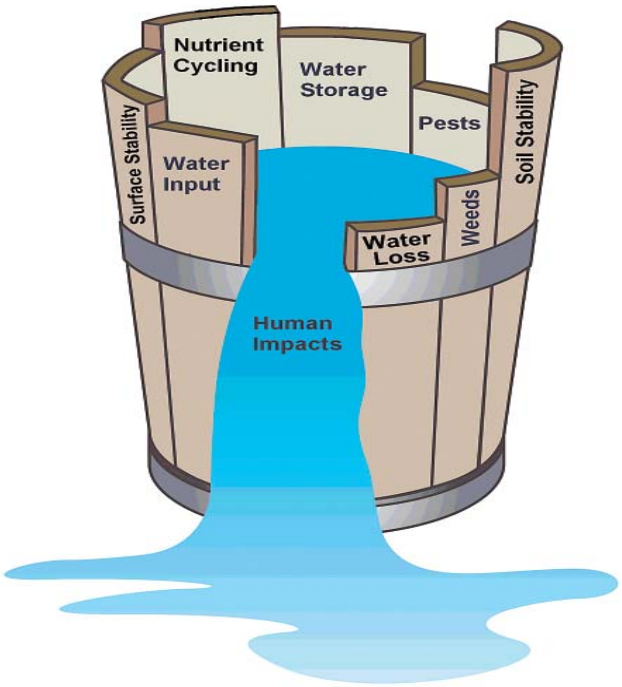

Figure 11 ~ A comprehensive survey of potential limiting factors to establishing vegetation should be carried out. All mitigation strategies should be designed to overcome specific limiting factors.

community development (long-term) is developed. Any mitigating measure that will be applied, including soil and site treatments, should be prescribed to overcome specific limiting factors identified on the site. Attempting to intervene on the site before identifying limiting factors is akin to a doctor writing a prescription without taking the time to diagnose the problems.

Planning Phase Three

Phase Three matches plant species, genetic sources, stocktypes, and planting methods to the environmental conditions of the site. The vegetation is surveyed and analyzed. From a comprehensive list of species and plant communities present on the reference sites, the revegetation specialist determines which species are best adapted to the site and best suited to revegetation needs. Options for sources, stocktypes, and application methods are considered in order to achieve the desired results.

	Critical Plant Factors	Parameters
1	Water Input	Precipitation
		Interception
		In Itration
		Road Drainage
2	Water Storage and Accessibility	Soil Texture
		Rock Fragments
		Soil Structure
		Rooting Depth
		Mycorrhizal Fungi
3	Water Loss	Wind
		Aspect
		Competing Vegetation
		Soil Cover
4	Nutrient Cycling	Topsoil
		Site Organic Matter
		Nitrogen and Carbon
		Nutrients
		pH and Salts
5	Surface Stability	Rainfall and Wind
		Freeze – Thaw
		Soil Cover
		Surface Strength
		In Itration
		Slope Gradient
		Surface Roughness
		Slope Length
6	Slope Stability	Permeability
		Restrictive Layer
		Water Input
		Slope Length
		Slope Gradient
		Soil Strength
7	Weeds	Weed Sources
		Weed Growing Environment
8	Pests	Mammals
		Insects
		Disease
9	Human Interface	Road Maintenance
		Recreational Use

Figure 12 ~ List of limiting factors and their parameters.

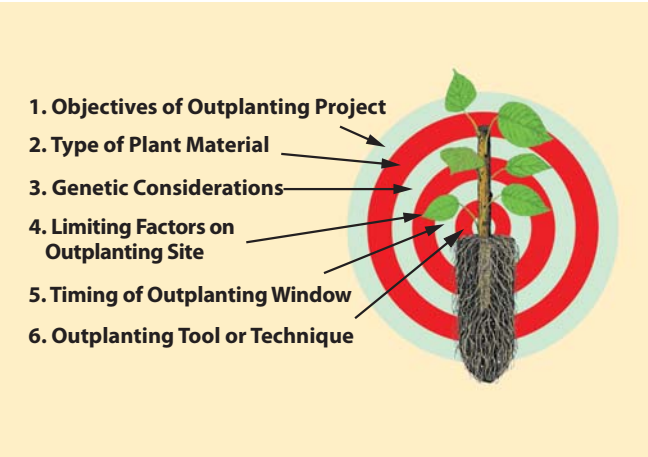

Figure 13 ~ The target plant concept identifies six requirements for establishing native plants.

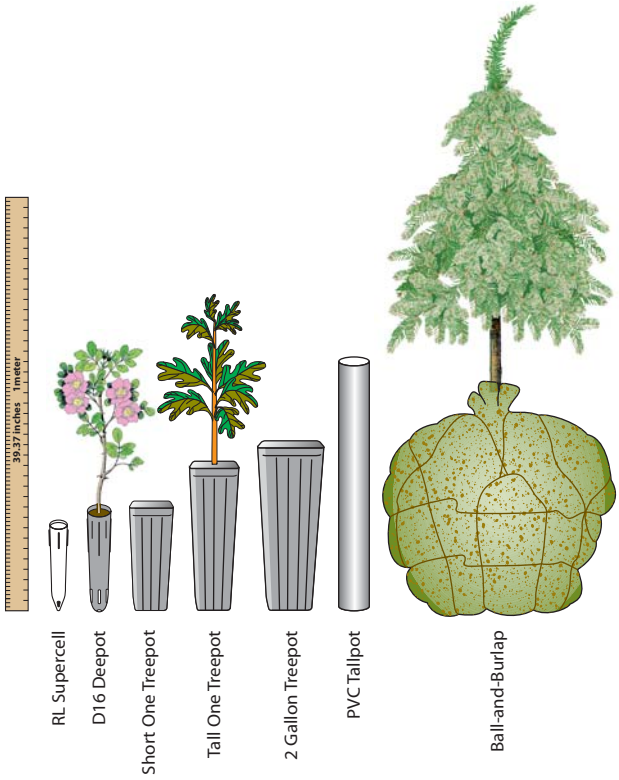

Figure 14 ~ Nursery stock is available in many container sizes and shapes. Revegetation specialists should consider advantages and drawbacks of different options before ordering plants.

Planning Phase Four

Phase Four combines all elements into a comprehensive strategy for revegetation. The possible options for site mitigation and revegetation methods are compared and considered, and the most promising are selected. Choices will be based on site factors and plant needs, and on other considerations, such as costs and availability of materials and services. There are always several ways to meet the revegetation objectives, and different options are considered in Phase Four. When preferred strategies have been selected, budgets and schedules are developed and recommendations are compiled and presented in the Revegetation Plan.

Implementation

Implementation involves coordinating and cooperating with different contractors and agency personnel before, during, and after construction of the road. Treatments for soils and site conditions, obtaining plant materials, and installing and caring for plants are part of the implementation process. The revegetation specialist needs to review plans with engineers, finalize treatment details and timelines, and develop the contracts necessary to successfully carry out the treatments. Keeping good records and carrying out quality assurance and early maintenance activities are essential aspects of the implementation phase. In all cases, coordinating the revegetation work with road construction or modification processes is a major challenge and a key opportunity to improve conditions for native plants.

As a resource, Implementation Guides in the *Roadside Revegetation: An Integrated Approach to Establishing Native Plants* report illustrate how to implement and/or contract for a particular treatment or mitigation measure. Guides are provided for: 1) working with soil/site treatments, 2) obtaining plant materials, 3) installing plant materials, and 4) caring for plants.

Monitoring and Management

Monitoring is necessary to determine if goals defined at the outset of the project have been met. Scope, methods, and parameters for monitoring are determined on a project-by-project basis and must be developed so that sufficient and meaningful information is obtained efficiently and interpreted properly. Keeping written records throughout the process of roadside revegetation is essential in order to evaluate each project.

Critical Plant Factors	Parameters		Mitigating Measures
1 Water Input	Rainfall	✓	irrigate, deep sow, mulch, high density sowing
	Interception		
	Infiltration	✓	deep tillage, harrow, disk, mulch
	Road Drainage		
2 Water Storage and Accessiblity	Soil Texture	✓	compost, clay
	Rock Fragments		
	Soil Structure	✓	deep tillage, compost, topsoil
	Rooting Depth	✓	deep tillage, compost
	Mycorrhizae	✓	topsoil addition, mycorrhizal inoculum
3 Water Withdrawal	Humidity	✓	mulch, surface roughness
	Wind		
	Aspect		
	Competing Vegetation		
	Soil Cover	✓	mulch, deep sow
4 Nutrient Cycling	Climate	✓	
	Topsoil	✓	topsoil addition, manufactured topsoil
	Site Organic Matter	✓	incorporated litter duff, mulch, logs
	Nitrogen & Carbon	✓	nitrogen-fixing species, topsoil, fertilizers, compost
	Nutrients	✓	topsoil, fertilizers, compost
	pH & Salts		
5 Surface Stability	Rainfall & Wind	✓	mulch
	Freeze-Thaw	✓	mulch
	Soil Cover	✓	mulch
	Surface Strength	✓	mulch, tackifier
	Infiltration	✓	disk, harrow, compost
	Slope Gradient		
	Surface Roughness		
	Slope Length	✓	reduce slope length
6 Slope Stability	Water Input		
	Hydraulic Conductivity		
	Restrictive Layer		
	Slope Length		
	Slope Gradient		
	Soil & Root Strength		
7 Weeds	Bare Soil		
	Weed Propagules	✓	prevent and control, quick native revegetation
	Native Propagules		
	Nitrogen		
8 Pests	Mammals	✓	sow non-palatable or non-desirable species
	Birds		
	Insects		
	Diseases		
9 Human Interface	Road Maintenance		
	Recreation Use		

Figure 15 ~ Mitigation measures are matched to site conditions. The goal is to overcome limiting factors to long-term plant establishment and to initiate healthy ecological processes. This figure shows some mitigation measures considered to overcome a specific site's limiting factors.

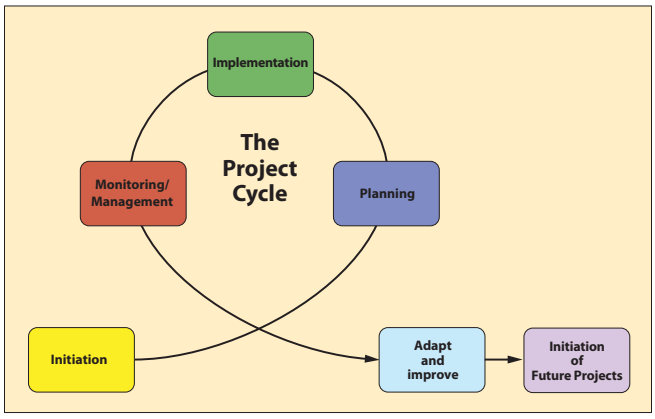

Figure 16 ~ The revegetation project cycle.

Monitoring continues several years after implementation, providing a chance to assess effectiveness and correct any shortcomings. In the Planning stages, project objectives were developed to describe an overall vision for the project. The DFCs refined the objectives into specific, measurable goals for the project site. Monitoring is an opportunity to evaluate the effectiveness of the revegetation efforts as they relate to objectives and goals.

Monitoring is essential for adaptive management of the project. Adaptive management is a systematic approach to good management guided by a process of regularly assessing and learning from what works and does not work on a project. As a project develops, monitoring can be used to assess progress and plan any necessary corrections.

When statistical methods will be necessary, monitoring protocols are available, describing statistical sampling design, data collection techniques, and analysis methods for quantifiable parameters to determine success of roadside revegetation projects. Monitoring protocols cover the following measurements:

- ***Soil cover*** – to determine if treatments increased soil cover for erosion control.
- ***Species cover*** – to determine if treatments increased native grass and forb cover.
- ***Species presence*** – to determine if there was an increase in the number of seeded native grass and forb species.
- ***Plant density***– to determine how many seedlings or cuttings became established after planting to assess whether stocking is adequate or the site needs replanting. Plant survival can also be determined from this protocol.

Building on a Legacy

FHWA is a pioneer in addressing concerns about incorporating native plants in road projects. In 2000, FHWA published a landmark book edited by B.L. Harper-Lore and M. Wilson, *Roadside Use of Native Plants,* that brought the importance of roadside native plants to national attention. Since then, FHWA has been a leader in supporting information resources and research to establish and manage native plants. FHWA helped support the development of Integrated Roadside Vegetation Management (IRVM) programs to better manage roadside plants beyond repeated applications of herbicides. FHWA also helped support the National Academy of Sciences in producing the report *Assessing and Managing the Ecological Impacts of Paved Roads*.

Internally, FHWA also has invested in several initiatives to improve integration of ecological concerns with road planning. These programs include the Eco-Logical approach, context sensitive solutions, Exemplary Ecosystem Initiatives, the newly forming Green Highways Partnership, and other cutting-edge initiatives and policies.

Roadside Revegetation: An Integrated Approach to Establishing Native Plants builds on these visions by applying the concepts of integrated planning, ecological thinking, context sensitivity, and environmental stewardship to the challenge of establishing native plants on roadsides.

Advances are being made in utilizing native revegetation in transportation projects, and progress is underway in the science and practice of restoration ecology and native plant propagation. For example, the Society for Ecological Restoration International recently published guidelines and principles applicable to restoring ecological function to degraded sites. Plant geneticists at a number of federal agencies came to a consensus about what truly defines a "native" plant and developed seed collection, transfer, and propagation guidelines to ensure that locally adapted materials are used with optimum results. In both the public and private sectors, seed and plant producers and installers have developed innovative methods to meet unique site conditions. *Roadside Revegetation* brings these advances to bear on the unique challenges of roadside environments.

- ***Plant attributes*** – to determine how fast planted shrubs and trees are growing.

Revegetating roadsides with native plant communities is a developing field. Practitioners are encouraged to share lessons learned, including successes and failures, to improve the knowledge base for future work.

A Way Forward

Balancing ecological health with safe and efficient transportation is an enormous challenge. Revegetation success is a key factor in determining whether the over 12 million acres that make up the transportation corridor of the United States will be hospitable environments to plants and other forms of life—or a wasteland. It is hoped that continuing improvements in interagency cooperation, enlightened policies, better science and technology, and the dedication of managers and field-based practitioners will continue to build a foundation for a more sustainable future.

Figure 17 ~ Beginning revegetation with native species on scenic highway to Mt. Bachelor, Oregon.

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