Chapter 7
Planning Phase Four: Integrate and Strategize

7.1 INTRODUCTION

In Phase One of the planning process, project objectives were clarified and revegetation units and reference sites were defined. Preliminary Desired Future Conditions (DFCs) were developed for each revegetation unit. During Phase Two, site attributes were defined, including limiting factors, options for mitigation, and available resources. In Phase Three, vegetation was analyzed to consider species, stocktypes, and plant establishment options. In Phase Four, the final phase of planning, the work of all the previous phases is pulled together. Phase Four integrates the understanding of site limitations and resources, mitigation options, species, and seeding or outplanting methods into a comprehensive strategy for revegetating the site. This integrated strategy will culminate in the Revegetation Plan.

The steps for developing the revegetation plan in Phase Four are as follows:

- Finalize revegetation units and DFCs
- Integrate survey information and develop potential revegetation strategies
- Compare and select revegetation strategies
- Assemble plan

A case study is provided to illustrate the thought process for the development and selection of revegetation strategies on a project.

7.2 FINALIZE REVEGETATION UNITS AND DFCS

Phase Four provides the opportunity to review, refine, and finalize revegetation units and the DFCs for each unit. The boundaries of revegetation units may be revised now that the sites have been more thoroughly surveyed. Additional ecological or management-based information may support creating additional revegetation units. Alternately, if management will be similar, an area originally divided into several revegetation units might be consolidated into one. Once the revegetation units are finalized, the DFCs for each unit can be finalized as well.

Site assessments defined resources and limiting factors (Phase Two), as well as species, communities, and succession over time or in response to human intervention (Phases One and Three). DFCs can be revised based on the information gathered during these assessments. For example, with more detail about the local native species and their specific requirements, some factors may emerge as less or more limiting for the species in your project. Water input might be low on the site. However, if native drought-tolerant (xeric) species abound, water will be less of a limitation for these species than if you were attempting to revegetate with more water-loving (mesic) species. It is possible that less mitigation for water will be necessary than originally assumed. The process of refining DFCs is essential in order to ensure that the objectives are feasible given the native species and ecological processes on the site.

Reference sites provided information on existing vegetation and illustrated what might happen on a site in one year, five years, or several decades. These reference sites model how revegetation units might be expected to respond to change and management. The potential successional development of each revegetation unit should be reviewed. Asking what the revegetation units could look like in both short-term (1-3 years) and long-term (5, 10, 15+ years) timeframes is part of the process for finalizing DFCs.

7.3 INTEGRATE AND DEVELOP REVEGETATION STRATEGIES

The final, realistic DFCs should lead the revegetation specialist to examine a number of options:

- no intervention or management;
- massive intervention and mitigation;
- key leverage points between previous extremes for desirable plant succession with minimal human intervention;
- timing of various interventions, from the beginning of the project through several years following establishment.

It would be a mistake to approach the array of available options in a piecemeal fashion, or by copying standard specifications and pasting them into a plan. There are no "silver bullet" products or treatment methods that will transform the site into a functioning plant community. A comprehensive understanding of the site and how revegetation treatments alone or in combination with other treatments will affect soil characteristics, plant establishment, and future successional processes is the key to successful revegetation. Several revegetation strategies can be developed for each revegetation unit by creating various combinations of mitigating measures. It is important to assess how these strategies compare with each other and how the combination of mitigating measures within a strategy will interact.

Strategies are often developed around major actions or themes. For instance, the three strategies in the case study were based on mitigating for the lack of topsoil by:

Strategy 1: Adding fertilizer
Strategy 2: Reapplying topsoil
Strategy 3: Blowing compost mulch

These are very different approaches, and the resulting strategies will vary considerably.

Developing revegetation strategies is an integrative and collaborative process between vegetation and soils specialists and the project engineers. This requires a good understanding of the site limitations, site resources, and experience with a variety of mitigating measures. All reasonable possibilities should be considered before any are rejected.

7.4 SELECT A REVEGETATION STRATEGY

The spreadsheets shown in Figures 7.2, 7.3, and 7.4 are helpful in summarizing site attributes for defining limiting factors, keeping track of potential mitigating measures, and comparing revegetation strategies for each revegetation unit. Following this process can lead to an informed decision on selecting a revegetation strategy for each revegetation unit.

Figure 7.4 (strategy comparisons) illustrates an example of a qualitative approach to evaluate the effect each potential treatment has on site characteristics responsible for successful revegetation. In this method, limiting factors are identified for positive or negative effects on plant growth. Each of these characteristics is assessed for the conditions expected after construction with no mitigation measures employed, and qualitatively given a rating as follows:

- - - Severely limiting
- - Limiting
- Somewhat limiting
+ Not limiting
+ + Beneficial
+ + + Very beneficial

Treatments are placed in the successive columns and rated for their effects on the soil characteristics. Ideally, the last treatment column should be mostly positives for a successful project. If there are still negatives, further treatments can be applied to the matrix. If an option is not economically or technically feasible, other combinations of treatments might be developed and compared. The selection of one combination of treatments over others will be based on revegetation objectives and feasibility of applying the treatment, including considerations of economics, available skills, and resources.

Both short-term and long-term thinking are required. Quick establishment of desirable vegetation is the short-term goal. Although mitigating limiting factors is essential for long-term revegetation success, mitigation efforts do not always directly aid in early establishment of plant materials. Success during this early period depends almost entirely on conditions in a narrow two-foot environment - one foot below the soil surface, and one foot above. Until plants can grow out of this zone, they will be affected by climate extremes (moisture, temperature, and so on), competition, and animal damage. The first few weeks after the installation of plant materials is often the most critical period in the revegetation process; plants should not be considered "established" until at least 1 to 2 years of growth. After the short-term goals are accomplished, the process of succession should be set for healthy long-term recovery. Sometimes a choice might involve slower short-term progress with more investment in long-term solutions.

7.5 ASSEMBLE THE REVEGETATION PLAN

At the end of Phase Four, revegetation strategies for all revegetation units have been selected. If the planning process went well, writing the actual plan should simply be a compilation of the various strategies. Revegetation Plans vary in length and depth. At a minimum, a plan will typically include the following components:

- Revegetation objectives
- Description and map of each revegetation unit
- Desired future conditions (DFCs) for each revegetation unit
- Analysis of site attributes (limiting factors and resources) and type of vegetation
- Description of mitigating measures
- Description of the revegetation strategy, including plant materials/stocktypes/application methods for each unit
- Key contacts and responsibilities
- Budget and timelines
- Strategies for monitoring achievement of DFCs
- Strategies for correcting shortcomings based on monitoring information

An example Revegetation Plan is provided in Chapter 8.

7.5.1 Networking

The revegetation plan is a valuable tool for communicating with the Federal Highway Administration, other government agencies, and the general public. The degree that a revegetation project succeeds is often proportional to the quality of these interactions. It requires identifying the agency players, affected or key community members, and local and regional workforce (see Chapter 2) and understanding their concerns. The best written plans are of little value if these relationships are not established and maintained. It is important to share versions of the plan with, and solicit input from, others involved in the project.

7.5.2 Timelines

From inception through implementation and monitoring, construction projects span many years. A timeline can help organize the series of steps required for a successful revegetation project, and should include all aspects and details of the project. The timeline is basically a "to do" list with corresponding "due dates." Awareness of timing is crucial, especially when obtaining plant materials. More information on timelines is provided in the Implementation Guides to Obtaining Plant Materials (Chapter 10).

7.5.3 Fiscal Concerns

Budgets are necessary to estimate costs. Methods to build budgets and timelines are outside the scope of this publication, but there are many resources available to assist with the process.

When the Planning Phase is complete, it will be time to move to the Implementation Phase. During implementation, the Revegetation Plan will be translated into task orders and prescriptions that specify how, when, where, and by whom the plan will be implemented.

CASE STUDY - DEFINE SITE, LIMITING FACTORS, AND DESIRED FUTURE CONDITIONS

Revegetation Unit Description

Five revegetation units were defined for this road project. The revegetation unit in this case study was defined from surveys of several reference sites and local reports.

Figure 7.1a - Reference Site 1. This site has been barren since construction. Soils are compacted and sheet erosion is active.

Soils are generally deep sandy loams (less than 20% rock fragments) derived from pumice parent material. Topsoils are 6 to 8 inches deep. Duff and litter layers are 2 to 3 inches deep. Infiltration rates are very high unless duff and litter layers are removed and soil is compacted. Slope gradients are less than 5H:1V, except for a few areas that approach 2H:1V. The climate is semi-arid, with an annual precipitation of 10 inches, delivered as snow in winter and intense thunderstorms in the summer months. Winters are very cold; summers are warm. Evapotranspiration rates are high from spring through fall. Vegetation on undisturbed reference sites is dominated by ponderosa pine, quaking aspen, bitterbrush, ceanothus, and Idaho fescue.

Disturbance Description

All vegetation will be removed and roots and stumps grubbed. Topsoil will be removed, leaving at least 2 feet of subsoil for rooting. Soils will be compacted, and the site is expected to appear similar to the photo of Reference Site 1 (Figure 7.1a).

Limiting Factors and Mitigating Measures

Figure 7.2 shows the potential limiting factors associated with this revegetation unit. Figure 7.3 displays possible mitigating measures that could be employed to overcome each limitation.

Figure 7.1b - Reference Site 2. This reference site is composed of squirreltail (*Sitanion hystrix*) and Oregon sunshine (*Eriophyllum lanatum*), representing the desired future condition of this project.

Desired Future Condition

The revegetation objectives for this unit are to develop a low growing stand of native grasses and forbs that are not attractive as deer forage, exclude invasive weeds, and add visual interest to a high recreational use road. Based on reference sites or recently recovered disturbances, vegetative cover of a well-established grass and forb stand is 50% to 70% in mid summer, with 10% to 30% bare soil. Vegetation establishment is very low the first year, with less than 20% cover typically occurring. DFC thresholds after the first year include: 20% vegetative cover, 30% bare soil, no knapweed. DFC thresholds after the third year include: 65% vegetative cover, 30% bare soil, no knapweed. Vegetative cover must be composed of 90% native vegetation.

Figure 7.2 - Case Study - Define limiting factors on the site.

Critical Plant Factors	Parameters		Site Characteristics
1 Water Input	Rainfall	✓	3" of rainfall in summer, thunderstorms July - Aug
	Interception		none
	Infiltration	✓	low infiltration when compacted
	Road Drainage		none
2 Water Storage and Accessiblity	Soil Texture	✓	low - sandy texture
	Rock Fragments		relatively little gravels and no cobbles or rock
	Soil Structure	✓	expected to be compacted
	Rooting Depth	✓	deep soils, but likely to be restricted by compaction
	Mycorrhizae	✓	expected to be little to none
3 Water Withdrawal	Humidity	✓	high ET rates in spring; quick drying of soil surface
	Wind		low - protected by surrounding forests
	Aspect		no southern aspects
	Competing Vegetation		little competing vegetation in first several years
	Soil Cover	✓	low - high surface evaporation
4 Nutrient Cycling	Climate	✓	cold winters, mild summers
	Topsoil	✓	none
	Site Organic Matter	✓	very low
	Nitrogen & Carbon	✓	very low
	Nutrients	✓	very low
	pH & Salts		moderate pH, low salts
5 Surface Stability	Rainfall & Wind	✓	intense thunderstorms in summer, high rainfall splash
	Freeze-Thaw	✓	moderate to high when surface is compacted
	Soil Cover	✓	low
	Surface Strength	✓	low - no cohesion in sands
	Infiltration	✓	low
	Slope Gradient		low slope gradients favorable to surface stability
	Surface Roughness		expected to be rough
	Slope Length	✓	30 feet slope run, on compacted soils can get rills
6 Slope Stability	Water Input		low
	Hydraulic Conductivity		NA
	Restrictive Layer		NA
	Slope Length		NA
	Slope Gradient		low slope gradients eliminates possibility of landslides
	Soil & Root Strength		NA
7 Weeds	Bare Soil		high
	Weed Propagules	✓	populations of knapweed along road corridor
	Native Propagules		high from surrounding area
	Nitrogen		low
8 Pests	Mammals	✓	deer populations in spring and fall; some gopher
	Birds		minor
	Insects		minor
	Diseases		minor
9 Human Interface	Road Maintenance		some gravels from sanding roads - minimal effect
	Recreation Use		snowmobile traffic - minimal

Figure 7.3 - Case Study - List possible mitigating measures for limiting factors.

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		

CASE STUDY - DESIGN POTENTIAL REVEGETATION STRATEGIES

From the list of possible mitigating measures, design several revegetation strategies.

Strategy 1

- Subsoil till the top two feet of soil to break up compaction.
- Fertilize with a slow-release fertilizer.
- Use working group of nitrogen-fixing species (lupine, ceanothus and bitterbrush) and hydroseed in fall with wood fiber mulch.

Short-term and long-term effects

Subsoil tillage reduces compaction and increases surface stability by roughening the surface, increasing infiltration and reducing freeze-thaw potential. Subsoil tillage also increases rooting depth.

Fertilizers will provide nitrogen and other nutrients for seedling establishment. Sufficient nitrogen may not be present to meet vegetation cover thresholds, but higher nitrogen levels in the soil might encourage annual weed growth.

Emergence of sown seeds could be poor, especially if there are periods of dry spring weather during germination. Surface soil holds very little moisture in exposed, dry areas, and the wood fiber in the hydromulch will not provide enough moisture around seeds for germination. Mycorrhizae is important on dry sites, but has not been added to the hydroseed mix. This could result in poor establishment of seedlings.

Discussion

This is the least expensive strategy, and the least likely to create conditions for long-term revegetation. Nevertheless, the deep, non-compacted soils, though lacking in organic matter, should be able to support a good stand of nitrogen-fixing species. This could restore nitrogen to the soil and build soil biomass over time.

Strategy 2

- Salvage and reapply 6 to 9 inches of topsoil, then subsoil till to 24 inches.
- Apply seeds through hydroseeding equipment and cover with an application of straw mulch and tackifier.
- Use a working group of visually pleasing species (predominately showy forb species).

Short-term and long-term effects

Topsoil will increase the water-holding capacity in the surface soil, as well as rooting depth, nutrients, organic matter, infiltration rates, and mycorrhizal inoculum. Knapweed (*Centauria* spp.) infestation is possible if care is not taken to avoid areas of knapweed during soil salvage operations. Long-term nitrogen needs for the site are met with the additions of topsoil, but short-term nitrogen availability for seedling establishment might be low. Subsoil tillage increases rooting depth, surface stability through surface roughening, and infiltration. Tillage also reduces the freeze-thaw potential. Application of straw will increase germination and early seedling establishment due to higher humidity around seeds during germination. Straw also protects the soil surface from rainfall splash during thunderstorms. Straw can be a potential source of weeds if certified straw has not been purchased.

Discussion

This is the most expensive measure, but will potentially support the highest amount of plant cover over the long-term. All major limiting factors have been mitigated in this strategy.

Strategy 3

Apply 2-inch layer of compost to soil surface using a compost blower. Apply seeds and mycorrhizal inoculum during this operation. Use a working group of visually pleasing species (predominately showy forb species).

Short-term and long-term effects

Soil moisture is increased around the seeds due to the higher water-holding capacity of compost. Seeds are buried during compost blowing, increasing the chances of germination and establishment. Smaller seeds buried under the deeper thicknesses of compost will have poor emergence. Nutrients are supplied through the compost for short- and long-term plant community needs. Nutrients are not as accessible on the surface of the soil, requiring a portion of the grass and forb root systems to be growing into the compost. Mycorrhizal fungi are supplied through commercial inoculum. Soils are still compacted, limiting rooting depth.

Discussion

This strategy should be adequate to establish plants. Since soils are still compacted, meeting long-term vegetative cover targets might be difficult. This strategy could be improved if the compost were applied to previously tilled soil, or applied to the surface and then tilled into the soil to mix the compost and loosen the soil.

Figure 7.4 - Case Study - Compare revegetation strategies. Evaluate each strategy using a qualitative system for comparison.

Critical Plant Factors	Parameters		No Action	Strategies		
				1	2	3
1 Water Input	Rainfall	low	- - -	- - -	- - -	- - -
	Interception					
	Infiltration					
	Road Drainage					
2 Water Storage and Accessiblity	Soil Texture	low	- -	- -	+	-
	Rock Fragments					
	Soil Structure	none	- -	+	+	-
	Rooting Depth					
	Mycorrhizae	low	-	-	+	+
3 Water Withdrawal	Humidity	very dry	- - -	+	+	-
	Wind					
	Aspect					
	Competing Vegetation					
	Soil Cover	low	-	-	+	+
4 Nutrient Cycling	Climate					
	Topsoil	none	- - -	- - -	+ +	- - -
	Site Organic Matter	none	- -	- -	+	+
	Nitrogen & Carbon	none	- - -	-	+ +	+
	Nutrients	none				
	pH & Salts					
5 Surface Stability	Rainfall & Wind					
	Freeze-Thaw	mod-high	-	+	+	+
	Soil Cover	low	-	-	+	+
	Surface Strength					
	Infiltration	low	- -	+ +	+ +	=
	Slope Gradient			+	+	
	Surface Roughness					
	Slope Length					
6 Slope Stability	Water Input					
	Hydraulic Conductivity					
	Restrictive Layer					
	Slope Length					
	Slope Gradient					
	Soil & Root Strength					
7 Weeds	Bare Soil					
	Weed Propagules					
	Native Propagules	low			-	
	Nitrogen					
8 Pests	Mammals	deer use		-		
	Birds					
	Insects					
	Diseases					
9 Human Interface	Road Maintenance					
	Recreation Use					

7.6 NEXT STEPS

Phase Four, the final phase of the planning process, integrates all the information gathered from the previous three phases. The understanding of limiting factors and resources, mitigation options, species, and planting methods are combined into a comprehensive strategy for revegetating the site. The steps of Phase Four are to: 1) finalize revegetation units and DFCs; 2) integrate survey information and develop potential revegetation strategies; 3) compare and select revegetation strategies; and 4) assemble plan. A case study with a decision matrix illustrates how to weigh various options and strategies to choose the most appropriate ones for the project. Phase Four culminates in the writing of the Revegetation Plan, which details the strategy and provides schedules and budgets for the project. The Revegetation Plan is an important tool for communicating with agencies, individuals, and the community about the project. An example Revegetation Plan is provided in the next chapter.