2000 Billings Land Reclamation Symposium

REVEGETATION EVALUATIONS -- HOW LONG MUST WE WAIT?

R. A. Prodgers[1], T. Keck[2], and L. K. Holzworth[3]

ABSTRACT

Is revegetation a "permanent" fix that will function indefinitely? Or is it merely a long-lived cover crop? When monitored for more than a decade, revegetation success becomes a time-dependent variable. This investigation focuses on how well short-term evaluations in Butte, Montana, related to midterm results. Twenty single-species plantings replicated in three treatments in a primary succession scenario were evaluated over a 15-year period. The treatments were preparatory crop (green manure), stockyard manure, and no amendment. Each stand was numerically ranked on a scale of one to ten every few years. The correlations between second-year and 15th- year evaluations ranged from 43 to 60 percent. The correlations between sixth-year and 15th- year evaluations were stronger in two of the three treatments, and yet the appearance of vegetation six years following planting may be an inadequate basis for prescribing treatments over large areas at great cost. By the 11th year, correlations of ratings with year 15 were greater than 80% in two treatments, but only 66% in the remaining treatment. The number of satisfactory and unsatisfactory stands in all treatments tended to equilibrate between years 10 and 15, presumably for the life spans of successful species. Correlations were strengthened by the high number of early revegetation failures, which always remained failures. Correlations were weakened by plantings that established and persisted for several years but later declined. Since fertility and nutrient cycling are major limitations in primary succession, the highest correlations were found within the most successful treatment: stockyard-manure amendment. We believe that our findings relating short-term to midterm plant performance are relevant where plant-limiting substrates (biologically inert coversoils, contaminated soil, tailings, etc.) are being revegetated. It can take a decade for plant-limiting site factors to manifest themselves in plant performance, or for nutrient immobility to curtail primary production. Eventually, long-term trends become the dominating ones.

Key words: premature revegetation evaluations, short-term and midterm plant performance, hard-rock revegetation, primary succession, nutrient mobility, organic amendments, fertility.

---

[1] Bighorn Environmental Sciences, 305 W. Mercury, Butte, MT 59701
[2] USDA Natural Resource Conservation Service, 3 Whitetail Road, Whitehall, MT, 59759.
[3] USDA Natural Resource Conservation Service, 10 E Babcock Rm. 443, Bozeman, MT, 59715.

It is familiar that many successions do not occur in time scales convenient for human examination... Robert McIntosh

INTRODUCTION

Long-term studies are rare in the ecological sciences (Michener 1997). In evaluating revegetation treatments, an ecological perspective is often subordinate to the pressure to declare victory or conclude investigations while funds are available. Briggs and others (1995) observed that many riparian revegetation projects have been evaluated just two or three years following project completion, leaving questions of long-term success unaddressed. Josselyn and others (1993) found that the lack of uniform, long-term monitoring and the application of knowledge gleaned from past projects to new ones was the least effective element of wetland restoration programs. The same often is true of upland revegetation.

The test plots investigated here were seeded in 1981 and sampled throughout a 15-year period. Many of the findings from these revegetation trials apply to a particular type of substrate, climate, organic amendment, and set of species. More generally, this 15-year monitoring program showed how long it may take to evaluate accurately the effectiveness of revegetation prescriptions in a primary succession scenario. The primary questions was, to what degree are early evaluations indicative of later trends and long-term success?

TEST PLOT CONDITIONS, TREATMENTS, AND LAYOUT

Location

The study area is located southeast of the Texas Avenue overpass near the Berkeley Pit in Butte, Montana. Butte is located at latitude 45.95, longitude 111.05. The test plots are at about 1,676 m (5,500 feet) elevation. Climate is cool and dry. Based on National Oceanic and Atmospheric Administration (NOAA) compilations, average annual precipitation between 1964-1998 was 32 cm (12.8 inches). During that period, precipitation exceeded 46 cm (18") in four years, but in six years it was less than 23 cm (9"), including a series of three consecutive years. Mean annual snowfall is 145 cm (57"). Mean monthly temperature is 4º C (39º F), ranging from around -8º C (17º F) in December and January to slightly more than 16 º C (60º F) in July and August. The frost-free season is 60 to 80 days.

Substrates

The test area began as a flat, coarse substrate of residual soil, not necessarily the original soil surface, covered in places with mine waste and slag. The residual soil contains significantly more clay than granitic borrow material, and hence has greater cation exchange capacity (CEC) and water-holding capacity. Concentrations of metals in the buried soil and waste rock have not been characterized, but 15 years after test plot construction, reactivity was extremely acid to strongly acid (pH = 4.5 to 5.5).

In 1979, what appeared to be mine waste in the southwest portion of the test area was leveled and covered to a depth of about 15 cm (6") inches with about 1,300 m^3 (1700 cy) of pit-run crushed limestone (minus 1/4 inch) from the quarry west of Anaconda. Portions without mine waste appeared to decomposed granite (grus). A layer of granitic alluvium 0.5 to 0.6 meters (1.6 to 2.0 feet) thick was applied over the entire area, which was approximately 220 by 90 meters (two hectares, five acres).

Coversoil material applied at the Texas Avenue test plot area consists of coarse, granitic alluvium from the southeast corner of the Berkeley Pit. As applied, this material was devoid of organic matter. Textures range from very gravelly, loamy coarse sand to gravelly, coarse sandy loam with an approximate range in clay content of four to eight percent. Rock fragments are predominantly pea gravel from decomposed granite (grus) with some larger angular gravel from granite and alpite. Rock fragments (>2 mm) comprise 20 to 40 percent of the coversoils material by volume. This material has characteristically low CEC and water-holding capacity. Fifteen years following application, field pH of coversoils ranged from mildly alkaline (pH = 7.4) to moderately alkaline (pH = 8.0). After drying, laboratory analysis indicated moderately alkaline pHs of 8.2-8.3.

Distinctions between coversoils originating as deep borrow materials and those originating from the A or A + B horizons of stripped soils are extremely important. Coversoils from deep borrow materials contain virtually no organic matter and lack important soil organisms such as heterotroph and nitrifying bacteria, fungi, ammonifying organisms, mycorrhizal fungi, and protozoa. It is useful to think of them as “biologically inert coversoils” because nutrient quantity and mobility eventually become critical limiting factors. In addition to having humus and soil organisms, native soils in uplands around Butte have a higher clay content than granitic coversoil material and have developed distinct horizons, whereas coversoils are relatively uniform throughout.

Amendments

The area was divided into three treatments along east-west boundaries. Before permanent planting, all treatment areas were fertilized with 340 kg/ha (300 pounds/acre) of 16-20-0 and 113 kg/ha (100 pounds/acre) of 0-0-60. All treatment areas were chisel-plowed and harrowed several times in late October. Anaconda Minerals Company/ARCO did the site preparation work and provided some seed.

The northern portion was planted to winter wheat in June 1981. This preparatory crop did not establish well, although short-term effects were evident. That summer, approximately 380 m^3 (500 cy) of stockyard manure were applied to the middle segment, or about 570 m^3/ha (300 cy/A). The depth of the poorly incorporated manure averaged two inches. The southern third received no amendment other than fertilizer. In the interest of brevity, we will refer to the treatments as no amendment (NA), preparatory crop treatment (PCT), and stockyard manure treatment (SMT).

After a decade and a half, soils of the PCT and NA areas could not be distinguished based on physical or chemical characteristics. Soils of the SMT had greater organic content and fertility than soils of the NA and PCT areas (Table 1). With the exception of alfalfa plantings, plant-available and organic nitrogen was very limited in soils of areas not treated with stockyard manure. Since partially decomposed manure fragments remained at the surface in the SMT, the two- to six-inch-depth increments best characterize the effects of manure amendment.

Seedings

The USDA Soil Conservation Service (SCS, now Natural Resource Conservation Service, NRCS) provided seed of 14 cultivars from the Bridger Plant Material Center and oversaw planting, which was done by the Anaconda Minerals Company using a 10-foot Brillion seeder in early November 1981. A dormant fall seeding, such as this one, aims at germination the following spring when moisture conditions are optimal. In this report, the year following planting (i.e., 1982) is considered year one.

Plot layout is portrayed in Figure 1, with cultivars identified. (Cultivars won't be mentioned again, in the interest of brevity, unless more than one cultivar of a species was seeded.) Twenty plots, each planted to an individual species, were made across the three treatments. Large test plots are approximately 12 meters wide by 30.5 meters long (40' x 100'), whereas the smaller ones are six meters wide. The smaller planting accommodated limited quantities of some types of seed. More than 15 years after planting, the crisp boundaries of successful seedings remain.

Management

Mining ceased in 1983 and ownership changed in 1986, so the plots were not refertilized and weeds were uncontrolled. Once seeded, the plants were on their own. This scenario is not unusual in the Butte-Anaconda area and is a practical test of revegetation treatments.

SAMPLE AND STATISTICAL METHODS

Plant performance was sampled in two ways. SCS personnel provided stand ratings in years 1, 2, 3,4,5,6,7, and 11. Various attributes were ranked. The most useful for evaluating revegetation success was "stand ratings." Each stand was numerically ranked on a scale of one to ten. In this report, these rankings were used for statistics and further combined to distinguish satisfactory, moderately satisfactory, and unsatisfactory stands.

In year 15, each planting/treatment was evaluated for species canopy coverage (Daubenmire 1959) with ten 0.5 m^2 rectangular plots. Plots were systematically located at least three meters from boundaries. The chief advantage of this ocular estimation technique is that it provides species composition information with minimal sampling. The frame perimeter was marked to indicate reference area percentages, e.g., one percent, five percent, 10 percent, etc.

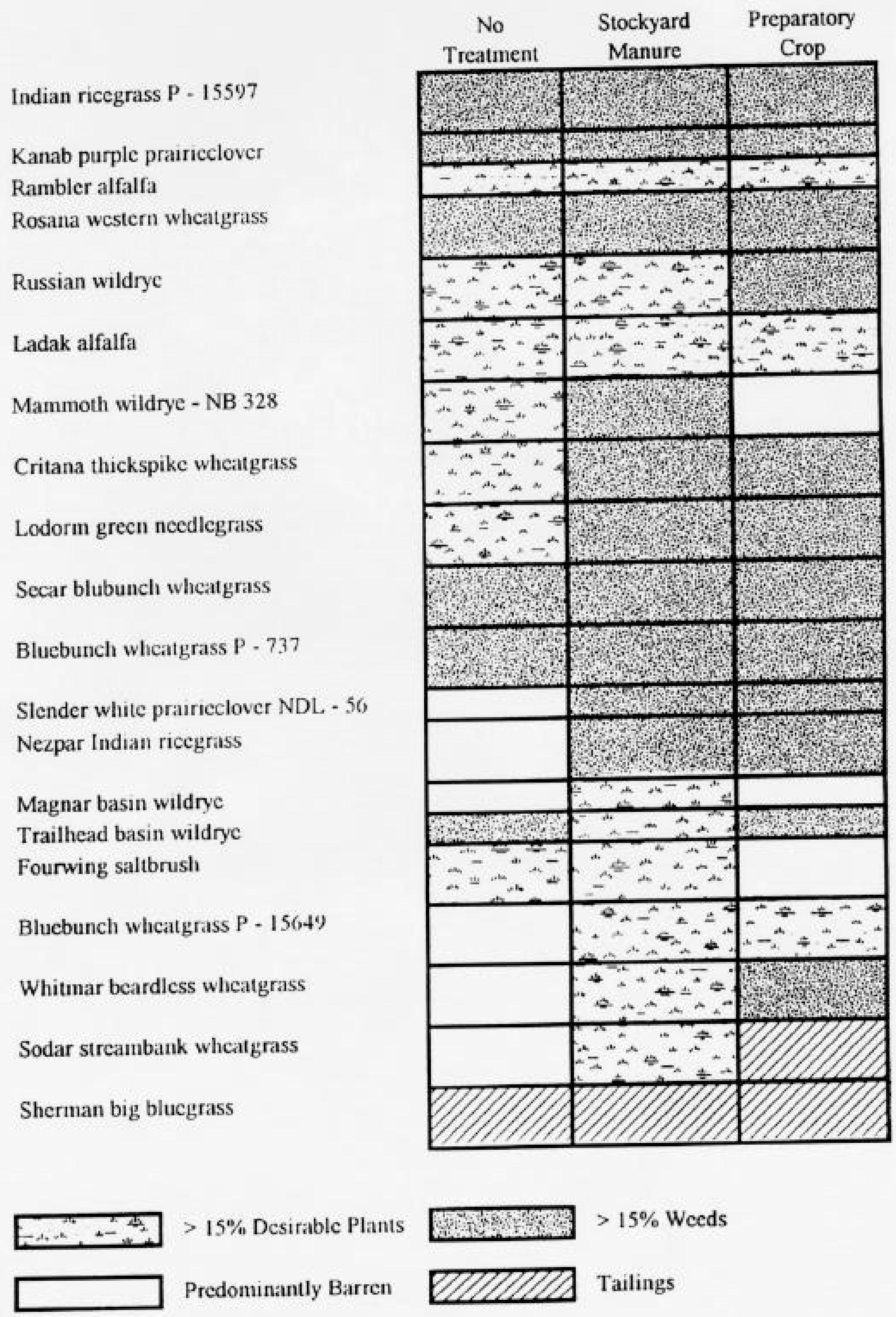

FIGURE 1. Treatment and Planting Layout at the Texas Avenue Test Plots.

Table 1. Nitrates and Organic Matter in Manured and Nonmanured Coversoils at Texas Avenue Test Plots, 15 Years Following Fertilization. (Based on samples from four grass and one alfalfa seedings.)

DEPTH INCREMENT (INCHES)	MANURED	NONMANURED
	NO_3 (Mg/Kg)	
0-2	30.0	2.6
2-6	2.5	0.6
6-12	0.6	0.5
	ORGANIC MATTER (%)	
0-2	6.9	0.6
2-6	1.1	0.1
6-12	0.2	0.1

For this report, the quantitative cover data collected in year 15 were transposed to rank level, complementing data collected in earlier years. The Kruskal-Wallis (nonparametric) one-way analysis of variance was used to determine significant differences in rankings among years. Significant differences were defined based on $p<0.05$, but the results were identical for $p<0.1$. The Spearman Rank Correlation procedure was used to evaluate the degree of association of stand rankings in years 2 vs. 15, 6 vs. 15, and 11 vs. 15.

RESULTS

Figure 1 portrays the general appearance of the test plots after 15 years. Satisfactory plots in Figure 1 indicate >15% canopy coverage of desirable species in each plot -- not just planted species. Red and white clover contributed to the cover of desirable species in the NA and to a lesser extent in the PCT areas. Quackgrass and some other wheatgrasses outside their planting areas contributed to the quantity of desirable species in the eastern portion of the SMT. Birdsfoot trefoil, reportedly never planted, was a major factor in the satisfactory rating of a bluebunch wheatgrass planting in the PCT. However, the stand ranks used in statistical evaluations are based solely on the planted species.

Plant Performance

In August 1983, when stands were two years old, the vegetational appearance of treatments often belied long-term performance. Early monitoring is more useful in documenting the establishment dynamic than in predicting eventual success. By the sixth year, the number of successful species was sometimes greater (SMT and PCT areas), sometimes less (NA area) than in the second year. However, it was not until approximately year 11 that plant performance equilibrated, presumably for the life spans of the dominant species (Table 2). Figures 2 through 5 indicate the performance of representative species through time in different treatments.

In the SMT and NA areas, the correlation between second- and 15th-year stand ratings began in the 40 to 60 percent range. Ratings in year six were somewhat better correlated with year 15 (Table 3). By year 11, correlations with year 15 were greater than 80 percent. In the PCT area, the correlation of second- and 15th-year stand ratings was similar, but instead of strengthening, the correlation of sixth- and 15th-year ratings weakened. This can be explained by a great increase in the number of satisfactory ratings in the sixth year, but in later years the number of satisfactory ratings declined to initial levels (Table 2). The correlation between years 11 and 15 also was weaker than in the other treatments (Table 3), although the number of satisfactory treatments remained constant (Table 2). Summing up, the older the stands, the more ratings approach equilibrium. But even after 10 years, a risk of premature evaluation remains.

No Amendment. Establishment and early plant growth of nonweedy species were best in the NA area. In year two, 11 species/cultivars were rated good to excellent. The best were Ladak alfalfa and Russian Wildrye.

Fifteen years later, spotted knapweed was the dominant species across the NA area. Among planted species only alfalfa could be called a success apart from volunteers. Canopy coverage of the two alfalfa varieties averaged 41 percent, with only two percent knapweed cover. However, the Rambler alfalfa stand contained 34 percent cheatgrass, whereas Ladak alfalfa had only about five percent. Alfalfa had spread to adjacent planting areas, where it helped Russian wildrye, presumably by providing available nitrogen. The beneficial role of alfalfa and previously identified volunteer legumes in accelerating primary succession is obvious.

Rank correlations (Table 3) indicate that stands less than about 10 years old were poor indicators of later stand condition. Rankings in year two did not differ significantly from year six. Year six ratings also didn't differ from year 15. Rankings in the 11th year did not differ from year 15, but were dissimilar from years one and six.

Table 2. Stand Condition in Relation to Years Since Planting. (n = 20 plots/treatment.)

SPECIES	NO AMENDMENT				PREP. CROP TREATMENT				MANURE TREATMENT			
	YEAR											
RATINGS	2	6	11	15	2	6	11	15	2	6	11	15
SATISFACTORY	11	9	2	2	2	7	2	2	2	8	3	3
MOD. SATISFACTORY	4	4	3	3	5	4	0	0	5	5	7	4
UNSATISFACTORY	5	7	15	15	13	9	18	18	13	7	10	13

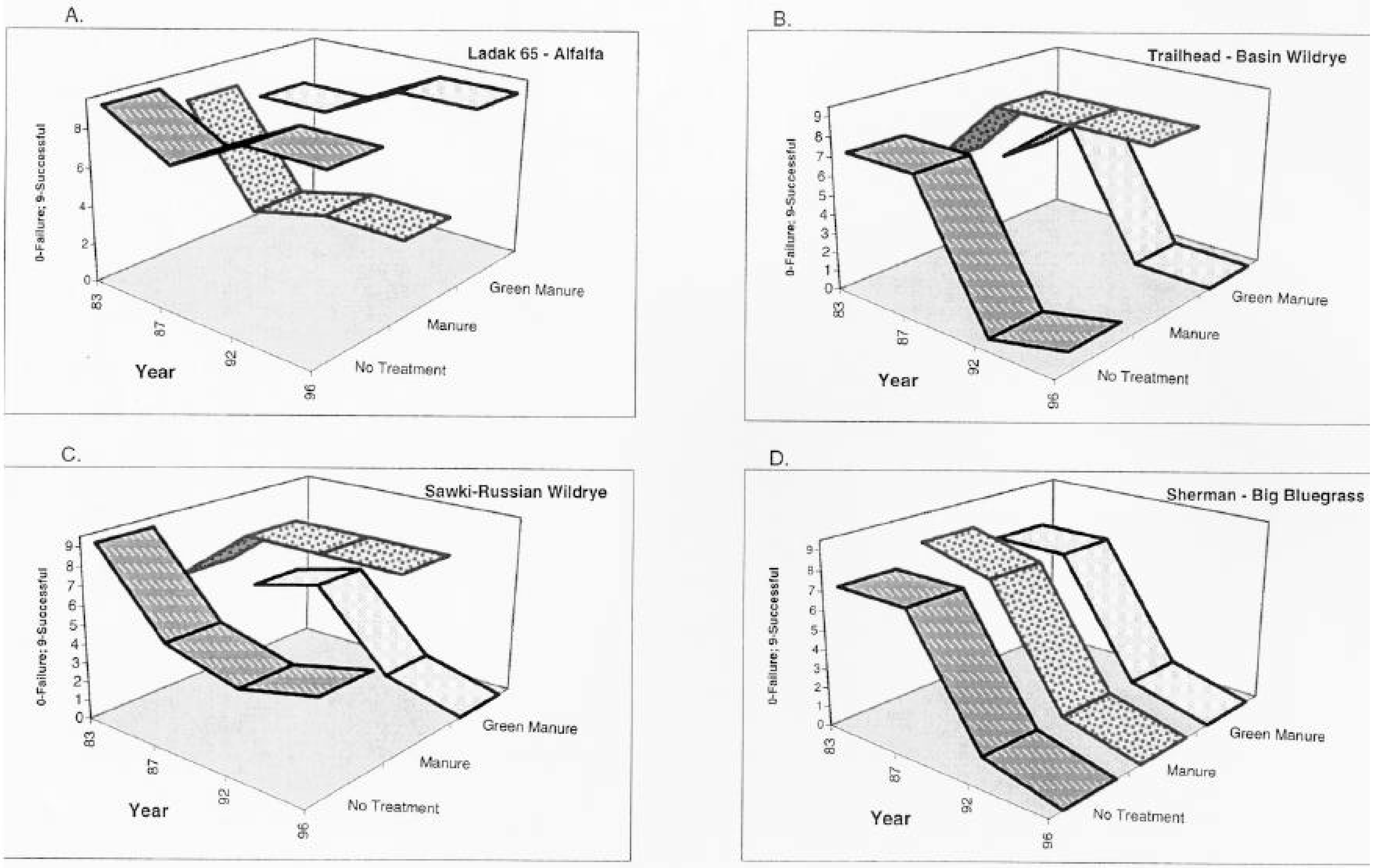

FIGURE 2. Three classes of plant performance. Alfalfa (A) was the only satisfactory seeded species on non-manured substrates 15 years after planting. Basin wildrye (B) and Russian wildrye (C) established slowly and persisted only on the manured coversoil. Big bluegrass (D) established strongly but did not persist – a type of performance that weakens between-year correlations.

Table 3. Spearman Rank Correlations.

YEAR	NO AMENDMENT	PREP. CROP TREATMENT	MANURE TREATMENT
		-% -	
2 vs. 15	43	49	60
6 vs. 15	50	32	71
11 vs. 15	81	66	84

Preparatory Crop Treatment. Ultimately the PCT area came to resemble the NA area, but in the early years differences were significant. Whereas three-quarters of the plantings in the NA area were initially successful to some degree, fewer than half were satisfactory in the PCT. Most successful were big bluegrass and Ladak alfalfa. By year six, the PCT had 11 satisfactory and moderately satisfactory plantings (Table 2), still lower than other treatments but a marked improvement from year two.

After 15 years, the area initially planted with winter wheat had the poorest overall plant performance. Levels of cheatgrass and knapweed were the same as in the NA area. Only alfalfa could be judged a success, but both alfalfa cultivars did better in the NA area.

Although the PCT seemed to have negative effects on plant performance in both the short- and long-term, it is extremely unlikely that a preparatory crop was harmful. Soil/substrate factors may have varied across the test area, and for reasons not obvious alfalfa did not spread in the PCT area. Also, volunteer legumes were not as abundant as in the NA area. Reduced abundance of soil-nitrifying symbionts probably impaired the performance of other species within the NA area. Because contagious distributions often are phenomena in themselves, we cannot conclude that the relative lack of volunteer legumes was caused by the PCT, and in fact more legumes have volunteered since completion of this study..

Rank correlations (Table 3) indicate that early stand ratings were mediocre predictions of long-term plant performance. Sixth-year rankings were particularly poor predictors of plant performance in year 15. Rankings in years two and six did not differ significantly, nor did rankings in years 11 and 15. The relation of ranking in years 11 and 15 was weaker than in other treatments.

Stockyard Manure Treatment. After 15 years, total live plant cover was almost double that of other treatments. The yield advantage of rather heavy manure amendment can remain 40 years after treatment (Heady 1952). The manured amendment resulted in the most satisfactory perennial grass performance but also the most weeds. Knapweed cover was double, and cheatgrass cover triple the amounts found in NA and PCT areas.

All the grasses performed better on the more fertile, physically enhanced soils. The following grasses, most of which did poorly on other treatments, were at least marginally satisfactory in the SMT: thickspike wheatgrass (which also volunteered into the Ladak alfalfa planting), bluebunch wheatgrass, slender wheatgrass, quackgrass and Kentucky bluegrass (both volunteers), basin wildrye (two cultivars), and Russian wildrye. Of these, Russian wildrye and basin wildrye were the standout successes, both in abundance and in demonstrated ability to exclude weeds.

The early appearance of the SMT area, however, was not promising. Two years after planting, almost every stand in the SMT was rated very poor to fair. Weeds were abundant, and only big bluegrass and streambank wheatgrass established stands that were judged good in year two. Of the ultimately successful grasses, basin wildrye was rated fair, and Russian wildrye was rated a little below that. However, vigor of plants established at that time was better than in nonmanured treatments. None of the legumes did as well in the SMT as in the NA area. Typically, nitrogen additions reduce nodule weight and density (Alexander 1991, Chapter 19).

Rank correlations between years six and 15 were better than in other treatments (Table 3), probably because soil fertility wasn't so limiting in the manured treatment. By year 11, rankings were well correlated with plant performance in the 15th year. Correlations between years were stronger in all cases, and there were no significant differences among mean ranks in any years.

DISCUSSION

Most revegetation failures at Texas Avenue and on the Butte Hill can be attributed to the interactions of five factors:

1. Droughty, infertile, and shallow soils,
2. Lack of adequate N and nitrogen cycling,
3. Species/cultivars unsuited to their environment,
4. Elevated metal concentrations in coversoils, and
5. Weed infestations.

Some combination of these limiting factors typify much of the revegetation being done in the Butte-Anaconda area and at hard rock mines elsewhere.

The observations reported here indicate that plant performance a half-dozen years after planting can be a poor basis for predicting how well seedings will ultimately perform. Even on *in situ* soils, revegetated plant communities are in a state of flux for at least three years following establishment. Not only can composition shift significantly, but productivity often exceeds sustainable levels. Ziemkiewicz and Takyi (1990) found that revegetation in cold regions often appears successful for several years, only to deteriorate as surface cover diminishes and erosion occurs, largely as a result of nutrient immobilization.

In revegetating barren substrates, single plantings may not be realistic approaches to enduring plant communities. The lack of available nitrogen and the tendency for nutrient immobilization are so limiting that a combination of good organic amendment and nitrogen fixation are the quickest routes to a substrate that can support enough plants to prevent accelerated erosion. What would otherwise take centuries, including the development of nutrient reservoirs in the organic fraction and a functioning soil food web, can in important respects be compressed into a few decades. At that time, slower-growing species requiring lower soil fertility are most appropriate and in many cases should be planted.

If a single seed mix is planted, one has to ask what will happen when the initial generation of plants dies. The longevity of plants relative to professional careers is a major limitation to successional studies. Woody plants are long-lived, but even individual bunchgrasses may persist for three decades (Houston 1982, Appendix 6, figure 6.15.), and the life spans of genets are indeterminate. When successions occur, will they be the more or less natural successions of natives or the unnatural successions of exotics? Rarely is this investigated.

CONCLUSION

Our evaluations over a 15-year period show that plant performance rankings six years following seeding may have only a 50 percent correlation with plant performance nine years later. About two-thirds of the plantings across all treatment were rated as satisfactory in year six, but most of them ended up dominated by knapweed and assorted other weeds. Hence, we conclude that the appearance of vegetation six years following planting may be an inadequate basis for prescribing treatments over large areas at great cost.

In this study, correlations were bolstered by plantings that quickly failed and remained failures. Correlations would be even lower if long shots such as prairie clover, Indian ricegrass, and fourwing saltbush has been replaced with more likely prospects.

Enhanced revegetation success on the manured treatment in conjunction with the satisfactory performance of alfalfa alone on the NA and PCT treatments after 15 years indicates how important it is to provide plant-available nitrogen in a substrate lacking a nitrogen reservoir. With nitrogen fixation comes productivity, and with productivity comes niches for decomposer soil organisms which also are agents of soil aggregation. Primary succession is largely a matter of soil development, largely through autogenic processes, in which the site becomes suitable for different species or plant communities. In this progression (as it is often conceived), competitive species generally replace stress-tolerant species and ruderals (*sensu* Grime 1979). The fact that the manured treatment had twice the plant cover of other treatments and the only fully satisfactory stands of grass also indicates the need for an organic nutrient pool and soil food web.

Where important limiting conditions are present, treatment evaluations must focus not just on short-term performance, but also on how the treatment addresses each limiting factor. Revegetation success is a time-dependent variable. Eventually, long-term trends become the dominating ones.

We believe that our findings relating short-term to midterm plant performance have relevance beyond the particulars of these test plots. They are applicable when revegetating plant-limiting substrates (primary succession, contaminated soil, tailings, etc.) but not topsoil with an accumulation of organic matter and a healthy pool of soil microorganisms.

REFERENCES

Alexander, M. 1991. Introduction to Soil Microbiology. Second ed. Krieger Pub. Co., Malabar, FL. 467 pp.

Briggs, M., Roundy, B., and W. Shaw. 1995. Trial and error. Restoration and Management Notes 12: 160-166.

Daubenmire, R. 1959. A canopy-coverage method of vegetational analysis. Northwest Sci. 33(1): 43-64.

Grime, J. 1979. Plant Strategies and Vegetation Processes. Wiley, N.Y.

Heady, H. 1952. Reseeding, fertilizing, and renovating an ungrazed mixed prairie. J. Range Mgt. 5:144-149.

Houston, D. 1982. The Northern Yellowstone Elk: Ecology and Management. Macmillan Pub. Co., NY. 474 pp.

Josselyn, M., Chamberlain, S., Goodnight, K., Hopkins, H., and A. Fiorillo. 1993. Evaluation of coastal conservancy enhancement projects, 1978-1992. San Francisco State Univ., Tiburon, Ca.

McIntosh, R. 1980. The relationship between succession and the recovery process in ecosystems. pp. 11-62 *In:* J. Cains (ed.) The recovery process in damaged ecosystems. Ann Arbor Sci. Pub. 167 pp.

Michener, W. 1997. Quantitatively evaluating restoration experiments: research design, statistical analysis, and data management considerations. Ecol. Restoration 5(4):324-337.

Ziemkiewicz, P., and S. Takyi. 1990. Organic matter dynamics on reclaimed coal mines in the Canadian Rockies. pp. 127-133 *In*: Proc. of the 1990 Mining and Reclamation Conference and Exhibition, Vol. I. Charleston, W. Va. 319 pp.

CULLED FINDINGS

In some cases, the course of plant succession following the death of planted dominants is likely to be affected more by the status of the soil and propagule influx than the species composition of initial revegetation.

The success of *Trifolium pratense* and *T. repens,* volunteers in the NT and to a lesser extent the PCT area, is potentially one of the most useful developments at the Texas Avenue test plots. With 6 percent canopy coverage across all plantings, these species ranked third in abundance behind knapweed and alfalfa. Since sampling in 1997, clover coverage appears to have increased in both nonmanured treatments, and *Melilotus officinalis* and *Medicago lupulina* are locally well-represented some years. Not only can legumes can be recommended for planting on coarse, infertile soils in a cold continental climate, they well may invade without assistance. Their demonstrated ability to reproduce gives them special status among the successful species. Where planted species are fairly dense and plant competition is keen, especially for soil moisture, they perform less well. In other words, they're pioneers.

It was Daubenmire's conviction (1968, p. 39) that the presence/abundance of each species reveals something about the plants' environment -- whether or not we can discern it. At the test plots, some weeds were associated with infertile substrates, others with more fertile, organic-rich soils, and the most pernicious weed around Butte (spotted knapweed) is well-suited to both substrates. The NT and PCT areas invited these colonizers: *Phacelia hastata*, *Chaenactis douglasii*, and *Achillea millefolium.* Common weeds were *Gypsophila paniculata* (Table 4) and *Linaria dalmatica*, the latter often a weed of rocky substrates. These species were rare on the manure treatment in 1996.

Cheatgrass did much better on the SMT. Elsewhere it was found in abundance only in conjunction with the taprooted, late developing alfalfa, which also made nitrate much more available in the soil. Quackgrass was virtually absent from other treatments, but volunteered on the manure substrate. Kentucky bluegrass is another species that prospered on more fertile soils. While never abundant, dandelions were found only on the manure treatment.

Spotted knapweed was the most abundant species on all treatments. Cover was approximately 15 percent on infertile substrates and twice that on the SMT. In the terminology of Grime (1979) but perhaps defying his classification, this biennial could be classed a "stress-tolerant, competitive ruderal" – a most successful combination.

We conclude by cautioning that faulty revegetation assessments are likely to occur based on premature evaluation. Once important decisions have been implemented, there is a tendency for all parties to declare victory and decamp. Failures boost no one's career, and there are powerful incentives for both regulators and responsible parties to boast success when both have shared responsibility for design and implementation of reclamation plans.

Based on our research at Butte, grass/forb stands that exhibit progressive decline within five or six years are good candidates for ultimate revegetation failure -- not that they can't play important roles in revegetation when temporal factors are considered in fashioning revegetation prescriptions. In contrast, the apparently satisfactory condition of stands even after more than five years may unreliably indicate eventual success. Stands rated good or excellent after 10 years are likely to persist for the life spans of the dominant species. However, reproduction is a separate issue -- and one seldom monitored. It is possible that the best revegetation at Butte is no more than a persistent preparatory crop. Whether further vegetational development will lead to semi-natural vegetation or fields of exotic weeds remains unknown.

CITATIONS

Josselyn, M., Chamberlain, S., Goodnight, K., Hopkins, H., and A. Fiorillo. 1993. Evaluation of coastal conservancy enhancement projects, 1978-1992. San Francisco State Univ., Tiburon, Ca.

Munshower, F. 1994. Practical handbook of disturbed land revegetation. Lewis Pub, CRC Press, Boca Raton, FL. 265 pp.

Ryerson, D., and J. Taylor. 1974. Rangeland fertilization in Montana - a literature review. pp. 1-19 IN: Proc. Range Fertilization Symposium, Havre, MT. July. Mt. Ag. Expt. Sta. Res. Rep. 70. Pages not consecutively numbered.