EROSION CONTROL

& Conservation Plantings on Noncropland

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This publication contains suggestions for establishing a vegetative cover to control soil erosion and runoff from lands wholly or partially denuded of cover. Building construction, solid waste disposal, strip mining, road building, and construction of dams, waterways, and diversion terraces are some of our activities that can cause land to be barren or inadequately covered by vegetation.

Nature, too, often causes land disturbances through flooding, landslides, and rainstorms. "Disturbed" lands can erode further unless protected. Usually the first line of defense against erosion on disturbed sites, whether caused by people or by nature, is to protect and stabilize the site as quickly as possible with a deep-rooted, long-lived, and persistent vegetative cover of adapted plant species.

Revegetation of a disturbed site can range from easy to difficult. However, there are very few disturbed sites on which an acceptable plant cover cannot be established and maintained *if the following procedure is used:*

- Carefully analyze any limiting site factors, both physical and chemical.
- Select an appropriate combination of adapted plant species.
- Select and use an appropriate set of establishment procedures consistent with the needs of the plant species to be seeded and the need to overcome any limiting site factors.

While disturbed sites vary considerably, differences are usually a matter of degree rather than of kind. Thus, techniques used to revegetate a site disturbed in constructing a road, dam, or waterway do not vary greatly from those used to revegetate a site disturbed by strip mining or solid-waste disposal. However, the level of inputs may vary.

To establish a vegetative cover, use seed of adapted plant species and varieties having a high germination capacity. Use seeding methods favorable for soil moisture and temperature conditions that encourage rapid germination and establishment. Supply adequate amounts of essential plant nutrients. Soil test to determine the presence of any materials toxic to plants. Applying adequate amounts of lime and fertilizer, and using recommended establishment techniques, can overcome many unfavorable soil conditions. They can also produce an adequate vegetative cover of the desired species.

SEED INFORMATION

Seed quality

For erosion control and conservation plantings, seed should be high in germination ability and purity. *Read the seed tag.*

All seed sold in Pennsylvania and other states is required by law to bear a tag or label showing the percentages of germination, pure seed, inert matter, crop seed, and weed seed. The seed tag or label must show the date the seed was tested. *By law, all seed offered for sale in Pennsylvania must be retested at intervals of nine months or less.* When purchasing seed for use in revegetation, check the analysis on the seed tag and compare with the minimum seed standards suggested in Table 1. Germination and purity percentages should equal or exceed the minimum seed standards listed. If it is necessary to use seed with a germination percentage less than the minimum recommended in Table 1, increase the seeding rate accordingly to compensate for the lower germination. See the section below on pure live seed. Remember, "cheap" seed of low germination and purity can jeopardize a successful revegetation process.

Pure live seed

Pure live seed, abbreviated PLS in Tables 1 and 3, is a term defining the planting quality of seeds. To calculate PLS, multiply the percentage of pure seed by the percentage of germination, and divide the product by 100. Thus: (85% pure seed x 72% germination) ÷ 100 = 61% PLS. To determine how much actual seed to plant, divide the percentage PLS into 100. Thus, in our example, 100 ÷ 61 = 1.6. Hence, 1.6 pounds of seed with a purity of 85% and a germination of 72% would need to be planted for each pound specified in the desired seed mixture.

By using PLS, you can adjust the amount of seed required to compensate for low purity and low germination. Seed of common agricultural species, such as tall fescue and birdsfoot trefoil, is usually 98% or more pure seed; therefore, PLS is essentially the germination percentage.

For example, if the purity is 98% and the germination is 85%, PLS is 83%. To determine how much of the seed to plant: 100 ÷ 83 = 1.3; then, 1.3 pounds of seed with a purity of 98% and a germination of 85% would need to be planted for each pound specified in the desired seed mixture.

In contrast, seeds of some of the warm-season grasses, such as switchgrass and big bluestem, tend to be low in both purity and germination. In these cases, it is essential to make use of the PLS concept.

Inexpensive seed

When purchasing seed, remember that "cheap" seed is generally not a bargain. Inexpensive seed usually is below minimum standards in germination or purity, or both (Table 1). In addition, inexpensive seed often contains excessive amounts of weed seed or seed of other crops. Finally, it often is not true to varietal type. As a result, inexpensive seed generally costs more per unit of pure live seed than what initially seemed to be the more expensive seed.

For example, consider seed that costs $0.95 per pound, has a purity of 85%, and has a germination of 60%, and compare this with seed costing $1.50 per pound, having a purity of 99% and a germination of 90%.

Inexpensive seed:
PLS = (85) x (60) ÷ 100 = 51%
100 ÷ 51 = 2 lb of seed needed/lb seed specified
Cost = $0.95 x 2 = $1.90

More expensive seed:
PLS = (99) x (90) ÷ 100 = 89%
100 ÷ 89 = 1.1 lb seed needed/lb seed specified
Cost = $1.50 x 1.1 = $1.65

Thus, the inexpensive seed that seemed to be a bargain actually costs more per pound on a pure live seed basis. Inexpensive seed is not always a bargain; its use may result in revegetation failure.

Hard seeds

Unscarified seeds of legumes such as crownvetch, birdsfoot trefoil, and flatpea may have water-tight seedcoats. These do not absorb water, swell, and germinate until the seedcoat is broken, commonly by frost or microbial action during the year following seeding. Seeds impervious to water are termed hard seeds.

Most hard seeds are viable and germinate to produce a seedling when the seedcoat becomes permeable to water. Thus, the percentage of hard seeds in a given lot of legume seed is added to the percentage of readily germinating seed to obtain the total germination percentage. *For erosion and conservation plantings on areas difficult to vegetate, legume seedlots should contain a certain minimum amount of hard seed as an insurance factor.* See Table 1 for suggested germination specifications.

Table 1. Species for erosion control and conservation plantings.

Species	Growth habit[1]	Wet soil	Tolerates Dry site	Low fertility	Acid soil (pH 5–5.5)[2]	Aluminum[3]	Persistence[4]	Ready Purity (%)	Minimum seed specifications[5] Hard germ (%)	Total seed (%)	germ (%)	Seeds/lb (1000's)
Warm-season grasses												
Deertongue	bunch	yes	yes	yes	yes	H	L	95	75		75	250
Weeping lovegrass	bunch	no	yes	yes	yes	M	S to M	97	75		75	1500
Switchgrass[6]	bunch	yes	yes	yes	yes	M	L	—— —— —— (60 PLS) —— ——				390
Big bluestem	bunch	no	yes	yes	yes	M	L	—— —— —— (60 PLS) —— ——				150
Cool-season grasses												
Tall fescue	bunch	yes	no	yes	no	L	M to L	95	80		80	227
Redtop	sod	yes	yes	yes	yes	L	M	92	80		80	5000
Fine fescues	sod	no	no	yes	no	L	L	95	80		80	400
Perennial ryegrass	bunch	yes	no	no	no	L	S to M	95	85		85	227
Annual ryegrass	bunch	yes	no	yes	no	L	S	95	85		85	227
Kentucky bluegrass	sod	no	no	no	no	L	M to L	85	75		75	2200
Reed canarygrass	sod	yes	yes	yes	no	L	L	95	70		70	520
Orchardgrass	bunch	yes	yes	yes	yes	L	M to L	95	80		80	654
Timothy	bunch	yes	no	yes	yes	L	M	95	80		80	1230
Smooth bromegrass	sod	no	yes	yes	no	L	M	95	80		80	136
Legumes[7]												
Crownvetch	sod	no	yes	yes	no	L	L	98	40	30	65	120
Birdsfoot trefoil[8]	bunch	yes	no	yes	yes	L	L	98	60	20	80	400
Flatpea	sod	no	no	yes	yes	L	L	98	55	20	75	10
Serecia lespedeza	bunch	no	yes	yes	yes	M	L	98	60	20	80	335
Cereals												
Winter wheat	bunch	no	no	no	no	L	S	98	85		85	15
Winter rye	bunch	no	no	yes	yes	L	S	98	85		85	18
Spring oats	bunch	no	no	no	no	L	S	98	85		85	13
Sudangrass	bunch	no	yes	no	no	L	S	98	85		85	55
Japanese millet	bunch	yes	no	yes	yes	L	S	98	80		80	155

1 Growth habit refers to the ability of the species either to form a dense sod by vegetative means (stolons, rhizomes, or roots) or to remain in a *bunch* or single plant form. If seeded heavily enough, even bunch formers can produce a very dense stand. This is sometimes called a sod, but not in the sense of a sod formed by vegetative means.

2 Once established, plants may grow at a somewhat lower pH, but cover generally is only adequate at pH 6.0 or above.

3 Tolerance of aluminum is relative. Soil and spoils must be limed to a pH of 5.5 to 5.7 to eliminate possible aluminum and manganese toxicity. Tolerance ratings: H = high, M = medium, L = low.

4 Persistence under favorable conditions: L = long duration, M = moderate duration, S = short duration (1 year or less).

5 *Minimum seedlots are truly minimum, and seedlots to be used for revegetation purposes should equal or exceed these standards.* Thus, deertongue grass should germinate 75% or better. Crownvetch should have at least 40% readily germinable seed and 30% hard seed. Commonly, seedlots are available that equal or exceed minimum specifications. Remember that disturbed sites are adverse for plant establishment. Ready germination refers to seed that germinates during the period of the germination test and that would be expected, if conditions are favorable, to germinate rapidly when planted. The opposite of ready germination is dormant seed, of which hard seed is one type.

6 Switchgrass seed is sold only on the basis of pure live seed (PLS).

7 Need specific legume inoculant. Inoculant suitable for garden peas and sweetpeas usually is satisfactory for flatpea.

8 Birdsfoot trefoil is adapted over the entire state, except in the extreme southeast where crown and root rots may injure stands.

Storing seed

Seeds are living organisms and should be protected from extremes of temperature and moisture. Most seeds in a dry condition tolerate moderate freezing without a loss of germination. However, seeds to be used for revegetation should not be stored at temperatures over 90°F or in humid atmospheres. Many seeds rapidly lose germination when exposed to temperatures over 100°F for more than a few minutes.

Keep seed containers out of direct sunlight and do not store in the trunk of an automobile, in the back of a truck, or in closed containers exposed to the sun where temperatures may be well over 100°F. Keep seed in a dry, cool location, preferably in sealed containers.

Storing legume inoculant

Store legume inoculant in a cool place, such as a refrigerator or cooler, until you use it. Do not store legume inoculant in the trunk of a car or in a truck or van. Legume inoculant contains bacteria called *Rhizobia*. Only living *Rhizobia* can form nodules on the roots of legumes and fix atmospheric nitrogen. Packets of legume inoculant are sealed to exclude air and to prevent drying. Use only fresh, unopened packets of legume inoculant; all packets have an expiration date beyond which the inoculant should not be used. Read the date.

Suggested varieties

If a named cultivar or variety of a given plant kind or crop species is suggested, *certified seed* is your best assurance of obtaining seed of high quality and known genetic identity. Certified seed has a known genetic identity that has been field and laboratory inspected for varietal purity. "Common seed," seed of unknown genetic origin, is not a variety but a seed source. Generally, common seed of a given plant kind may be used for conservation plantings if certified seed of suggested varieties is not available. Use seed high in germination and high in purity. See Table 1 for suggested minimum seed specifications. Exceptions are discussed later. See Table 2 for variety suggestions.

Table 2. Suggested varieties of grasses and legumes for erosion control and conservation plantings.

Plant species (plant kind)	*Suggested varieties*
Grasses	
Tall fescue[1]	If endophyte-free tall fescue is desired, use Johnstone, Barcel, or Festorina. Otherwise use Kentucky 31 for low-maintenance sites and turf-type varieties for high-maintenance sites.
Redtop	"Common seed" or named varieties
Fine fescues[1]	Any named variety
Reed canarygrass	Palaton and Venture
Kentucky bluegrass	Blend seed of two or three named varieties. Varieties for low-maintenance sites may include Victa, Fortuna, Gnome, Baron.
Perennial ryegrass[1]	Any fine-leaf turf-type variety
Annual ryegrass	"Common seed" satisfactory
Orchardgrass	For pure stands or with legumes for pasture only: Potomac or "Common." For mixtures with legumes for hay or silage: Pennlate, Dawn, Justus, Rancho, Rough Rider
Timothy	Climax, Toro, Richmond
Smooth bromegrass	Saratoga, Barton, Baylor
Weeping lovegrass	Morpa or "common seed"
Switchgrass	Blackwell for droughty sites, Cave-in-Rock for forage, Shelter for wildlife habitat
Big bluestem	Niagra
Deertongue	Tioga (only variety available)
Legumes	
Flatpea	Lathco (only variety available)
Serecia lespedeza	Appalow for mowed sites, "common seed" satisfactory for unmowed sites
Birdsfoot trefoil[1]	Empire, Norcen, Leo, Viking, Maitland, Dawn.
Crownvetch[1]	Penngift
Cereal grains	
Spring oats[1]	
Winter wheat[1]	
Winter rye[1]	Small-seeded type; Aroostook or Balbo type
Sudangrass	
Japanese millet	Named varieties not available

[1] Named varieties that originated in Pennsylvania or the eastern United States generally are more resistant to unfavorable soil conditions than are varieties of the same plant kind that originated in the Midwest or West.

SPECIES INFORMATION

Legumes

Legumes such as flatpea, birdsfoot trefoil, and crownvetch often take longer to germinate and establish than many common grasses and weeds. But once established, crownvetch and flatpea are vigorous and tend to dominate stands because of their ability to produce new plants vegetatively. Birdsfoot trefoil does not spread vegetatively but spreads readily from seed. A mixture of legumes and grasses should be managed to favor the legumes and ensure their establishment.

Except where they are to be used for forage, legumes such as red clover, white clover, alsike clover, and alfalfa are not recommended for erosion control and conservation cover. Alfalfa requires a high level of management and is subject to many diseases and insect pests. Red clover is short-lived, often lasting no more than a year or two because of disease. In addition, red clover is very competitive and may prevent the establishment of more desirable and longer-lived species such as birdsfoot trefoil. See the section on forages for information on these species.

Flatpea

Lathco flatpea was released as a conservation cover crop for use under transmission lines and on logging roads, roadsides, spoil banks, and similar areas. It is not recommended for forage use. Lathco flatpea is a long-lived perennial legume that spreads vegetatively and provides a dense mat of foliage to reduce erosion and water loss. Flatpea is very competitive and may suppress young trees and shrubs. For this reason, it can be useful in suppressing woody vegetation where access needs to be maintained, such as on right-of-ways for pipelines, transmission lines, and forest roads.

Flatpea requires well-drained soils with a pH of 6.0 or above. It may require two or three years to become well established, but once established it maintains a dense vegetative cover for many years. Flatpea requires a specific strain of legume inoculant, but inoculant labeled for garden pea, sweetpea, and hairy or smooth vetch is usually satisfactory.

Serecia lespedeza

Mixture 9 in Table 3 includes serecia lespedeza as the legume. Lespedeza has not performed well in most parts of Pennsylvania. While serecia lespedeza is quite tolerant of acid and infertile soils, *it is not well adapted to Pennsylvania climatic conditions.* Under Pennsylvania conditions, establishment of serecia lespedeza has been erratic and uncertain. In addition, serecia and other species of lespedeza seldom produce seed in Pennsylvania. In most years, they flower too late to produce viable seed.

Since serecia and other species of lespedeza do not spread vegetatively, as do flatpea and crownvetch, and do not produce seed under Pennsylvania conditions, as does birdsfoot trefoil, the plant has no way to fill in thin places in the stand or to maintain itself. *Mixtures containing lespedeza should be tried only in the extreme southeastern and southwestern corners of Pennsylvania* in those counties bordering Maryland, Delaware, and West Virginia.

Sweet clover

Seed of sweet clover is inexpensive and readily available, and the plant has often been used for reclamation and conservation cover. Sweet clover requires well-drained soils with a pH of 6.0 or above. But sweet clover, either an annual or biennial plant, does not persist for longer than one year. Typically, sweet clover makes very vigorous growth in the seeding year, lives through the winter in a rosette stage, flowers, and produces seed the next summer. The plants then die.

Sweet clover, being vigorous and competitive the seeding year, may prevent less competitive species, such as birdsfoot trefoil and certain of the long-lived grasses, from becoming established. Thus, after sweet clover plants set seed and die, little or no vegetative cover is left. For this reason, sweet clover is not suggested under Pennsylvania conditions except as a short-lived species for temporary cover. New plants may volunteer from shattered seed, but they may not yield a stand dense enough to control erosion.

Crownvetch

Crownvetch is an excellent plant for erosion control and conservation cover. It is very long lived, winter hardy, and free of disease and insect pests. Crownvetch is somewhat slow to establish, but once established it spreads vegetatively and fills in thin stands or bare spots. It is very competitive with other plants seeded with it.

Crownvetch seeds prolifically and has been used extensively in Pennsylvania and other states to stabilize slopes on highways and railroads, and around schools, factories, and similar structures. It also has been successfully used to stabilize and reclaim coal wastes and strip-mined sites. Crownvetch requires a well-drained soil

Table 3. Seed mixtures for conservation plantings.

Key to mixtures in Table 4	*Species*	*Seeding rate PLS[1] (lb/A)* *sites*	*sites*
1[2]	Spring oats (spring), or	64	96
	annual ryegrass (spring or fall), or	10	15
	winter wheat (fall), or	90	120
	winter rye (fall)	56	112
2[3]	Tall fescue, or	60	75
	fine fescue, or	35	40
	Kentucky bluegrass,	25	30
	plus redtop[4], or	3	3
	perennial ryegrass	15	20
3	Birdsfoot trefoil, plus	6	10
	tall fescue	30	35
4	Birdsfoot trefoil, plus	6	10
	reed canarygrass	10	15
5	Crownvetch, plus	10	15
	tall fescue, or	20	25
	perennial ryegrass	20	25
6[5]	Crownvetch, plus	10	15
	annual ryegrass	20	25
7	Birdsfoot trefoil, plus	6	10
	crownvetch, plus	10	20
	tall fescue	20	30
8	Flatpea, plus	20	30
	tall fescue or	20	30
	perennial ryegrass	20	25
9[6]	Serecia lespedeza, plus	10	20
	tall fescue, plus	20	25
	redtop[4]	3	3
10	Tall fescue, plus	40	60
	fine fescue	10	15
11	Deertongue, plus	15	20
	birdsfoot trefoil	6	10
12[7]	Switchgrass or big		
	bluestem, plus	15	20
	birdsfoot trefoil	6	10
13	Orchardgrass, or	20	30
	smooth bromegrass,	25	35
	plus birdsfoot trefoil	6	10

1 PLS means pure live seed. PLS is the product of the percentage of pure seed times percentage germination divided by 100. For example, to secure the actual planting rate for switchgrass, divide 12 pounds PLS by the PLS percentage shown on the seed tag or calculated as previously discussed. Thus, if the PLS content of a given seedlot is 35%, divide 12 PLS by 0.35 to obtain 34.3 pounds of seed, the amount of seed required to plant one acre. All mixtures in this table are shown in terms of PLS.

2 If high-quality seed is used, for most sites seed spring oats at a rate of 2 bushels per acre, winter wheat at 11.5 bushels per acre, and winter rye at 1 bushel per acre. If germination is below 90%, increase these suggested seeding rates by 0.5 bushel per acre.

3 This mixture is suitable for frequent mowing. Do not cut shorter than 4 inches.

4 Keep seeding rate to that recommended in table. These species have many seeds per pound and are very competitive. To seed small quantities of small seeds such as weeping lovegrass and redtop, dilute with dry sawdust, sand, rice hulls, buckwheat hulls, etc.

5 Use for highway slopes and similar sites where the desired species after establishment is crownvetch.

6 Use only in extreme southeastern or extreme southwestern Pennsylvania. Serecia lespedeza is not well adapted to most of Pennsylvania.

7 Do not mow shorter than 9 to 10 inches.

with a pH of 6.0 or above. Use legume inoculant labeled specifically for crownvetch.

Birdsfoot trefoil
Birdsfoot trefoil is a legume commonly planted in Pennsylvania for erosion control, reclamation, and conservation cover. Unlike alfalfa, flatpea, crownvetch, and lespedeza, birdsfoot trefoil tolerates imperfectly drained soils. It grows best on well-drained fertile soils (pH 6.0 or above) but tolerates somewhat acid and infertile soil conditions better than other common species of legumes.

Birdsfoot trefoil is long lived and a prolific seed producer. This seed "shatters," or falls to the ground, and germinates to fill in thin stands or bare sites. For conservation purposes, use a mixture of a low-growing pasture type, such as Empire, Leo, or Norcen, and a tall-growing hay type, such as Viking or Imported. Imported or European seed is not a variety but a seed source. Most lots of imported European seed are a tall-growing or hay type.

Grasses

Many species of grass are used for erosion control, reclamation, and conservation plantings. These may be divided into two groups: cool-season species and warm-season species.

Cool-season species include grasses common in Pennsylvania, such as orchardgrass, tall fescue, timothy, ryegrass (both annual and perennial), fine fescues, redtop, reed canarygrass, and Kentucky bluegrass. As the name implies, cool-season grasses grow best during cooler parts of the year (spring, early summer, and fall). They may go dormant during hot, dry summers.

In Pennsylvania, warm-season species are dormant or slow growing during much of the spring and fall but grow well during summer. Warm-season species useful in Pennsylvania include deertongue grass, switchgrass, and weeping lovegrass. Warm-season species do not compete well with cool-season species, particularly during spring and fall. As a group, warm-season grasses tolerate more acid and less fertile soils than do cool-season grasses.

Cool-season grasses
Tall fescue is a deep-rooted, long-lived, persistent grass that is used for pasture as well as for conservation purposes. It is used extensively along highways, in lawns and athletic fields, and in strip-mined areas that are being revegetated.

Redtop is a rapidly establishing but short-lived grass adapted to many adverse sites. It tolerates imperfectly drained, acid, and infertile sites. Redtop, in combination with another grass and a legume, is often used in conservation mixtures.

Fine fescues are planted extensively for lawns, roadsides, and reclamation. They are fairly tolerant of acidic and infertile soils. They usually are combined with another grass and a legume for this purpose.

Reed canarygrass is a long-lived and persistent grass that is adapted to both poorly drained and well-drained sites. It spreads by rhizomes to form a dense sod. Reed canarygrass is used to some extent as a forage plant. It is excellent for erosion control and conservation cover, and is often seeded in waterways and ditches. However, reed canarygrass seed is often low in germination. For this reason, use only seed with high germination that has been tested within the previous 4 to 5 months.

Kentucky bluegrass is used extensively on lawns, highways, athletic fields, and similar sites. Kentucky bluegrass also is used for pasture. It requires fairly well-drained and fertile soils. Its use for erosion control is limited.

Perennial ryegrasses. Most seed mixtures suggested in Table 3 specify perennial ryegrass rather than annual ryegrass. However, only the "turf type" fine-leaved perennial ryegrass varieties are suggested. Varieties of perennial ryegrass developed in the northeastern United States are somewhat more tolerant of acid soils than varieties developed in the midwest.

Common perennial ryegrass, purchased on the basis of low cost per pound, is often of the Linn variety. While termed perennial ryegrass, Linn ryegrass may not be winter hardy under Pennsylvania conditions. If not winter killed, it produces seed the year after seeding and usually dies. Linn ryegrass can be extremely competitive with the more desirable and persistent grass and legume species, which often establish more slowly than the ryegrasses. In contrast, turf-type varieties of perennial ryegrass have narrower leaves than Linn perennial ryegrass and annual ryegrass, are not as competitive, and may persist many years under favorable conditions.

Annual ryegrass is not suggested for most purposes because it germinates quickly and grows rapidly in the seeding year. It produces a large, vigorous plant. The year following seeding, annual ryegrass produces seed and dies. The vigorous vegetative growth of annual ryegrass can prevent or retard the establishment of the longer-lived but slower-establishing grasses and legumes.

Orchardgrass is a moderately winter-hardy, tall-growing grass that may winter kill in colder areas of Pennsylvania. While used extensively for forage, it is seldom planted for erosion control and conservation cover unless the site is to be grazed. Orchardgrass does not tolerate acid soils and low fertility.

Timothy is a winter-hardy, bunch-type grass with a shallow, fibrous root system. It tolerates moderately acid and infertile sites as well as imperfectly drained soils. It has been used to some extent for reclamation under Pennsylvania conditions. Timothy combines well with birdsfoot trefoil.

Smooth bromegrass requires well-drained, fertile soils with a pH of 6.0 and above. It offers few advantages for erosion control and conservation cover under Pennsylvania conditions.

Warm-season grasses
Table 3 includes switchgrass, big bluestem, and weeping lovegrass, in seed mixtures 11 and 12, for erosion control and conservation cover. These grasses are adapted to warm and somewhat dry conditions and for this reason are called warm-season species. Such species require warmer temperatures for growth than cool-season species such as timothy and orchardgrass and, therefore, begin growth somewhat later in the spring. Likewise, the warm-season grasses terminate growth earlier in the fall than the common cool-season grasses.
Weeping lovegrass, a native of South Africa, is adapted to warm and somewhat dry sites. It is a short-lived perennial species that often winter kills under Pennsylvania conditions. Weeping lovegrass is included in certain seed mixes because it furnishes a quick groundcover until slower-growing but longer-lived species, such as deertongue grass or switchgrass, become established.

Do not use more than the suggested rate of weeping lovegrass. If seeded at rates in excess of 1 pound per acre, these plants become severely competitive. Such competition may prevent establishment of other species.

Weeping lovegrass seeds are small, so it is often difficult to seed only 1 pound per acre. To remedy this, dilute seeds by mixing them with an inert material, such as dry sawdust, sand, or rice hulls.

Switchgrass is a deep-rooted, long-lived perennial grass with considerable tolerance to relatively low pH and low fertility and to relatively high levels of aluminum. These conditions are often found on roadsides, particularly in western Pennsylvania, and on coal wastes and strip-mined spoil areas.

Care is required to establish grasses like switchgrass. Such species are best sown early in spring (mid-March to mid-May) on a *firm* seedbed. The need to use a firm seedbed and soil cover cannot be overemphasized. Use packer wheels on the drill. There should be adequate soil to provide a .25- to .5-inch cover over the seed. Alternatively, broadcast the seed and mulch as described later. Switchgrass has considerable potential for conservation plantings on adverse sites in Pennsylvania.

Big bluestem is a tall-growing, deep-rooted bunch grass that is more drought tolerant than other warm-season grasses. It is better adapted to excessively drained soils with low water-holding capacity. Like switchgrass, this species has good tolerance to low pH and low fertility; hence, it can be used on coal wastes and strip-mined soils.

Big bluestem should be seeded between mid-April and mid-May on a firm seedbed. The seed should be planted .25 to .5 inches deep using a drill equipped with packer wheels. Big bluestem seed is chaffy and does not flow well unless it has been debearded, a process that removes chaff and hair from the seed. Some companies sell debearded big bluestem seed.

It generally takes two years for big bluestem to reach its maximum growth potential because of slow germination and seedling growth. Stands that appear good at the end of the first year usually develop into good stands the second year.

Deertongue is a relatively new conservation cover plant for acid and infertile sites such as mine-spoil and coal-refuse banks. Tioga is the first variety of this species to receive a varietal name. Deertongue grass is very tolerant of relatively low pH, relatively high concentrations of aluminum and manganese, and infertile soils. Sow seed of deertongue grass as early as possible in spring to help overcome seed dormancy.

Seed two to three years old, if of high germination and vigor, often germinates and establishes more rapidly than seed harvested the previous year. Freshly harvested and even year-old seed of deertongue grass typically requires exposure for three to four weeks to cool or cold temperatures (30˚ to 45˚ F) in the imbibed state—that is, wet and swollen—before germinating.

In the seedling stage, deertongue grass does not tolerate competition from other grasses and weeds. Do not plant mixtures of deertongue grass and species such as tall fescue, fine fescue, Kentucky bluegrass, redtop, reed canarygrass, annual or perennial ryegrass, crownvetch, and flatpea. Refer to seed mixture 11 in Table 3 for a suggested mixture that includes Tioga deertongue grass. This mixture has been compounded to favor the deertongue grass.

Seed mixtures

See Tables 3 and 4 for seed mixtures for different sites and uses. Characteristics of each species are listed in Table 1, and preferred varieties are listed in Table 2. Each seed mixture, except numbers 1, 2, and 10, contains a legume to provide nitrogen.

Unfortunately, cool-season grasses and legumes, such as tall fescue and birdsfoot trefoil, commonly used to revegetate disturbed sites, are relatively intolerant of aluminum in the rooting medium. To counteract conditions of low pH and toxic levels of aluminum, apply large quantities of ground agricultural limestone. Raising the pH to 5.7 or above eliminates most aluminum toxicity problems.

Some sites, however, contain pyrite minerals in coal wastes. These weather and produce sulfuric acid, which again reduces pH with a resulting increase in available aluminum. Using adapted aluminum-tolerant species (see column marked “Aluminum” in Table 1), in addition to adequate amounts of ground agricultural limestone for establishment and maintenance, can help overcome the problem. Aluminum and manganese toxicity are not restricted to coal wastes and strip-mine spoil but can occur whenever the pH is below 5.7.

Hints on choosing seed mixtures

In Table 3 two seeding rates are listed. These are headed “Most sites” and “Adverse sites.” If liming, fertilization, and preparation of seedbed are properly done and if care is taken to drill and cover the seed (or mulch applied following drilling or hydroseeding), the rate for “Most sites” should suffice. However, on eroded or coarse and poorly prepared seedbeds, particularly if the soil or spoil is very acid, infertile, and possibly toxic, if seed is broadcast on the surface, and if a mulch is not used, the seeding rate for “Adverse sites” should be used.

Recommended seed mixtures are based on the number of seeds per pound and on the growth characteristics of each plant species. Some species, such as crownvetch and flatpea, are quite competitive once established. If soil and growing conditions are good, these species may dominate the stand. This is acceptable since both are excellent conservation cover species and are long lived, relatively free of plant pests, and persistent. But neither crownvetch nor flatpea is very competitive at an early stage of growth. Birdsfoot trefoil establishment also can be suppressed by excessive competition from associated species.

Of the grasses listed in Tables 1 and 3, all are quite competitive when established, but, as with the legumes, excessive competition from other plants can slow or suppress their establishment. Species such as redtop, weeping lovegrass, the ryegrasses, and tall fescue usually germinate and establish relatively quickly if soil and weather conditions are not limiting. However, deertongue grass and switchgrass often require two to three years and even longer to develop a stand of acceptable density. Weeping lovegrass starts quickly but is short lived at best (a few years) and often winter kills under Pennsylvania conditions.

Do not exceed the recommended amount of seed per acre for weeping lovegrass and redtop. Seeds of these species are small and, consequently, very numerous per pound (Table 1). For example, an excessive seeding rate of weeping lovegrass or redtop can depress or even suppress establishment of the more desirable plant species seeded with it.

Take care to choose plant species adapted to site conditions or to change the site conditions, if needed, to favor the plant species chosen. Growers often use a combination of these two approaches.

The seed mixtures suggested in this publication are simple mixtures, that is, mixtures of two or three species. Agronomic experience at many locations indicates that simple mixtures are easier to seed, establish, and manage than are complex mixtures of 6 to 10 more plant species *It is suggested that the seed mixtures listed in this publication not be altered.*

At times, complex or so-called “shotgun” mixtures are used. These may include seed of 6 to 15 or even more plant species. The rationale for including many species in

Table 4. Mixtures for various sites.

Grass and legume-grass mixtures suitable for erosion control and stabilization of various conservation structures are listed below. Carefully study Tables 1 and 3 before selecting a seed mixture. Use only seed high in germination that equals or exceeds minimum specifications in Table 1. Variable drainage refers to areas where well-drained soils and poorly drained soils are intermingled.

	Use mixtures from Table 3	
	Nurse crop	*Seed mixture (select one mixture)*
Slopes and banks (unmowed)		
Well-drained	1 plus	3, 5, 8, or 12[1]
Variable drainage	1 plus	3 or 7
Slopes and banks (mowed)		
Well-drained	1 plus	2 or 10
Slopes and banks (grazed/hay)		
Well-drained	1 plus	2, 3, or 13
Gullies and eroded areas	1 plus	3, 5, 7, or 12[1]
Conservation structures		
Sod waterways, spillways, frequent water flow areas	1 plus	2, 3, or 4
Drainage ditches		
shallow, less than 3 feet deep	1 plus	2, 3, or 4
deep, nonmowed	1 plus	5 or 7
Pond banks, dikes, levees, dams, diversion channels, and occasional water flow areas		
mowed areas	1 plus	2 or 3
nonmowed areas	1 plus	5 or 7
for hay or silage on diversion channels and occasional water flow areas	1 plus	3 or 13
Highways[2]		
Nonmowed areas		
pure crownvetch	1 plus	5 or 6
well-drained	1 plus	5, 7, 8, 9, or 10
variable drainage	1 plus	3 or 7
poorly drained	1 plus	3 or 4
Areas mowed several times per year	1 plus	2, 3, or 10
Utility right-of-way		
Well-drained	1 plus	5, 8, or 12[1]
Variable drainage	1 plus	3 or 7
Well-drained areas for grazing/hay	1 plus	2, 3, or 13
Effluent disposal areas	1 plus	3 or 4
Sanitary landfill areas	1 plus	3, 5, 7,11[1], or 12[1]
Stripmined spoils, mine wastes, fly ash, slag, settling-basin residues, and other severely disturbed areas (lime to soil test)	1 plus	3, 4, 5, 7, 8, 9, 11[1], or 12[1]
Severely disturbed areas used for grazing/hay	1 plus	3 or 13

1 For seed mixtures 11 and 12, only use spring oats or weeping lovegrass (included in mix) as nurse crop.

2 Contact the Pennsylvania Department of Transportation district roadside specialist for specific suggestions on treatment techniques and management practices.

the mixture is to ensure that there is some component adapted to each portion of the site. However, a careful analysis of these complex mixtures suggests that many components are poorly adapted and have little chance of becoming established. While many species often are included in a shotgun mixture, many or all may have the same ecological needs and not be adapted to different site conditions. Other components vary widely in competitiveness and fail on this score. In either case, the final result of seeding shotgun mixtures often is inadequate soil protection. Frequently, plants of only one or two species establish, and there may not be a dense enough cover to protect the site adequately.

A careful study of this section should provide sufficient information to help you choose adapted plant species mixtures for most disturbed sites.

Persistent species for vegetative cover

State regulations for strip-mined sites require at least 70% groundcover to be maintained for five years before performance bonds are fully released. For vegetative cover, birdsfoot trefoil, crownvetch, and flatpea are persistent and desirable legumes. Persistent grasses that provide good vegetative cover are tall fescue, fine fescue, reed canarygrass, deertongue grass, and switchgrass. However, persistence often depends upon making site conditions favorable for the species sown. Use of such persistent species should not be restricted to strip-mined sites since they are valuable wherever a long-lived cover is desired.

Species for temporary cover

Cereals

Small grains such as rye, wheat, and oats can provide rapid but temporary cover to help protect and stabilize a disturbed site. While often termed “nurse crops,” associated plants such as rye, wheat, or oats can compete with and seriously depress the establishment and growth of desirable species such as birdsfoot trefoil, flatpea, crownvetch, tall fescue, and deertongue grass.

In general, when seeding small grains with slower-growing grass and legume species for erosion control, reduce the seeding rate of the small grain below the rate used for grain production so as to favor the grass or legume component. Barley requires well-limed (pH 6.5 and higher), fertile soils and is not suggested for use on disturbed sites. At times, species such as

sudangrass, sorghum, or millet (either Japanese or foxtail) may be used as quick cover on disturbed sites.

Aroostook rye

Aroostook rye, recently released by the Soil Conservation Service, USDA, is more cold tolerant and winter hardy than most varieties of winter rye. Aroostook rye grows well in northern Maine and, under Pennsylvania conditions, can be planted somewhat later than other varieties of rye.

See Table 5 for seeding rates for temporary cover.

Table 5. Temporary cover for erosion control on construction sites and other sediment-producing areas where additional soil disturbance is anticipated.

- *Mulching:* Mulches alone help protect areas from erosion. Mulches also provide initial protection if area is to be seeded later. Use hay or straw at a rate of 3 tons per acre. See information under "Mulching." For information on other suitable mulching materials, contact the Pennsylvania Department of Transportation district roadside specialist.
- *Site preparation:* Apply 1 ton of agricultural-grade limestone per acre, plus fertilizer at the rate of 50-50-50 per acre, and work in where possible. Secure a soil test before making a permanent seeding. After seeding, mulch with hay or straw at a rate of 3 tons per acre.

Species	*lb/A*
For spring seeding (up to June 15)	
Annual ryegrass	40
or spring oats,	96 (3 bu)
or spring oats plus ryegrass,	64 oats (2 bu) plus 20 lb annual or perennial ryegrass
or winter wheat,	180 (3 bu)
or winter rye	168 (3 bu)
For late spring and summer seeding (June 16 to August 15)	
Annual ryegrass,	40
or Japanese or foxtail millet,	35
or sudangrass,	40
or spring oats,	96 (3 bu)
or winter wheat,	180 (3 bu)
or winter rye	168 (3 bu)
For late summer and fall seeding (August 16 and later)	
Annual ryegrass,	40
or winter rye,	168 (3 bu)
or winter wheat,	180 (3 bu)
or spring oats (can be used but winter kills)	96 (3 bu)

ESTABLISHMENT

Liming and fertilization

Many disturbed sites are acid and infertile. Some coal waste and strip-mined sites, particularly in the western portions of Pennsylvania, contain toxic levels of aluminum or manganese. Many of these sites also are coarse textured and deficient in moisture, at least in the several inches of surface.

One way to overcome the limitations of coarse-textured soil and a resulting droughty situation is to ensure that the desired plants can root deeply into the underlying soil or spoil. To do this, subsurface as well as surface layers must be limed and fertilized, if possible to a depth of 24 inches or more. Aluminum and manganese at pH values of less than 5.5 to 5.7 can be toxic to most of the plants commonly used for revegetation. *Most agricultural species used for reclamation grow well only at pH values of 6.0 or above.*

If a seedbed can be prepared, *lime and fertilize in accordance with soil test recommendations.* Work the lime and fertilizer as deeply as possible into the soil or spoil. Field cultivators, heavy-duty harrows, or heavy disks can be used to help incorporate lime or fertilizer on tillable soils. On strip-mined areas, ripper teeth on the toolbar of a bulldozer or grader can be used to help incorporate lime and fertilizer deep into the soil or spoil. Small disks and harrows generally are not sufficient to incorporate lime and fertilizer.

On cuts such as those made for diversion terraces, waterways, and highways, the underlying soil or parent material may be dense and the incorporation of lime and fertilizer difficult. On such sites, as well as on strip-mined areas, lime and fertilizer should, where possible, be incorporated deeply if the vegetative cover is to persist and be dense enough to control erosion.

On many strip-mined sites, 10 or more tons of ground agricultural limestone may be needed per 6 inches of soil depth. Some strip-mined spoils and soils require 15 to 20 or more tons of ground agricultural limestone per 6 inches of depth. *Caution*: It has been suggested that no more than 4 tons of calcium carbonate equivalent per acre per application be added to agricultural land. This recommendation should be disregarded for the very acid soils of low pH sites, including many disturbed and most strip-mined sites. In one series of 1,138 soil samples from disturbed sites, the mean lime requirement was over 7 tons per acre per 6-inch layer of soil. *There is no substitute for a soil test from a reputable laboratory.* Generally, 2 to 3 tons per acre of ground limestone, as is often used, is not sufficient for Pennsylvania strip-mined sites and landfills, nor for many highway embankments and diversion terraces.

Most disturbed sites are infertile. Again, a soil test from a reputable laboratory is recommended. If soil test results are not available, apply at least 6 tons of agricultural grade limestone and 100-200-200 (100 pounds of N, 200 pounds of P_2O_5, and 200 pounds of K_2O) per acre to lands disturbed by highway construction, diversions, and dams. Work lime and fertilizer in deeply where possible. In the absence of soil test results for strip-mined sites, apply at least 10 tons of ground agricultural limestone and 100-200-200 per acre and work in as deeply as possible.

When available, apply the equivalent of 20 to 25 tons of dry cattle manure per acre on strip-mined sites or other disturbed sites. Work manure into soil or spoil as deeply as possible. Other animal manures and treated municipal sludge or other organic wastes also can be used. Information on the use of sludge is available from your county extension agent, the local Soil Conservation Service office, and regional offices of the Pennsylvania Department of Environmental Resources.

On many disturbed sites, the availability of sufficient nitrogen in the second and

succeeding years after seeding can be a problem. Early and successful establishment of a good stand of an adapted legume can provide sufficient nitrogen for the associated grass. If the legume stand is thin or absent, grasses may suffer from nitrogen deficiency, possibly leading to thinning of the stand and loss of the vegetative cover. To counter this, either use half slow-release nitrogen when seeding or topdress with added nitrogen the second year after seeding.

Plants of most species used for conservation plantings root only where soil spoil has been limed to a pH of at least 5.5 to 6.0 and where fertility is sufficient to support plant growth.

Time of seeding

For best results, grass and legume seedings should be made in spring (March, April, and early May). However, through proper choice of seed mixtures, seed specifications, and establishment techniques, disturbed sites can be seeded almost any time from spring to fall. Legume seedings need a growing period of at least ten to twelve weeks to produce seedlings sufficiently large and hardy to survive the winter. Grasses generally require at least four to six weeks of growth prior to hard frosts.

It is suggested that legumes be seeded before July 15 in northern and western Pennsylvania (corn maturity zones 1 and 2) and before August 15 in southeastern Pennsylvania (corn maturity zone 4). For zone 3, seed before August 1. *If legumes must be seeded after the above dates, select legume seedlots with a high content (30%to 35% or more) of hard seed.*

If at all possible, mulch the seeding with straw or old hay. By selecting and using legume seedlots with a high percentage of hard seed and by applying a mulch, you can seed legumes at almost any time of the year.

A small grain or cereal crop often is used to provide quick cover and to help stabilize slopes while the permanent grass and legume species are becoming established. Normally, spring oats are seeded in the spring and early summer, and winter wheat or winter rye from early August until early October. However, oats may also be seeded in the late summer and early fall. Oats usually winter kill, but the dead plants create a mulch to help protect the soil and do not compete with the desired grasses and legumes the following year. Wheat or rye may be seeded in the spring or early summer if not to be harvested for grain. Ranked in order of winter hardiness, rye is most hardy, followed by wheat, barley, and oats.

Seeding methods

Before seeding, apply the recommended amount of ground agricultural limestone and work as deeply as possible into the soil. At seeding time, work recommended fertilizer as deeply as possible into the surface soil or spoil. Inoculate legume seeds with the specific legume inoculant just before seeding, within 24 hours.

Drills

Seed can best be applied with a drill or hydroseeder. A drill fitted with depth bands and packer wheels should be used. Grass and legume seeds should be planted .25 to .5 inch deep. Larger seeds, such as those of flatpea, wheat, rye, and oats, should be planted 1 to 1.5 inches deep.

Place seeds at a controlled depth in a firm seedbed and firm the soil around them. This is necessary to provide a ready supply of soil moisture for germination and seedling growth. *While an overly compacted or crusted seedbed can slow, reduce, or even prevent germination and emergence of seedlings, lack of a sufficiently firm seedbed also can be harmful.* This is especially true for sandy soils or for strip-mined sites. At times, it may be necessary to use a cultipacker or similar tool to firm the seedbed before seeding.

Broadcast seeding

Unless weather conditions following broadcast seeding are very favorable—cool and moist with frequent precipitation—most surface-applied seeds imbibe water, germinate, and die because they are not surrounded by a layer of firmed, fine soil to provide a ready water source. Some people attempt to cover broadcast seeds by dragging a tree branch, plank, or old bulldozer track over the broadcast site. Others attempt to cover seeds by disking or harrowing. Such attempts generally fail because the seed is either covered too deeply or not covered at all.

Surface broadcasting of seed followed by an application of a straw or hay mulch can give excellent germination and establishment. If seed must be broadcast and not mulched or covered, double the rates recommended in Table 3. *Broadcasting the seed on the soil or spoil surface by hand or cyclone seeder, or from the air via helicopter or fixed-wing aircraft, usually are poor methods of seeding unless the area is mulched afterwards.*

Hydroseeding

Hydroseeding is a method of seeding in which lime, fertilizer, grass seeds, legume seeds, and inoculant are mixed with water and applied as slurry, generally at a rate of 1,000 gallons per acre.

Up to 4,000 pounds of agricultural grade limestone per acre can be mixed with 1,000 gallons of water per acre in a hydroseeder. If more than 4,000 pounds of lime per acre are required, the excess over 4,000 pounds should be applied by a truck spreader, lime spreader, or air-blast spreader. Multiple applications with a hydroseeder also are possible. Fertilize at a rate of 50-100-100 per acre. In the year following seeding, topdress with an additional 50-100-100 pounds of fertilizer.

When hydroseeding legumes and fertilizer together, add the legume inoculant just before application, since some fertilizers are harmful to *Rhizobia*. Do not allow the seed and inoculant to be in contact with fertilizer in the hydroseeder for longer than half an hour to an hour. If the inoculant is in the tank for longer than an hour, add a new supply of inoculant. Use *five times* the rate of inoculant recommended on the package when seeding with a hydroseeder.

Inoculating legumes

Under proper conditions, legumes fix nitrogen from the atmosphere in a form that the legume and associated plant species can use. The actual nitrogen fixation occurs in "nodules" on the roots of the leguminous plant. A special group of root-nodule bacteria called *Rhizobia* live in the nodules and fix nitrogen. The plant provides carbohydrates for the bacteria.

The same species and strains of *Rhizobia* are not adapted to all species of root-nodule legumes. Thus, birdsfoot trefoil and crownvetch each require species of root-nodule bacteria different from those which induce nodulation on roots of red clover or alfalfa. For convenience, several species and strains of bacteria are often combined into one packet by the inoculant manufacturer. Thus, packets of inoculant suitable for garden peas, sweet peas, and vetch generally are also satisfactory for flatpea.

Some inoculant manufacturers combine *Rhizobia* suitable for red clover and alfalfa into one packet. Read the directions on the inoculant packet to be sure it is suitable for the legume species to be planted. Each packet or container of inoculant has an expiration date beyond which the inoculant should not be used. Note this date.

Root-nodule bacteria are very sensitive to heat and drying. Packets of inoculant and inoculated seed should not be left in the sun, in the trunk of an automobile, or in any other location subject to extremes of temperature. Seed should be inoculated with the proper strain of root-nodule bacteria just before seeding. This is important, because soils to be revegetated usually do not contain bacteria suitable for the legume species to be sown. The root-nodule bacteria applied to the seed must establish in the soil and persist until the seedling legume is in the proper growth stage so that infection and nodulation can occur. *When seeding on adverse sites, such as dry sandy soils or strip-mined land, use inoculant at a rate five times higher than recommended on the inoculant package.*

Preinoculated seed

Some dealers and seed companies offer legume seed that has been preinoculated with legume root-nodule bacteria (*Rhizobia*). While this is a decided convenience for the user, improper storage and handling of the preinoculated seed can lead to death of the *Rhizobia* and subsequent failure to nodulate and fix atmospheric nitrogen. If the inoculant on the seed is exposed to temperatures over 90˚F for several hours or more, many of the *Rhizobia* may die, leaving insufficient numbers to cause nodulation. In addition, not all of the various methods of preinoculating seed are equally effective in prolonging the viability of *Rhizobia*. This is especially important because the species of legumes being grown on many strip-mined ares (birdsfoot trefoil, flatpea, and crownvetch) may not have been previously grown on the soils or spoils being reclaimed.

Thus, *Rhizobia* on the seed have to endure, often under unfavorable conditions of pH, fertility, heat, and drought, until seedling plants of the new legume species are large enough and in the proper physiological stage to be invaded, infected, and nodulated. Under the best of conditions, this may require three or more weeks. And under unfavorable conditions in which germination or seedling growth of the legume is impeded, months may elapse before the seedling is in a suitable stage for nodulation.

Conversely, where a given legume, such as red clover or alfalfa, has been grown previously, there are often sufficient *Rhizobia* in the soil to induce nodulation, even if the *Rhizobia* introduced on the seeds are not viable. Thus, it is of utmost importance to introduce sufficient quantities of viable *Rhizobia* when growing a species of legume on a site where that species has not grown previously.

Even if preinoculated seed is used, an excellent safety factor is to add fresh inoculant to the preinoculated seed when revegetating disturbed areas such as strip-mined spoils, landslides, logging roads, and similar severely disturbed sites. The fresh inoculant can be added to the preinoculated legume seed (if mixed with grass seed) or even to the legume seed/grass seed mixture. Use heavy rates of inoculant, about five times the amount recommended on the legume package. This may cost a few dollars, but it is a minor part of the cost of revegetation.

As with all inoculated seed, heat is the enemy of preinoculated seed. Store preinoculated seed in a cool place, below 70˚F if possible. Keep out of direct sunlight as much as possible. Do not store preinoculated seed in the trunks of cars, in the cabs of trucks, or in metal containers left in the sun.

Mulching

All conservation and erosion control areas, whether seeded with a drill, broadcasted, or hydroseeded, should be mulched to reduce soil erosion and to aid seed germination and seedling establishment. Grass hay and cereal straw are preferred mulches and should be applied to produce a loose layer .75 to 1 inch deep. Generally, 3 tons of mulch per acre are sufficient. As a guideline, a thickness of five to six overlapping straw or hay stems is acceptable for mulching. Straw or hay should not be chopped or finely broken during application. On steep slopes, hay rather than straw mulch is recommended. *Caution:* Hay mulch may introduce undesirable weeds; use clean mulch if weeds might be a problem. However, weeds may be useful on strip-mined sites to help diversify the plant cover.

Long straws and stems are more readily anchored in place and afford seedling plants more protection than does chopped straw or hay. Mulches of hay or straw may be tied down with commercial netting of various types or with asphalt emulsion or cutback asphalt at a rate of 100 to 150 gallons per acre. Application of cellulose fiber over the straw or hay mulch at a rate of 800 to 1,000 pounds per acre also is an excellent way to tack or hold the mulch in place.

Other mulches and mulch-anchoring materials are available. Be cautious when using wood chips, because they may smother or prevent the emergence of small grass and legume seedlings. If conditions are suitable, a heavy disk harrow with the blades set straight may be used to press some of the hay or straw stems into the soil, thus anchoring them. Soil organisms use nitrogen in decomposing a mulch. Therefore, mulch decomposition may require that extra nitrogen be applied.

Started plants

Crownvetch “crowns” or potted plants may be used to obtain quicker cover on critical slopes and other problem areas. Potted plants of flatpea may also be used in this way. Lime and fertilize according to soil test recommendations. If soil test results are not available, apply 8,000 pounds off agricultural grade limestone per acre. Fertilize at a rate of 50-100-100 and work fertilizer into soil or spoil. Crowns or potted plants should be spaced in staggered rows about 18 to 24 inches apart. On bare areas, apply 20 pounds per acre of perennial (turf-type) ryegrass seed after setting plants to provide a temporary cover until the crownvetch plants are established. After planting, the area should be mulched as described above.

Crownvetch crowns and potted plants or Lathco flatpea plants also may be effective in establishing vegetation on areas where existing vegetation is deteriorating. Flatpea and crownvetch have the ability to spread from the roots. Birdsfoot trefoil normally is not used in this way, as it cannot spread from the roots. The year following planting, broadcast 50-100-100 fertilizer over the planting. Mulching usually is not required when started plants are used in thin or deteriorating vegetation. If there are sizable bare areas, mulch the started plants after setting.

Maintenance

For waterways and diversion channels where the crop is harvested, follow appropriate fertilization and liming recommendations given in the *Penn State Agronomy Guide.* Waterway channels often require additional nitrogen to maintain a tight cover.

Use caution when applying herbicides on fields having grass and legume sod waterways and diversion terraces. Many herbicides suitable for row crops can kill common cool-season grass and legume species used in waterways and diversion channels. Also take care in chemically controlling weeds in sod waterways so that herbicides are not washed onto other cropland or into streams.

On conservation and erosion-control areas where grasses predominate, fertilize every two to three years as needed to maintain a dense vegetative cover. Apply fertilizer according to soil test recommendations; if soil test results are not available, apply 60-60-60 per acre during the growing season. If legumes predominate, fertilize as recommended by a soil test; if soil test results are not available, apply 0-60-60 per acre as needed to maintain a dense stand. Check lime requirements every four years; apply agricultural grade limestone as needed.

If the vegetative cover on sod waterways and in diversion channels is deteriorating, lime, fertilize, and reseed as for original establishment, or overseed, or use no-tillage methods.

Winter Cover Crops

Much erosion can be prevented by planting a winter conservation cover crop on cropland. Table 6 gives recommendations for seeding such cover crops.

Table 6. Seeding winter conservation cover crops on cropland.

In row crops after last cultivation

Species:

Annual ryegrass, 20 lb/A if drilled; 30 lb/A if broadcast

Fertilization:

Cover crop fall grazed: apply 40-0-0/A after harvest of row crop

Cover crop spring grazed: apply 40-0-0/A in early spring or apply 8 to 10 tons of cattle manure/A in late fall

Following harvest of row crop

Species:

Annual ryegrass (mid to late September), 20 lb/A if drilled; 30 lb/A if broadcast

Winter wheat (to October 1), 120 (2 bu) lb/A

Winter rye (to mid October), 112 (2 bu) lb/A

Aroostook winter rye (late October), 168 (3 bu) lb/A

Fertilization:

Conventional seedbed preparation: 40-40-40/A; apply at time of seeding

Cover crop spring grazed: apply 40-0-0/A in early spring if nitrogen not applied in fall

In row crops using aerial or blower application

This method is particularly advantageous when corn is harvested for silage or the crop residue is removed. Seeding may be done in silage corn using aircraft or in narrow strips by using a forage harvester or blower in late August or early September. Early September seedings should produce a good cover before the soil freezes. For grain corn, seed the cover crop in mid- to late September. Residues from triazine herbicides may hinder establishment of a cover crop.

Species:

Winter wheat, 120 (2 bu) lb/A

Winter rye, 112 (2 bu) lb/A

Fertilization:

Fertilization is not normally needed at time of seeding.

Cover crops spring grazed: apply 40-0-0/A in early spring or apply 8 to 10 tons of cattle manure/A in late fall.

Note: No-till planting is an alternative to plowing down cover crops before planting corn or other row crops.

Prepared by Peter Landschoot, associate professor of turfgrass science

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