

PROJECT COMMITTEE ON PLANT ECOLOGY

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GROUND COVERS FOR WARTIME USE

A Brief Survey of Roadside and Agronomic Practices of Value in the Development of Access Roads, Drill Fields, Airfields and Other Military Areas

Introduction. Following the 1941 meeting of the Highway Research Board, members of this Committee had opportunity to discuss mutual problems with military and civilian engineers engaged in the development and maintenance of access roads, drill fields and airfields in military and war industrial areas. During these conversations it was suggested that the experience of past years by the various State Highway Departments in developing methods of protecting bare soil from erosion by wind and water be made available in brief report form.

The lessons of past experience in roadside development and highway maintenance are now being repeated on military and war industrial areas. Thus for example:

In regions of erodible soils and high intensity of rainfall unprotected soils on the shoulders, slopes and gutters of access and service roads in military areas have been badly eroded by surface water. On both airfields and drill fields, where ground surfaces are unprotected by pavements or by turf cover, clouds of dust have developed which shorten the service life of aircraft motors and are a hazard to personnel in training. Experience indicates that where a ground cover of turf grasses and other low vegetation can be established these problems can be solved.

The State Highway Departments and many other public and private organizations have contributed experienced technical personnel now engaged in turf and other ground cover establishment designed to control dust, and erosion on access roads, drill fields and airfields. It is hoped that the following report will be of service to these men and others interested in the problem.

Scope. This report covers the high points of experience of landscape engineers, highway engineers, and agronomists in establishing ground cover plants on the poor soils of highways, airfields and other non-agricultural areas. Much of this summarized information will apply only in selected localities where the described conditions and ground cover plants occur. It is intended to cover briefly some of the more familiar, well-tested methods and materials through which the Committee believes erosion has been best controlled on highway areas, and may be best controlled in similar ground surfaces of military reservations.

Subdividing the Ground Problem. Two general types of areas ^{1/} will be found to require protective ground cover in cantonments and other military areas.

1. Areas continually used by traffic, including earth road shoulders, airfields, drill fields, and athletic fields.

2. Surface areas not used by any type of traffic, including all other areas of soil disturbed by excavation and grading during development for war purposes.

Turf for Areas Used by Traffic. Details of latest practices in establishing turf ground cover on road shoulders, drill fields and airfields were briefly outlined in the 1941 report of this Committee. (See pages 84 to 108 - 107A to 126A.) It may be of interest to briefly review a few basic points concerning turf suitable for airfields, drill fields and road shoulders derived from these published sources.

1. The country as a whole can be divided into three broad climatic or growing regions: cool humid, warm humid, and dry (western). Special groups of turf forming grasses have been adapted for airfield and drill field use in each of these regions. (See pages 71, 72, and 75 of 1941 report above mentioned.)

2. Adequate surface drainage and a well-aerated soil are essential for rapid and satisfactory turf establishment under all conditions. Such adequate drainage is commonly provided by (a) provision in cross section design for adequate runoff by means of ground surface pitch on airfields ranging between one and two percent (turf covered road shoulders are preferably graded with a pitch of one in. per ft. or about 8 percent) and (b) use of a permeable seed-bed soil containing 55 to 70 percent of sand, fine cinders or equivalent granular soil particles.

3. Most airfield, drill field or road shoulder soils will require an admixture of lime plus a fertilizer containing adequate nitrogen, phosphoric acid and potash, if turf is to be rapidly established in humid regions.

4. Addition of organic matter in the form of farm manures, or equivalent organic material is often essential, particularly on light, sandy types of soils, and in dry regions.

5. Technical analysis of site, drainage and soil conditions, wise salvage and use of existing soil materials, and technical supervision of grading, seeding, sprigging or sodding are the keys to success in all turf operations.

6. Above all it is important that the needs of growing turf be provided for in original airfield or drill field design and grading.

^{1/} See also Report of the Committee on Soil Erosion, page 42.

Once fields have been compacted with sheeps-foot rollers proper plowing and other tillage is extremely difficult. Three to five inches of surface soil should not be compacted until after grasses have become established.

Turf for Areas Not Used by Traffic. There are many areas of new construction on military reservations which do not carry traffic but which will require protection against erosion. For example, the construction of barracks, hospitals and other buildings will expose bare soil on which lawn types of ground cover may be desirable. Here essentially the same turf grasses may be used as on adjacent drill and airfields. A major difference in soil preparation of the two types of areas lies however in the fact that lawns do not have to carry the load of aircraft, tractors, trucks and other vehicles. Such lawn areas can, therefore, be established on existing heavy clay loam, clay, or silty surface soils which, without addition of granular materials, would be quite unsuitable for a good airfield or drill field surface, or for a satisfactory earth road shoulder, because they will not support wheel loads when wet.

Where existing soils are poor and of unsatisfactory texture, fertility, or organic matter content, cover crops can often be used either for quick temporary cover, or as "green manure crop" in advance preparation of lawn sites for permanent turf cover to follow. Under some conditions a perennial legume cover crop alone may be a satisfactory permanent cover for lawn surfaces. For meadows and other outlying areas local mixtures of pasture grasses are recommended, and have been successfully used.

Use of Cover Crops. A cover crop has been defined as "any solid ground cover whether or not specifically planted for this purpose". Thus a dense cover of weeds on an old field is a cover crop; a seeded grain or legume will serve the same purposes of protecting bare soil; or a mulch of hay, straw, or leaves from nearby woodlands will also serve to prevent erosion and conserve moisture for use in later seeding, sodding or planting work. Many of our State Highway Departments have used grass, grain, and legume cover crops to advantage and they have been a part of standard agricultural use in all the humid regions of the country.

Slopes and embankments of railroads and access roads and bridges, slopes adjacent to structures of many types, and exposed soil on many areas which do not carry traffic may be quickly and economically covered by the use of cover crops. Well-selected cover crops have advantages not possessed by the usual turf grasses in that -

1. Cover crops when plowed under add large amounts of organic matter to the soil during a single growing season. Undisturbed sod also builds up organic matter over a period of years. 2/

2/ Experiments at Cornell University under Messrs. Lyon and Wilson demonstrated that in a ten-year period, 415 pounds of organic nitrogen were added to the soil under an acre of bluegrass pasture sod, in the form of decayed root and top growth.

2. Leguminous cover crops add nitrogen to poor soil and thus increase the rate of growth of grasses seeded with them or of grasses, vines, or other permanent ground cover seeded or planted afterward. Soils which will not support permanent ground covers may be improved by the plowing under of selected cover crops to the point where the best available permanent turf grasses can be used on the areas involved.

Cover Crops Which can be Quickly Established. From available published information ³ and the experience of farmers, agronomists, and landscape engineers, there has been evolved a group of cover crops which can be very quickly established on various types of bare soils. The following is a partial list of grasses and grain crops which germinate quickly and form a dense ground cover. (Also see Table 1.)

Some Fast Growing Grasses and Grains

<u>Common Name</u>	<u>Scientific Name</u>	<u>Type</u>	<u>Character of Growth</u>	<u>Seeding Season</u>
Domestic ryegrass	Lolium	Annual	Coarse bunch turf	Spring-Early Fall
Perennial ryegrass	"	Perennial	Coarse turf	" " "
Redtop	Agrostis	"	Fine turf	" " "
Foxtail millett	Setaria	Annual	Coarse high grain	Early Summer
Japanese millett	Echinochloa	Annual	Very coarse Very coarse	" "
Sudan grass-Sorghum		Annual	high grain	" "
Oats	Avena	"	Medium coarse grain	Spring-Fall
Barley	Hordeum	"	Coarse high grain	Early Fall
Winter rye	Secale	"	" " "	Late Fall
Winter wheat	Triticum	"	" " "	" " "
Buckwheat	Fagopyrum	"	Grain-medium height	Spring

³/ See list of References (175 to 183) on Pages 68 and 69.

Table 1. Some common available cover crops

(For quick temporary cover or green manuring in preparation for permanent turf or vine cover)

Common name ^{1/}	Region of country where now used	S O I L S		Seeding season
		Best suited to	Special conditions	
Ryegrass (domestic) (Rank growth)	All regions	Clays and loam	Medium to high fertility	Spring-summer-fall
Sudan grass	All regions	Sands to clay-loams	Variable	Early summer
Japanese millet	All regions	Clay and loams	Tolerates acid soils	Early summer
Soy bean	Cool-humid	Clay to loams	Tolerates acid soils	Late spring
Lespedeza (Korean)	Warm-humid	Clays and sands	Tolerates acid soils	Spring
	Southern cool-humid			
Eye	All regions	Fertile clay-loam	Tolerate poor soils	Fall-spring
Cowpeas	Warm and cool-humid	Fertile clay-loam	Tolerate poor soils	Late spring
Winter wheat	All regions	Fertile clay-loam	Tolerate poor soils	Fall-spring
Oats	All regions	Fertile clay-loam	Tolerate poor soils	Spring
Crimson clover	Warm-humid	Clays and loams	Will tolerate moderate acidity	Spring-summer-fall
Barley	All regions	Fertile clay-loam	Sensitive to poor soil	Spring-fall
Ladino clover	Cool-humid	Fertile clay-loam	Requires abundant minerals-moisture	Spring-fall
Bar clover	Warm and cool humid	Clays and loams	Tolerant to wet and acid conditions	Fall
Alsike clover	Cool-humid	Clays and loams	Tolerant to wet and acid conditions	Spring and late summer
Red clover	Cool-humid	Clays and loams	Will tolerate moderate acidity.	Spring and late summer
Hairy vetch	Warm and cool-humid	Clays and sands	Particularly useful on sandy soil	Fall
White clover	Cool-humid	Clays and loams	Will tolerate moderate acidity	Fall-spring
Sweetclovers	Cool-humid and dry	Clays to loams	Requires neutral or alkaline soil	Spring

^{1/} Cover crops are listed in the relative order of the rapidity of their establishment of an effective ground cover.

Common name <u>1/</u>	Average seeding pounds per acre <u>2/</u>	Depth of soil cover over seed <u>3/</u>	Growth height (feet)	No. of seed per pound
Rygrass (domestic) (Rank growth)	50-60	S	2-3	227,000
Sudan grass	25-30	S	3-5	55,000
Japanese millet	25-30	S	2-3	155,000
Soy bean	120	D	3-4	1,250-7,775
Lespedeza (Korean)	20-25	M	Low	240,000
Rye	120	D	3-4	18,000
Cowpeas	120	D	2-3	2,900
Winter wheat	120	D	3	16,000
Oats	120	M	2-3	19,000
Crimson clover	20-25	S	1-2	150,000
	hulled seed			
Barley	120	M	3-4	13,000
Ladino clover	5-10	S	Low	700,000
Bur clover	50-100	S	Low	209,000
	in bur			
Alsiko clover	8-12	S	1-2	700,000
Red clover	15-20	S	1-3	250,000
Hairy vetch	30-40	M	Low	20,000
White clover	5-10	S	Low	700,000
Sweetclovers	15-20	S	3-4	250,000

- 1/ Cover crops are listed in the relative order of the rapidity of their establishment of an effective ground cover.
- 2/ Rates of seeding listed are for use when one kind of seed is used alone. Rates will be reduced as required when mixtures of cover crop seeds are sown.
- 3/ S - shallow surface to 1/2-inch cover over seed; M - intermediate 1/2 to 1-inch cover over seed; D - deep 1 to 1-1/2-inch cover over seed.

TABLE 2
A COMPARISON OF SOME
COMMON GRASSES, GRAINS AND LEGUMES

Grain, Grass, or Legume	Type of Plant	Permanency of Cover Provided	Average Germination Period Days ^{1/}	Seasonal Growth in -
1. Rye	Annual	Temporary	6	Winter - Spring
2. Wheat	Annual	Temporary	6	Winter - Spring
3. Barley	Annual	Temporary	6	Mainly - Spring
4. Sweet Clover	Biennial	Semipermanent	6	Growth - Spring Summer
5. White Clover	Perennial	Semipermanent	6	Growth - Spring Fall
6. Red Clover	Perennial	Semipermanent	5	Spring - Fall
7. Alsike Clover	Perennial	Semipermanent	6	Spring - Fall
8. Millet	Annual	Temporary	8	Summer grower
9. Oats	Annual	Temporary	7	Growth mainly in Spring
10. Timothy	Perennial	Semipermanent	8	Spring - Fall
11. Redtop	Perennial	Semipermanent	10	Spring - Fall
12. Meadow Fescue	Perennial	Permanent	14	Spring - Fall
13. Orchard Grass	Perennial	Permanent	14	Spring - early Summer - Fall
14. Domestic Rye Grass	Perennial	Semipermanent	14	Spring - Fall
15. Crested Wheat Grass	Perennial	Permanent	14	Spring
16. Smooth Brome Grass	Perennial	Permanent	14	Spring
17. Lespedeza - Common	Annual	Semipermanent	14	Summer - Fall
18. Lespedeza - Korean	Annual	Semipermanent	14	Summer or Fall
19. Vetch - Hairy (red)	Biennial	Temporary	14	Spring - early Fall
20. Fescue - Sheeps	Perennial	Permanent	21	Spring - early Fall
21. Bent grasses	Perennial	Permanent	10-21	Spring - early Fall
22. Bermuda Grass	Perennial	Permanent	21	Spring-Summer
23. Carpet Grass	Perennial	Permanent	21	Spring-Summer
24. Bluegrass - Kentucky	Perennial	Permanent	21-28	Spring - Fall
25. Bluegrass - Canada	Perennial	Permanent	21-28	Spring - Fall

^{1/} Germination period assumes necessary initial soil moisture and temperature permitting activity of seed embryo.

From the above list a cover crop can be selected to meet various climatic and soil conditions. These cover crops can be seeded during construction operations to stop erosion and dust formation, either alone or as a "nurse crop" with more permanent grasses. Within a few weeks after seeding these cover crops will provide a complete ground cover. See Table No. 2, "A Comparison of Some Common Grasses, Grains, and Legumes." The permanent turf grasses can be seeded successfully only in spring or early fall in the cool humid region and the turf grasses require several weeks or even months to establish protective cover during unfavorable seasons. A selected cover crop may be successfully seeded during almost any part of the growing season in humid regions. The coarse grain types of cover can be cut when mature and left on the ground as a mulch to conserve moisture and plant nutrients for permanent grasses or other ground covers seeded with them. ^{4/} The above group of cover crops will add large amounts of organic matter when plowed under as green manure crops. They do not add nitrogen and hence are often mixed with the following group of legumes in standard agricultural practice.

Cover Crops of Medium or Slow Establishment. The group of leguminous cover crops given in Table 3 cannot be as quickly established as can the grains. Mixtures of seeds form a more complete cover established in less time than either grain crops or legumes seeded alone. The legumes also fix nitrogen in the soil and therefore when needed in mixture with grains or grasses increase their rate of growth.

Mulching Methods. Roadside experience indicates that steep cut and fill slopes and similar rough areas not used by traffic can be immediately protected against erosion by the use of mulches. Reference is here made to the 1940 and 1941 reports of the Project Committee on Soil Erosion and to sample specifications for mulching on pages 124A-125A, in our 1941 report. The advantages of mulches are:

1. Immediate dust and erosion control
2. Improved soil aeration
3. Increased infiltration of water
4. Prevention of extremes in soil temperature; protection against frost heaving
5. Conservation of plant nutrients and organic matter in the soil
6. Conservation of soil moisture
7. Increased rate of establishment of grasses or other ground cover

^{4/} On areas which are frequently mowed annual grasses, grains, and legumes in Eastern humid regions tend to be replaced by a volunteer growth of permanent sod forming grasses. On unmowed areas of field or pasture in humid regions perennial or woody native ground covers tend to replace annual seeded cover.

TABLE 3 - LEGUMINOUS COVER CROPS

<u>Common Name</u>	<u>Scientific Name</u>	<u>Type*</u>	<u>Character of Growth</u>	<u>Seeding Season</u>	<u>Remarks</u>
White clover of wild, Kent, Dutch, and N. Y. strains/ <u>1</u> Ladino clover	Trifolium spp. Trifolium spp.	Annual or perennial Perennial	Low Low	Spring-Early Fall Spring-Early Fall	Seeded with hay and turf types of grasses
Alsike clover* Crimson clover* Red clover* Alfalfa	Trifolium sp. Trifolium sp. Trifolium sp. Medicago sp.	Annual Annual Annual Perennial	Medium height Medium height Medium height Medium height	Spring-Early Fall Spring-Early Fall Spring-Early Fall Early-spring summer	These clovers require lime and good moist soil Best on alkaline soils
Bur clovers	Medicago sp.	Perennial	Low	Early summer	Seeded in mixture with grasses
Sweetclovers	Melilotus spp.	Annual	High - coarse	Early summer	Requires lime
Lespedezas	Lespedeza spp.	Annual and Perennial	Low - to medium high	Early summer	Seed Korean L. alone or on poor clay
Winter vetch	Vicia sp.	Annual	Low	Early fall or spring	Often seeded with rye, etc.
Soy bean	Glycine sp.	Annual	Medium height	Early summer	Prefers heavy soil
Birdsfoot trefoil	Lotus spp.	Perennial	Very low	Spring or early fall	Grows on acid soils

*Note: "Weak" perennials listed as annuals.

1 - There are many other local strains of white clover, i.e., Ohio, Louisiana, New Zealand, etc.

Experience in highway and roadside development indicates the need for covering bare soil exposed by excavation, immediately following grading operations. Mulching is the quickest and most immediately effective method of protecting soil against erosion. Seeding of cover crops, grains, and grasses when combined with mulching combines the advantages of both types of ground covers. Table 4 contains a list of common mulch materials.

Where mulching and seeding are combined on areas which carry traffic, the hay, straw, or other mulch material should be disced or rolled into the soil to prevent displacement by wheels of vehicles or propeller blast of airplanes.

Conclusion. It is impossible in this brief report to mention all of the applications of these ground cover methods to the various areas developed for war purposes. For example, the whole broad subject of "protective concealment" of permanent and semipermanent installations is closely related to the ground cover problem. Wherever earth excavation has been performed bare soil is exposed. Nothing stands out from the air like newly excavated soil. Some form of mulch or growing ground cover is almost always available for use in merging excavated areas into the surrounding terrain.

In this connection, statements made by the late Major MacKenzie who was in charge of camouflage instruction of the British Armies in 1915 to 1918 are well worth remembering. "The lessons of history regarding camouflage have been largely ignored by soldiers and statesmen". --- "Nature's methods (of camouflage) are the only sound ones. Use of paints, nets, etc., too often actually advertise the object it is desired to conceal." In other words, where there is time natural concealment is preferable to any artificial camouflage methods.

The Japanese are said to have used pregerminated grass seed on airfields captured in the Dutch East Indies. At least, we learn that bare yellow earth of new fields built by the Dutch became part of a green island "landscape" within a few days after the Japanese invasion.

A well-known engineer recently returned from an inspection of New Zealand airfields which are largely turf covered, said: "We never saw an airfield in that country until the pilot began to set the plane down".

The experience of engineers in protecting bare highway soil from erosion should be of value in protecting new military developments from erosion by surface water and in preventing dust formation on airfields. It is believed that by making State highway experience available to those in charge of military construction and maintenance we may also help to save structures, military equipment, and the lives of fighting men in combat areas, by masking ground installations from observation by enemy fliers.

TABLE 4
SOME COMMON MULCH MATERIALS

Material	Average Loose depth in inches applied over seeded area	Average loose depth applied under a light cover of soil	Remarks
Hay	1 to 2	3 to 8	(Light 1-2 mulch (successfully used (on airfields
Straw	1 to 2	3 to 8	(Light 1-2 mulch (successfully used (on airfields
Weed cuttings	1 to 2	3 to 8	(Heavy mulches under (a cover of soil (best used on rough, (steep slopes not (on field
Peat moss - Sedge peat	1/4 to 1/2	1 to 2	(Harrow into (surface soil
Tobacco stems	1 to 2	3 to 6	(Heavy mulch under (soil cover not (suitable on sur- (faces used by (traffic
Potato vines	1 to 2	3 to 6	(Heavy mulch under (soil cover not (suitable on sur- (faces used by (traffic
Cottonseed hulls	1/2 to 1	2 to 3	(Effect of heavy (2 to 3-in. mulch (on grasses not (known. Light mulch (has been used on (airfields
Pine needles	Not recommended	2 to 3	(Forest litter (mulches may be (toxic to certain (grasses.
Hardwood leaves (acid) (Various oak species)	Not recommended	3 to 6	(These may best be (used in connection (with vine covers, (or rough turf and (bunch types of (grasses. Of value (on rough, steep (slopes.
Hardwood leaves (neutral) (Maples, poplars, etc.)	Not recommended	3 to 6	(These may best be (used in connection (with vine covers, (or rough turf and (bunch types of (grasses. Of value (on rough, steep (slopes.
Brush - twigs, etc.	2 to 3	Not recommended	(These may best be (used in connection (with vine covers, (or rough turf and (bunch types of (grasses. Of value (on rough, steep (slopes.