Reprinted from *Proceedings of the X International Grassland Congress, 1966*

PRINTED IN FINLAND

SECTION 4

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USE OF THE SOIL-VEGETATION SURVEY IN PREDICTING SUCCESS OF ESTABLISHMENT OF IMPROVED GRASSLAND SPECIES

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Summary

Soils of two Great Soil Groups are considered: Grumosols — calcareous and alkaline to neutral, base saturation greater than 80 %, fine to gravelly moderately fine textures, high available moisture; Non-calcic Brown Soils — neutral to moderately acid, base saturation 60—85 %, fine to gravelly medium texture, low to high available moisture.

Soils of these Great Soil Groups are often intermingled.

A 15-year study of a 70-hectare sowing of an annual forage legume, *Trifolium hirtum*, in a field with four soils, coupled with data from soil-vegetation surveys, indicates that pH, water-holding capacity, and drainage are the critical soil characteristics responsible for delimiting distribution of resident *Erodium* species and success of establishment of *T. hirtum*. Predictions of success can now be made on millions of hectares of California grasslands.

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The successful production of any crop species depends on many factors involved in the climate-soil-plant-management complex. Within the limits of climatic adaptation, the latter three are critical for non-irrigated grassland species. Acknowledging that all aspects of management (seedbed preparation, fertility, pest control, grazing, etc.) must be taken into account, we are limiting our discussion here to soil-species relationships.

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5406/67/2

Annual Range
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Introduction

The successful production of any crop species depends on many factors involved in the climate-soil-plant-management complex. Within the limits of climatic adaptation, the latter three are critical for non-irrigated grassland species. Acknowledging that all aspects of management (seedbed preparation, fertility, pest control, grazing, etc.) must be taken into account, we are limiting our discussion here to soil-species relationships.

Climate and landscape

The "interior" Mediterranean-type climate of the study area is characteristic of much of California's rangelands. This type of climate has a mean annual rainfall of 305 to 635 mm. Winters are wet and cool, with occasional frosts and summers are hot and dry. There is a mean annual temperature of 16 ± 2° C, a mean January temperature of 7 ± 2° C, and a mean July temperature of 26 ± 2° C.

The soil series involved in this study are representative of two Great Soil Groups: 1) Grumosols and 2) Non-calcic Brown Soils. The fine textured Grumosols of the Denverton and Nacimiento series are widely scattered throughout the Coast Ranges of California. They generally occur on smooth, rolling foothills at elevations of 60 to 600 meters. Together with similar types of soils of the Linne, Shedd, Ayar, Altamont, and Sehorn series they occupy over 1,000,000 hectares in California.

The gravelly Newville and Corning soils are examples of maximal Non-calcic Brown Soils. They are mainly distributed around the fringes of the Great Valley of California and in some of the larger foothill valleys of the Coast Ranges. They generally lie at elevations below 450 meters on partially dissected terrace lands. The total area of these and other similar Non-calcic Brown Soils of the Positas, Hartley, Ohmer, Perkins, and Redding series exceeds 7 million hectares (6).

Grumosols. Denverton soils are deep, well drained Grumosols developed from calcareous, softly consolidated sedimentary rocks. They occur on very gentle to moderately steep concave slopes and saddles in association with the Nacimiento soils. They are clay textured throughout. They have an A-C profile with a dark-brown (hues of 10 YR or 7.5 YR), very slightly acid A horizon which grades into a brown or light reddish-brown, midly alkaline and calcareuos C horizon. Lime is finely disseminated and segregated in soft masses. The soil is massive when wet but with drying it develops a very coarse prismatic (adobe) structure with deep cracks extending into the C horizons. Commonly, the upper 25 mm of the A horizon is granular. Organic-matter content ranges from 1.5 to 2 % in surface soil to less than 0.5 % in the lower part of the subsoil. The cation exchange capacity (CEC) is 30 to 35 meq/100 g of soil. Calcium and magnesium are the dominant exchangeable cations. Base saturation increases from 75 to 80 % in the surface to over 90 % in the subsoil. Available moisture-holding capacity is high and inherent fertility is moderately high.

Nacimiento soils are well drained Grumosols developed from calcareous, weakly consolidated siltstones and soft shales and sandstones. They are moderately deep to deep, fine textured, and calcareuos throughout. Lime increases with depth. Typically, they have a grayish-brown (hues of 10 YR and 2.5 Y) clay A horizon that grades into a pale brown, brown or light olive-brown C horizon of similar texture. The upper 25 to 50 mm of the A horizon is granular. The soil is massive when wet, but upon drying develops a very coarse prismatic (adobe) structure with deep cracks that extend into the subsoil horizons. Organic-matter content decreases from 1.5 to 2 % in the surface to less than 1 % in the subsoil. Montmorillonite and kaolinite, the dominant clay minerals, are about equal in amount and make up roughly 90 % of the clay complex. The CEC is 35 to 40 meq/100 g of soil. Calcium and magnesium are the dominant exchangeable cations. Base saturation is greater than 95 % throughout the soil profile. Water-holding capacity is high, as is inherent fertility.

Non-calcic Brown Soils. Corning soils are well drained, maximal Non-calcic Brown soils developed from unconsolidated, poorly sorted gravelly terrace materials. They occur on nearly level to very gently sloping high terraces that have a hummocky (hogwallow) micro-relief. They have a well developed ABC profile. Typically, they have a yellowish-red, medium to strongly acid, gravelly loam A horizon that abruptly overlies a reddish brown or red, medium acid, dense, slightly gravelly clay B horizon. This claypan subsoil grades into a mottled yellowish red, red and light yellowish brown, medium to slightly acid, gravelly sandy clay loam C horizon. Both the A and C horizons are massive. The B horizon, when dry, has a prismatic structure, which grades to angular blocky with depth. The organic-matter content ranges from 0.5 to 1 % in the surface to less than 0.5 % in the subsoil and substratum. Dominant clay minerals, approximately equal in amount, are kaolinite, montmorillonite, and vermiculite. The CEC ranges from 8 to 12 meq/100 g of soil in surface to 20 to 30 meq/100 g of soil in the subsoil and substratum. Calcium and magnesium are the primary exchangeable cations. Calcium is dominant in the surface and magnesium is more prevalent in the subsoil and substratum. Base saturation ranges from 60 to 75 % in the A horizon, 80 to 95 % in the B horizon, and is greater than 90 % in the C horizon. Available moisture-holding capacity is low and inherent fertility is low to very low. Nitrogen, phosphorus, and sulfur are limiting nutrients.

Newville soils are well drained, maximal Non-calcic Brown Soils developed from weakly consolidated terrace deposits. These materials are poorly sorted gravels and cobbles in a finer textured, non-calcareus matrix. They occur on gentle to steep dissected terrace slopes, generally below Corning and Redding soils. They have a well developed ABC profile. Typically, they have a brown, slightly acid, gravelly loam A horizon which abruptly overlies a strong brown to reddish brown, slightly to medium acid, gravelly clay B horizon. Underlying this gravelly fine textured subsoil is a mottled light yellowish brown, brown, and strong brown, slightly acid to neutral, somewhat stratified gravelly sandy clay loam substratum. The surface and substratum are massive. The dense clay subsoil, when dry, has a prismatic structure. Organic-matter content decreases from 1.25 to 1.0 % in the surface to less than 0.5 % in the subsoil. The dominant clay minerals, kaolinite, montmorillonite, and vermiculite occur in approximately equal amounts. The CEC is 10 to 15 meq/100 g of soil in the surface and 25 to 35 meq/100 g of soil in the subsoil and substratum. Calcium and magnesium are the dominant cations. Base saturation increases with depth, ranging from 60 to 75 % in the surface to more than 90 % in claypan and substratum horizons. Available moisture-holding capacity is low. Inherent fertility is low. Nitrogen, phosphorus, and sulfur are limiting nutrients (1).

Soil-vegetation surveys

The State Cooperative Soil-Vegetation Survey in California is a cooperative undertaking of the California Division of Forestry, the University of California, and the Pacific Southwest Forest and Range Experiment Station (U.S.D.A.). The principal objective of the survey is to obtain basic information on the kind and distribution of upland soils and vegetation, their relationships, and their characteristics and uses as an aid to better management of wildlands. One phase of the grassland study relates percent cover of herbaceous species to soil series and types (3). Somewhat comparable surveys on other areas are also conducted by the University of California, and agencies of the U.S.D.A. A state committee meets annually to correlate findings.

Species

Many annual grassland species have been involuntarily introduced into California since 1769. Pertinent to our discussion are three: *Medicago hispida* Gaertn., *Erodium botrys* Bertol., and *E. cicutarium* L'Her. (5). They are now distributed widely throughout the Mediterranean climatic zone of the state. The annual *Trifolium hirtum* A11 was introduced from Turkey by the Plant Introduction Service of the U.S.D.A. and first tested in California in 1944 (4). It is very productive on certain soils (7) but it is unsuccessful on others. All four are known as "self-seeding" annuals. During the many years of testing and, later, of commercial sowings of *T. hirtum,* observations were made by us and others of associated adventive annual species. There appeared to be a definite pattern of successful establishment of *T. hirtum* and distributions of the other 3 species. These successes and distributions were limited primarily by the soil type. Unfortunately, we lack information on the critical nutrient requirements of most of our "wild" and recently domesticated grassland species, including those under discussion.

The experiment

The commercial seeding in northern California of a 70-hectare field in 1951 gave us an opportunity to compare soils-species relationships involving the 4 soils and 4 species discussed above

Hordeum vulgare L. is generally sown one year out of 3 or 4 on such soils. The fields are grazed by cattle and sheep after the crop is harvested and in intervening years. Thus, many annual grassland species are present. Following a crop of barley, *T. hirtum* was drilled as part of a grassland mixture on a well-prepared seedbed in the fall of 1951. For purposes of brevity it is the only sown species discussed herein. Resident annual species in the field included the 3 mentioned above and referred to in Table 1.

Results

A rapid step-point method (2) was used to estimate herbaceous ground cover on each of the 4 soils. Estimates of the ground cover were

Table 1. Estimates of percent cover of species on 4 soils of a 70-ha. planting of *Trifolium hirtum*

	Grumosol				Non-calcic Brown			
Soils	Nacimiento		Denverton		Newville		Corning	
Area (ha.)	33.6		22.4		10.5		3.5	
Date	March 1956	June 1965	March 1956	June 1965	March 1956	June 1965	March 1956	June 1965
Medicago hispida	13	26	6	7	0	2	0	0
Erodium cicutarium	28	*	5	*	0	*	0	*
Trifolium hirtum	2	0	5	3	6	41	2	34
Erodium botrys	0	*	10	*	12	*	21	*
Annual grasses	16	50	12	63	24	41	17	58
Other species	12	9	6	9	16	2	17	1
Total cover	71	85	44	82	58	86	57	93

Sampled too late in season to identify these species

made in 1956 and 1965 (Table 1). Sampling consisted of 100 points and 10 ground cover estimates on each soil at each sampling date.

The data in Table 1 show the following: *M. hispida* and *E. cicutarium* are the dominant species on Nacimiento. They occur more sparsely on Denverton, and not at all on Newville and Corning. *E. botrys* and *T. hirtum* are not found on Nacimiento, occur somewhat sparsely on Denverton, and are dominant on Newville and Corning.

Discussion and conclusions

Commonly, several soil types may be intermingled in California grasslands. Each soil may support a somewhat distinctive flora, although numerous species are adapted to many soils. Soil-vegetation surveys provide data helpful in delimiting soils-species relationships involving native and resident species. It is helpful to know which species, present in large numbers, are peculiarly adapted to certain soils. This, of course, tells us nothing of the adaptation of improved species.

This study showed that *E. cicutarium* and *M. hispida* grow well on Nacimiento, *E. botrys* and *T. hirtum* on Newville and Corning, and the 4 species can grow on Denverton. It appears that pH, water-holding capacity, and drainage are the soil characteristics critical for these species. In such fields, with intermingled soils, a mixture of the two legumes is recommended. If a field included Non-calcic Browns only, *T. hirtum* (or legumes of similar edaphic adaptation) would be recommended.

Farmers and agricultural advisers can more readily determine vegetation components. It is useful to know, for example, that where *E. botrys* is dominant *T. hirtum* can be recommended.

Acknowledgments

We thank our colleagues in the Agricultural Extension Service and other state and federal agencies, and J. K. Sexton on whose ranch the experiment is being conducted.

Literature cited

1. Begg, E. L. 1965. Univ. of Cal. Soil Survey No. 15. 199 pp.
2. Evans, R. A. and R. M. Love. 1957. J. Range Mgmt. 10: 205—12.
3. Evans, R. A., W. R. Powell, and R. M. Love. 1962. Cal. Div. of For. Pub. (State Co-op. Soil-Veg. Survey) 17 pp.
4. Love, R. M. and D. C. Sumner. 1952. Cal. Agr. Exp. Sta. Circular 407. 11 pp.
5. Robbins, W. W. 1940. Cal. Exp. Sta. Bull. 637. 128 pp.
6. Storie, R. E. 1953. Cal. Agr. Exp. Sta. Manual No. 6. 55 pp. plus map.
7. Williams, W. A., R. M. Love, and J. P. Conrad. 1956. J. Range Mgmt. 9: 28—33.

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