Distribution of Legumes as Correlated With Surface Geology and Plant Succession[1]

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A study was initiated in 1961 to determine the relation of legumes to surface geology in Marshall County, Oklahoma. In 1962 the investigation was enlarged to include the correlation of legumes with the stages of plant succession. The work was carried on during the months of June and July of 1961 and 1962. In general, the correlation of legume species with surface geology was excellent, especially when related to the stages of plant succession within the various geologic formations.

GEOLOGY OF MARSHALL COUNTY, OKLAHOMA

Marshall County lies in the Red River Plain, a division of a larger physiographic province known as the Gulf Coastal Plain (Bullard, 1926). The oldest, or paleozoic, rocks are present in one small area in the northern part of the county along Turkey Creek. Since the outcrops were very small and the amount of soil even less, no studies were made on these formations.

Except for the paleozoic rocks, the geologic formations in Marshall County are Cretaceous, or recent, in age. The stratigraphic sequence of the formations investigated, from oldest to youngest, is as follows: Trinity Sand, Kamichi Clay, Duck Creek Limestone, Fort Worth Limestone, Denton Clay, Weno Clay, Woodbine Sand, and River Sand. Of these formations the Trinity Sand covers most of the western third, and the River Sand is exposed in much of the southern and eastern portions of Marshall County. The remainder of the county, including the central and northeastern sections, is covered by the limestone and clay formations. Evidence indicates that forest vegetaton was present on the sandy formations but that grasslands occurred on soils derived from limestones and clays. It seems probable, therefore, that the original vegetation consisted of an almost unbroken, central area of grassland surrounded by an upland forest, except near the northeastern edge of the county.

Both the limestone and clay formations weather to form heavy, tight, clay soils. However, the limestones, and especially the Duck Creek Limestone, break down to form black, waxy, clayey soils which are quite unlike those formed by the weathering of the clay formations. These have been designated as lime soils in this paper, to distinguish them from the other clay soils derived from the clay formations.

LEGUMES IN RELATION TO PARENT MATERIAL

During the summer of 1961 a total of 405 specimens was collected representing 72 species. Identifications were made primarily by the aid of manuals by Shinners (1958), Turner (1959), and Waterfall (1960).[2] The work of 1961 was done under the direction of Dr. George J. Goodman, whose help is greatly appreciated. Herbarium specimens of all species mentioned have been deposited in the Bebb Herbarium of the University of Oklahoma.

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[1]A contribution of the University of Oklahoma Biological Station, C. D. Riggs, Director. Sponsored by The National Science Foundation.

[2]"Nomenclature" according to Waterfall (1960).

The investigation in 1962 involved eight geological formations and 98 fields. The geological formations, with number of fields in parentheses, were as follows: River Sand (10), Trinity Sand (12), Woodbine Sand (8), Weno Clay (10), Kiamichi Clay (14), Denton Clay (11), Fort Worth Limestone (18), and Duck Creek Limestone (15). The above data show that the fields were fairly evenly distributed throughout the eight geological formations.

A total of 49 species was encountered on the eight geological formations in 1962. These formations, with the number of species found on each, are shown in Table I. It will be noted that the numbers of species are about equal in the formations which weather to form sands and clays. Fewer species were found on soils derived from limestones.

Legumes are relatively specific in regard to the substrate on which they grow. Of the common legumes encountered on ten or more fields, eight occurred primarily on sand (Table I) and four of those were never found on clay or lime soils. These species were *Galactia volubilis, Glottidium vesicarium, Strophostyles helvola*, and *Strophostyles leiosperma*. The last three were found in only a few fields in the bottomlands presumably because of their relatively high moisture requirements.

Only one common species was found primarily on clay, and only two species were confined to lime soils (Table I). If the species limited to two soil bases, there were four species growing on sand and clay, six on clay and lime soil, and only one on sand and lime soil (Table I). This suggests that the edaphic conditions in sand are quite different from those in lime soils.

TABLE I. NUMBER OF LEGUME SPECIES IN RELATION TO GEOLOGICAL FORMATIONS AND PARENT MATERIALS.

Geological formations	Species	Substrate	Species
River Sand	20	Sand only	8
Trinity Sand	19	Clay only	1
Woodbine Sand	14	Lime soil	2
Weno Clay	24	Sand and Clay	4
Kiamichi Clay	21	Sand & Lime Soil	1
Denton Clay	15	Clay & Lime Soil	6
Fort Worth Limestone	14	Sand, Clay, & Lime Soil	[illegible]
Duck Creek Limestone	13		

Of the 49 species encountered in 1962, seven occurred on three types of soil materials: sand, clay, and lime soils. Of these seven legumes, two were trees *(Cercis canadensis* and *Gleditsia triacanthos)*, and two were cultivated herbs *(Medicago lupulina* and *Melilotus officinalis.)* The native forbs were *Indigofera leptosepala, Psoralea tenuiflora,* and *Schrankia uncinata.* Since these seven species occurred on the three soil materials, it appears that they have a wide range of ecological amplitude to edaphic conditions.

A given species of legume was found on relatively few of the eight geological formations (Table II). The average species was found on 2.8 (35%) of the geological formations studied. Many legumes occurred on only one formation (Table II). Fewer but a considerable number of legume species were found on two, three, or four formations, and still fewer were found on as many as six rock types. No species was found on seven or eight (all) of the geological formations (Table II). These observations suggest that legumes are fairly specific in their habitat requirements.

LEGUMES IN RELATION TO SUCCESSION

During the summer of 1962 abundant data for legume species were procured for the various successional stages in the eight geological formations. The data showed that there was no correlation between the number of individual legume plants and succession on any of the geological forma-

TABLE II. LIST OF LEGUME SPECIES AND THE NUMBER OF GEOLOGICAL FORMATIONS ON WHICH THEY WERE ENCOUNTERED.

Astragalus crassicarpus	1	*Lespedeza violacea*	4
Arachis hypogea	1	*Lespedeza virginica*	6
Baptisia leucophaea	3	*Lotus americanus*	4
Cassia fasciculata	4	*Medicago lupulina*	2
Cercis canadensis	3	*Medicago orbicularis*	3
Centrosema virginiana	1	*Melilotus alba*	3
Crotalaria sagittalis	2	*Melilotus officinalis*	5
Dalea aurea	3	*Neptunea lutea*	5
Dalea candida	3	*Prosopis juliflora*	1
Dalea multiflora	2	*Psoralea cuspidata*	1
Dalea purpurea	6	*Psoralea digitata*	1
Desmanthus illinoensis	4	*Psoralea linearifolia*	1
Desmanthus leptolobus	6	*Psoralea rhombifolia*	1
Desmodium tweedyi	1	*Rhynchosia latifolia*	3
Galactia volubilis	2	*Schrankia uncinata*	6
Gleditsia triacanthos	2	*Sophora affinis*	1
Glottidium vesicarium	1	*Stylosanthes biflora*	1
Indigofera leptosepala	4	*Strophostyles helvola*	2
Krameria secundiflora	5	*Strophostyles leiosperma*	3
Lespedeza capitata	2	*Tephrosia virginiana*	1
Lespedeza hirta	1	*Vicia minutiflora*	2
Lespedeza intermedia	5	*Vicia villosa*	1
Lespedeza procumbens	5		
Lespedeza repens	4		
Lespedeza stipulacea	4		

tions. However, the number of species was closely correlated with seral development and appeared to follow a consistent pattern for the various geological formations. Table III shows the number of legume species in relation to succession (stages 1 to 5) for the eight geological formations. In general, the original cover on the sands was forest vegetation and that on clays and lime soils was prairie. With certain exceptions the terminal stage of succession on sand is forest and that on clays and lime soils is prairie (Table III). Considering the sands as a group it is noted that many species develop in the early stages, rise to their peak in the middle stage, and drop off in the later stages (Table III). This latter phenomenon was due to the fact that few legumes could survive in the forest (stage 5). It was not possible to find a terminal forest on River Sand. This was probably due to the fact that no fields had been abandoned long enough.

Considering the clays as a group it is noted that fewer species of legumes develop in the number one and two stages than in the corresponding stages of sands (Table III). In the number three stage on clays there are more species that at any other stage of succession.

As to the limestone group, species enter the stages of succession more slowly and build to their peak in the number five, prairie stage (Table III). It should be noted that no legume species were found in certain fields representing the earliest stage of succession on lime soils. This suggests that the physical nature of the soil might be a factor in the establishment of legumes in the early stages of succession.

TABLE III. NUMBER OF LEGUME SPECIES IN RELATION TO SUCCESSION IN THE VARIOUS GEOLOGICAL FORMATIONS.

Geological Formations	Terminal Stage of Succession	Stages of Succession				
		**1	2	3	4	5
River Sand	Prairie	7	11	10	7	—
River Sand	Forest	7	11	10	3	2
Trinity Sand	Prairie	4	11	16	6	7
Trinity Sand	Forest	4	11	16	2	2
Woodbine Sand	Forest	10	10	6	3	2
Kiamichi Clay	Prairie	2	7	18	—	8
Weno Clay	Prairie	3	8	15	10	7
Weno Clay	Forest	3	8	15	10	2
*Denton Clay	Prairie	—	5	8	8	3
*Denton Clay	Forest	—	5	8	8	1
Duck Creek Limestone	Prairie	3	4	4	5	9
Fort Worth Limestone	Prairie	2	5	7	5	8

*No first stage of succession encountered.

**Earliest stage, 1; latest stage, 5.

Information regarding grazing was obtained in all fields sampled in 1962. According to observations and data there was no correlation either between the number of individuals or the number of species of legumes and the amount of grazing. It was evident the livestock do not graze appreciably on native legumes. Only *Indigofera leptosepala* and *Schrankia uncinata* exhibited grazing evidence, and this was slight. This suggests that the abundance of native legumes in the prairies and pastures of Marshall County is due to their unpalatability.

CULTIVATED LEGUMES

Some ten species of cultivated legumes have been found in the fields of Marshall County. The two sweet clovers, *Melilotus alba* and *M. officinalis,* have survived for several years in many fields throughout the county, despite being grazed extensively by livestock. The next most abundantly planted legumes were button medic, *Medicago orbicularis,* which is planted for early pasture, and Korean lespedeza, *Lespedeza stipulacea.* These four species accounted for the bulk of the legume population in fields where they have been planted. The other six cultivated species were usually found on very young fields and then rarely in quantity. It is not known what effect the cultivated legumes have on the native legume population. However, it is necessary to recognize their presence and abundance in assessing the relationship between legumes, geology, and succession.

SUMMARY

1. In the summer of 1961 a study was instituted to determine the relation between legumes and surface geology. In 1962 the study was extended to include the relation of legumes to plant succession.

2. The geological formations studied included River Sand, Trinity Sand, Woodbine Sand, Weno Clay, Kiamichi Clay, Denton Clay, Fort Worth Limestone, and Duck Creek Limestone.

3. A total of 49 species of legumes were collected in the 98 fields on these eight formations. A given legume species was found on an average of 35% of the eight formations and none was found on as many as seven geological units.

4. Eight species occurred on sandy soil only, many species were found on two kinds of substrate and seven occurred on all three soil types: sands, clays, and lime.

5. The number of species, but not the number of individuals, of legumes was related to succession. In general the number of species of legumes was low in the early stages of succession, high during the middle stages, and declined in the late stages of the sere.

6. In the early stages of succession the number of species was lowest on lime soils and highest on sandy soils. In three lime soil fields no legumes were found in the earliest stage of succession.

7. There was no relation between the number of legumes and grazing, possibly because very few native legumes were grazed by livestock.

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