nificantly from that under each of the other treatments. The apparent greater emergence under the "scarify" and "remove" treatments is not significantly different from that in the check.

With the broad-leaved herbs, removal of litter by hand caused a significant increase in emergence as compared with the check. None of the other differences between treatments is significant.

Shrub seedlings were notably scarce, with a total of eight plants of yerba-santa (*Eriodictyon angustifolium*) being tallied for all treatments. Of these, five were in the burned flats.

Conclusions

1. More grass and broad-leaved herb seedlings emerged under complete litter removal than under any other treatment. This could suggest that the litter contained some inhibiting substance, but because differences in numbers of grass seedlings were found "not significant" at the 5 percent confidence level, no firm conclusion can be drawn.

2. Destruction of part of the litter by burning reduced grass emergence significantly, and, with the exception of the morningglory (*Convolvulus linearilobus*), was not required for the germination of several broad-leaved herbs regularly seen in early post-fire successional stages in chaparral.

3. Burning of litter may have enhanced germination of yerba-santa, which is considered to be a "fire"

species. Fire was not a requirement, however, because seedlings of this shrub emerged under two other treatments. Lack of emergence of other shrub seedlings must imply that the required germinating conditions did not exist under any of the treatments, or that no viable seeds were present. The latter is unlikely, because the soil was collected in a dense stand of Pringle manzanita, and seedlings of this shrub have been observed within the past year on disturbed areas near the collection site.

Literature Cited

- FENNER, R. L., AND J. R. BENTLEY. 1960. A simple pyrometer for measuring soil temperatures during wildland fires. U. S. Forest Serv. Pacific Southwest Forest & Range Expt. Sta. Misc. Paper 45, 9 pp.
- GLENDENING, G. E., C. P. PASE, AND P. INGEBO. 1961. Preliminary hydrologic effects of wildfire in chaparral. In Modern techniques in water management. Ariz. Watershed Symposium. Proc. 5: 12-15.
- HORTON, JEROME S. 1960. Vegetation types of the San Bernardino Mountains. U. S. Forest Serv. Pacific Southwest Forest & Range Expt. Sta. Tech. Paper 44, 29 pp.
- HORTON, JEROME S., AND C. J. KRAEBEL. 1955. The development of vegetation after fire in the chamise chaparral of southern California. Ecology 36: 244-262.
- PASE, CHARLES P., AND FLOYD W. POND. 1964. Vegetation changes following the Mingus Mountain burn. U. S. Forest Serv. Res. Note

RM-18, Rocky Mountain Forest & Range Expt. Sta., Ft. Collins, Colo., 8 pp.

SAMPSON, A. W. 1944. Plant succession on burned chaparral lands in northern California. Calif. Agr. Expt. Sta. Bul. 635, 144 pp.

STONE E. C., AND G. JUHREN. 1951. The effect of fire on the germination of *Rhus ovata* Wats. Amer. Jour. Bot. 38: 368-372.

SWEENEY, JAMES R. 1956. Response of vegetation to fire. Univ. of Calif. Pub. in Bot. 28: 143-250.

Some Yield Characteristics of Range as Influenced by Soil Type and Weather

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The variations in herbage yields related to differences in soils are little known for rangelands of the Northern Great Plains. In studies of native pastures as units, there is an inescapable variation within pastures due to differences in soils.

Data on both herbage yields and mulch accumulations have been published from soil areas where the vegetation could make a normal response to climate, reflecting regional climax. Yields from relict vegetation and other protected areas with ordinary upland soils on gentle relief and no obvious inhibitory factors were reported by Larson and Whitman (1942), Quinnild and Cosby (1958), and Cosby (1960). Sarvis (1941) and Whitman (1954) reported the comparative yield by species from range grasses on upland soil types.

This study in northwest North Dakota aimed to obtain additional yield information from normal upland soils, comparable with those previously reported; then to compare production from these soils with soils that produced more or less herbage than ordinary uplands because of physical site differences within the same climate.

The help of Mr. Robert L. Howey, Soil Scientist, Soil Conservation Service, Minot, North Dakota, in describing the soils is gratefully acknowledged.

Study Area

The study was in northern North Dakota within what is known as the Souris River Area. The western boundary is in the Max Moraine, in Range 90 west, where the elevation

Table 1. Number of seedlings that emerged during 72-day watering period.

Species	Litter treatment ¹				Total
	Check	Burn	Removed	Scarify	
Grasses:					
<i>Sporobolus cryptandrus</i>	10	0	19	8	37
<i>Eragrostis curvula</i>	4	2	6	9	21
<i>Cynodon dactylon</i>	3	0	0	3	6
Unidentified	4	1	7	5	17
Total	21	3	32	25	81
Broad-leaved herbs:					
<i>Verbena wrightii</i>	0	0	0	1	1
<i>Convolvulus linearilobus</i>	0	4	0	0	4
<i>Lotus wrightii</i>	0	1	1	0	2
<i>Portulaca coronata</i>	0	0	4	1	5
<i>Gnaphalium wrightii</i>	0	0	5	2	7
Unidentified	2	3	10	5	20
Total	2	8	20	9	39
Shrubs:					
<i>Eriodictyon angustifolium</i>	0	5	1	2	8
Total Plants	23	16	53	36	128

¹Numbers under each treatment represent the totals from four flats containing 2 square feet of soil surface each.

is between 2000 and 2500 feet, the elevation drops to about 1500 feet in the east. The east boundary is in glacial Lake Souris in Range 75 West. This area is nearly flat, "Its chief modifying features are sand dunes, some of which are 50 feet or more high, and fairly numerous depressions, which commonly contain lakes" (Lemke, 1960). Much of the intervening area is a ground-moraine plain. The study area is bounded on the north by Township 160 north and on the south by Township 151 north.

A common catena of the glacial till plains is comprised of four soil types, Zahl loam, Williams loam, Bonilla loam and Parnell silt loam.

Zahl loam consists of excessively drained, thin solum, dark colored loamy soils of the strongly convex slope breaks of the glacial till plains and morainic hills (Figure 1). The soil is representative of the Thin Silty range site.

Williams loam consists of deep-well-drained dark-colored loamy soils of the undulating to rolling till plains of the chestnut soil zone. The natural soil profile consists of a very dark brown A₁ surface horizon (2-5 inches thick) with strong granular and crumb structure over a dark brown B₂ subsoil (4-12 inches thick) with well developed prismatic structure. The noncalcareous solum varies in thickness (6-18 inches) and overlies a friable calcareous Cca horizon which grades into the unmodified glacial till parent material at depths ranging from 30 to 48 inches. The Williams soils are seasonally dry to the wilting point while the lower profile often remains dry throughout the season.

Bonilla loam consists of deep,

FIGURE 2. Landscape view of Bonilla loam in a broad swale surrounded by Zahl loam on ridges. This Silty range site has vegetation in Excellent range condition.

moderately well-drained, dark-colored loamy soils. It occurs on the footslopes and swales of the glacial till plains and morainic hills (Figure 2) and is in the Silty range site.

Parnell silt loam is a deep, moderately fine-textured black soil which occurs in the closed depressions of the glacial plains and moraine where they are subject to seasonal ponding. This soil is included in the Wet Land range site.

Sioux loam is closely associated with the above catena in the glacial plains. It consists of shallow dark-colored loamy soils underlain by gravel outwash at depths of 6 to 15 inches, which limit moisture storage and root development. The range site is Shallow to Gravel.

Arnegard silt loam is a deep, loamy, dark-colored alluvial soil of the sloping concave hillside slopes of the Souris River breaks (Figure 1). The soil is included in the Silty range site.

Coarse Dune-sand is a land type which consists of deep, loose, coarse, sand material with very little silt or clay content. It is very low in organic matter and water holding ca-

capacity. The range site is Coarse Sands.

Final correlation of soil names has not been made in the area. Range site names are those used by several agencies in range classification.

Vegetation is generally typical of the Mixed Prairie of the Northern Great Plains as described by Weaver and Albertson (1956). Undescribed however, is the presence of rough fescue (*Festuca scabrella*) in the northwest portion of the study area. It is the predominant species on many north-facing slopes, in this locality of the Max Moraine. The rough fescue areas are much like the Fescue Grassland described by Coupland and Brayshaw (1953). Also undescribed is the local abundance of slough sedge (*Carex atherodes*) and rivergrass (*Scolochloa festuacea*) which produced almost all of the herbage from Parnell silt loam.

Average 54-year annual precipitation at Powers Lake, near the west side, is 15.57 inches and at Townier on the east side it is 16.05 inches. This is a difference of only .48 inch from west to east.

Locations were picked for their high range condition and long rest period. Most of the data were obtained from a portion of the Lostwood National Wildlife Refuge on which there had been no grazing by domestic livestock nor haying since about 1935. On the east end, the Coarse Dune-sand is on an area with about the same rest time. There is no indication that erosion had occurred during recent times on the coarse dune-sand plot locations. They apparently had been stable during the drought of the thirties. Range condition at all plot locations were determined to be in the "Excellent" class (Dyksterhuis, 1949).

Circular 9.6 square foot plots were clipped from 1958 to 1963 in areas located for a specific soil type with a typical plant community, a soil with a special plant community, or one on which the plant community might be affected by exposure. Procedure in clipping, segregating, and naming materials followed that described by Dyksterhuis and Schmutz (1947). Herbage from the coarse dune-sand was divided into two categories but not from any other plots. Clippings were made at approximately the same time each year. The earliest date was August 27 and

FIGURE 1. Cross section of steep hillside showing variability of profile development. Thin profile to right, typical of Zahl loam, is on a strong convex position. The thick Arnegard loam profile in the center occupies a slight swale, sloping steeply to the east; it receives extra run-off from thin soils above, also considerable snow drift.

the latest October 4.

Plant species were recorded for each plot clipped and the percentage of total herbage contributed by species was estimated. New plots were used each year except in the rough fescue community where repeated clippings were made on two plots.

Results

The effect of soil type on total annual herbage yield is reflected in the results from a common soil catena in the Northern Mixed Prairie (Table 1). The annual herbage yield from excellent condition range on a Williams loam illustrates normal productivity in this climatic area. The more xeric Zahl loam yields less because of excessive runoff. The Bonilla loam is slightly more mesic than Williams loam because of local run-in and snow catchment, resulting in more total yield. Parnell silt loam yields extremely high when sufficient ponding occurs but is also subject to drought when there is no ponding. Vegetation for each soil type of the catena was regarded as typical for the soil type.

No yield data were collected in 1959. The average yield for Zahl loam was taken from 1960 through 1963. The highest yield was in 1963, the lowest in 1961. Average yield for Williams loam and Bonilla loam was collected 1958 through 1963 excepting 1959. The highest and lowest yields on Parnell silt loam were collected in 1961, the driest year of the period. The location having the highest yield received sufficient spring run-in for high production while the other remained dry. Mulch accumulation is the average of all plots by soil type for all years.

Sioux loam yielded an average of

1255 lbs. per acre during the 5 year period, with a high of 1500 lbs. in 1962 and a low of 770 in 1961. The average fresh mulch accumulation was 858 lbs. per acre and humic mulch 534.

Two types of plant community on Williams loam with a 15% north-facing slope were clipped for comparison of yield with the typical community. Average annual herbage yield from a rough fescue community for 5 years was 2892 lbs. per acre; highest yield was 3280 lbs. in 1963 and lowest 2130 in 1960. Average fresh mulch was 5424 lbs. per acre and humic mulch 5186 lbs. Very few seed heads were observed on rough fescue until 1963 when they were numerous. A mixed plant community dominated by needleand-thread (*Stipa comata*), on the same slope yielded 2344 lbs. per acre. The highest yield was 3210 lbs. per acre in 1958 and the lowest 1720 lbs. in 1961. Fresh mulch was 4666 lbs. per acre and humic mulch 5122 lbs.

No one factor is more important than moisture in a grassland climate. Dix (1958) determined moisture to be the most important single factor in determining kinds and numbers of plants to occupy given sites. Variables such as exposure, slope and topography, he found important only so far as they influenced soil moisture. The effect of plant and soil moisture relationship in soil development is apparent in the soil descriptions. Recent plant and soil moisture relationships, as influenced by soil type and weather, are reflected in the herbage yield.

Cool season grasses predominate over warm season ones in the northern Mixed Prairie. In this area available moisture most often favors

the cool season species. Soil is generally frozen 4 to 5 months. Rapid growth of cool season species follows the spring thaw and they are further favored by normally higher rainfall months immediately following. Arnegard loam on a south-facing slope of 25% was dominated by the warm season big bluestem (*Andropogon gerardi*) with prairie sandreed (*Calamovilfa longifolia*) secondary. Total annual herbage yield from this soil was 1340 lbs. per acre in the drought year of 1961. In 1962, a year when summer rain was above normal, yield was 3420 lbs., an increase of 2½ times. The increase between high and low years was least on Williams loam with a rough fescue community (1½ times).

Coarse dune-sand produced the least herbage of any soil or land type in the study. It was sampled only for the most favorable year, 1962. Total annual herbage was 1135 lbs. per acre, approximately 42% of a mixed plant community on Williams loam for the same year. Field sage-wort (*Artemisia caudata*), a low value forage plant, was segregated from other herbage and weighed separately. It contributed 56% of the total yield on open grasslands of the land type. No data were taken on areas where scrubby trees were a highly significant part of the vegetation. Of particular interest was a lichen *Cladonia tenuis*, common to the immediate area but not encountered on plots.

Observation of clipped plots showed an apparent decrease in herbage yield the year following clipping (Figure 3). The 1961 yield from a rough fescue community on a plot not previously clipped was 2910 lbs. per acre in 1961. Leaf lengths were 16 to 20 inches, fresh mulch was 6250 lbs. per acre and humic mulch 5170 lbs. A nearby plot, clipped in 1960 was reclipped, the yield was only 630 lbs. per acre and leaf length 3 to 8 inches. Three plots were used in the rough fescue community in 1962. One was not previously clipped, one was clipped two successive years and one for three years. The per-acre yields were 2960 lbs., 2060 lbs., and 1960 lbs. respectively. The drought year of 1961 showed a more adverse effect on the repeated clippings than did the more favorable season of 1962. Johnston (1961) reported growth was similarly retarded on rough fes-

Table 1. Total native herbage and mulch yields (air dry) from a common catena of glacial soils in northwest North Dakota.

Soil Type	No. Yrs.	Total Annual Herbage			Fresh Mulch	Humic Mulch
		Average	Highest	Lowest		
— — — — (Pounds per acre) — — — —						
Zahl loam (convex slopes and ridges)	4	1477	1880	990	1771	2037
Williams loam (general upland)	5	2016	2665	1350	3335	5355
Bonilla loam (concave slopes)	5	2457	3527	1560	4080	5639
Parnell silt loam (closed depressions) "Pot-hole"	1		7920 ¹	2320 ²	6383	22110

¹ Normal ponding

² No ponding

cue from close clipping under greenhouse conditions.

Summary and Conclusions

A sampling study was made of herbage yields by specific soil types in the Souris River area of North Dakota during 1958, 1960, 1961, 1962 and 1963. Sampling areas were selected from representative soil types and Excellent range condition.

A common catena was sampled in which Williams loam, a typical zonal representative of the Chestnut soils, was indicative of ordinary uplands on which vegetation can make a normal response to climate, reflecting regional climax. Average herbage yield was 2016 lbs. per acre, air dry, for the five years. The largest yield was from Parnell silt loam because of superior moisture availability from trapped run-in water. The greatest total annual yield from this soil (7920 lbs per acre) was approximately 3 times the highest yield from Williams loam. The most xeric of all soil types sampled was coarse dune-sand. The average herbage yield of all plots for one favorable year (1962) was 1135 lbs. per acre, 42% of Williams loam for the same year.

Cool season grasses are more common to climax vegetation of the

northern Mixed Prairie than warm season species. Weather normally favors their growth soon after spring thaw. A wider annual yield variation occurs on warm season species which are more dependent on timely summer rains.

On native perennial grasslands the potential average annual yields may vary greatly among mature soils of a catena. When the yield from a climatically normal soil was compared with yields from other mature upland members of a soil catena in the same macroclimate, differences approximated 25% over and under the yield from the normal soil. If immature and depressional members of the catena are included, the variation may approximate 100% up or down from the normal soil. Moreover, production on any upland member of such a catena in wet years may be double that in dry years—with even greater differences on members subject to ponding.

Differences in kinds of plants composing climax plant communities on a single member of a catena, in the same macroclimate, generally produced essentially the same total annual yield. However, a consociation of rough fescue on a normal profile produced more than other communities sampled on the comparable soil.

In areas long protected from grazing, the average amounts of both fresh and humic mulch varied directly with the natural productivity of soil members in a catena.

Literature Cited

- COSBY, H. E. 1960. Rings on the range. *Jour. Range Mangt.* 13: 283-288.
- COUPLAND R. T. AND T. C. BRAYSHAW. 1953. The Fescue grassland in Saskatchewan. *Ecology* 34: 386-405.
- DIX, R. L. 1960. Some slope-plant relationships in the grasslands of the Missouri Badlands of North Dakota. *Jour. Range Mangt.* 11: 88-92.
- DYKSTERHUIS, E. J. 1949. Condition and management of rangeland based on quantitative ecology. *Jour. Range Mangt.* 2: 104-115.
- DYKSTERHUIS, E. J. AND E. M. SCHMUTZ. 1947. Natural mulches or "litter" of grassland: with kinds and amounts on a southern prairie. *Ecology* 28: 173-179.
- JOHNSTON, A. 1961. Comparison of lightly grazed and ungrazed range in the Fescue grassland of southern Alberta. *Canadian Jour. Plant Science* 41: 615-622.

- LARSON, E. AND W. WHITMAN. 1942. A comparison of used and unused grassland mesas in the Badlands of South Dakota. *Ecology* 23: 438-445.
- LEMKE, RICHARD W. 1960. Geology of the Souris River area, North Dakota. *Geol. Survey Professional Paper* 325.
- QUINNILD, C. L. AND H. E. COSBY. 1958. Relicts of climax vegetation on two mesas in western North Dakota. *Ecology* 39: 29-32.
- SARVIS, J. T. 1941. Grazing investigations on the Northern Great Plains. *N. Dak. Agric. Expt. Sta. Bul.* 308. 110 pp.
- WEAVER, J. E. AND F. W. ALBERTSON. 1956. Grasslands of the Great Plains. Johnson Publishing Company, Lincoln, Nebraska. 395 pp.
- WHITMAN, WARREN C. 1954. Yield characteristics of native grass ranges. *Proc. N. Dak. Academy of Science. Vol. VIII.*

Evidence of Hybridization Between Certain Browse Plants

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In the fall of 1935, plants were observed in Logan Canyon, Utah, that had certain characteristics resembling birchleaf mahogany (*Cercocarpus montanus*) and others resembling curlleaf mahogany (*C. ledifolius*). Subsequently similar apparent hybrids were found elsewhere in the state.

During the winter of 1948, plants were found in the vicinity of Providence Canyon in northern Utah which were not typical of antelope bitterbrush (*Purshia tridentata*) nor cliffrose (*Cowania stansburiana*), but resembled both. Subsequently plants showing similar intergradations have been observed throughout Utah by the writer and others.

Field observations and feeding tests indicate that the *Cercocarpus* hybrids provide excellent forage for deer. In view of the increasing need to revegetate overused browse ranges, further information regarding these suspected hybrids may be valuable.

Methods

Attempts were made to cross the two species of *Cercocarpus*. Flowers from selected branches were emasculated and enclosed in bags to prevent natural pollination. Later pol-

FIGURE 3. Top: Two plots in rough fescue community on Williams loam, 15% north slope. Upper plot not previously clipped; lower plot clipped 1960 and 1961. Bottom: L. to R.: Forage from previously clipped plot; forage, fresh mulch, and humic mulch from plot unclipped previously.