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.

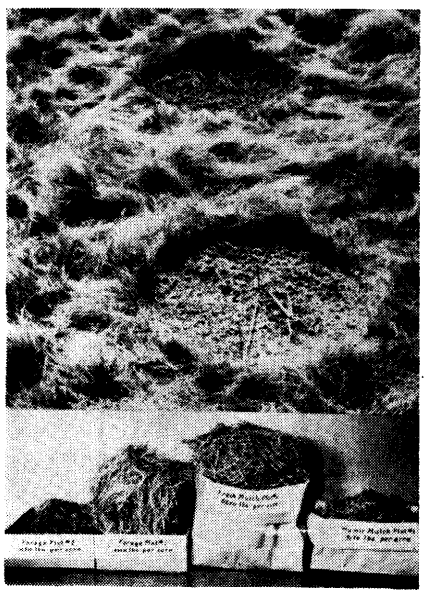

FIGURE 3. *Top:* Two plots in rough fescue community on Williams loam, 15% north slope. Upper plot not previously clipped; lower plot clipped 1960 and 1961. *Bottom: L.* to *R.:* Forage from previously clipped plot; forage, fresh mulch, and humic mulch from plot unclipped previously.

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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 mahagony *(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-

len from known sources was introduced into the bags. Some individual flowers were enclosed in drug capsules.

Six crosses were attempted: [1]Cmo x Cle; Cmo x Hyb; and Cle x Hyb, each plant alternately providing and receiving pollen.

No attempts were made to cross cliffrose with bitterbrush. Typical material was collected from different localities and compared to plants exhibiting signs of hybridization. Cliffrose was obtained from Stansbury Island, the type locality. Antelope bitterbrush was obtained from northern Utah and southern Idaho, north of the range of cliffrose. Desert bitterbrush *(Purshia glandulosa)* came from Beaver Dam Wash in southwestern Utah. These materials were compared to collections from a suspected interbred population with respect to several gross morphological characteristics.

Results

Attempts to hybridize the *Cercocarpus* species were first made in 1957. Plastic food bags were used to enclose the branches selected for treatment. They proved to be too nearly airtight. Transpired moisture accumulated in them and temperature inside became high. Small vents and a coating of aluminum paint failed to correct these difficulties. The drug capsules were too heavy for the small flowers. In consequence of these difficulties, only ten mature seeds were obtained by controlled pollination (Cle x Cmo). Twenty-five seeds were recovered from a bagged unemasculated branch of a natural hybrid plant which apparently were the result of selfing.

Further attempts at crossing were made in 1958. The selected branches were first enclosed in paper bags which in turn were covered with loosely fitting plastic bags left open at the bottom, thus permitting free circulation of air still providing protection from rain.

The weather, however, was not favorable to flower production on an extensive stand of birchleaf mahogany near the mouth of Logan Canyon which was to have been the major source of study material. By the time this species was flowering at the upper limit of its distribution in Logan Canyon, curlleaf mahogany had completed flowering except at the mountain summit. This greatly limited the opportunities for controlled pollination. Thirty crosses, each representing 6 to 15 emasculated flowers were attempted. Eighty seeds were collected (Table 1).

The apparently viable seeds were stratified in peat moss at temperatures of 35° to 45°F. The 1957 materials were held in a cold chamber 30 days, the 1958 seeds for 50 days. All were then placed in sand for germination. When it appeared that no germination was forthcoming, the seeds were recovered. Most of them upon being cut open were found to be dark and discolored. Thirteen, however, appeared to be in good

Table 1. Results of crossbreeding attempts with plants of the genus *Cercocarpus*.

Year	Number of attempts[1]	Plant pollinated	Source of pollen	Number of seeds recovered	Comments
1957	2	Hyb	Cle	0	Fruits started to develop
	2	Hyb	Cmo	0	No response observed
	1	Cmo	Cle		Fruits started to develop
	1	Cmo	Hyb	0	Bags destroyed
	1	Cle	Cmo	10	
	1	Cle	Hyb	0	No response observed
1959	1	Hyb	Cle	0	Fruits partially developed
	2	Hyb	Cmo	2	
	7	Cmo	Cle	7	
	8	Cmo	Hyb	19	
	6	Cle	Cmo	25	
	6	Cle	Hyb	27	

[1] Each attempt represents a branch with 6 to 15 flowers.

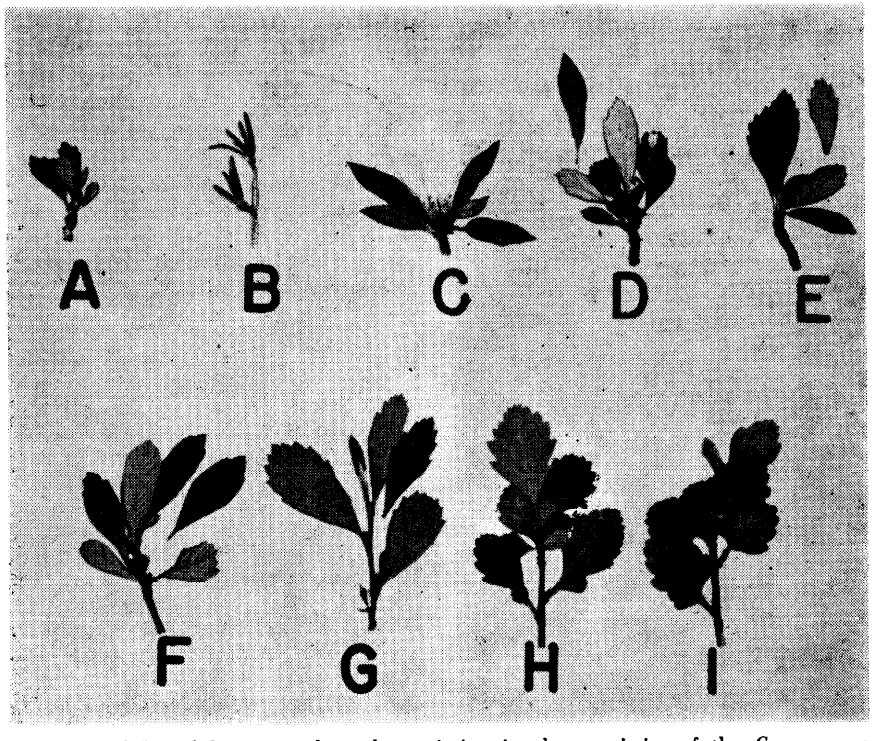

FIGURE 1. Selected leaves to show the variation in characteristics of the *Cercocarpus* complex. Each is from a different plant. A, Fully developed evergreen leaves, dentate at tips, the size suggesting a cross between *C. intricatus* and *C. montanus*. B, *C. intricatus*. C, *C. ledifolius*, leaves evergreen and entire. D, E, & F, Leaves evergreen with variable leaf shape and dentation. The form of these plants is similar to *C. ledifolius*. G and H, These are close to *C. montanus*. The bushes are low and multi-stemmed. Although they are largely deciduous, some leaves remain green all winter. The dentation of G does not approach the leaf base. I, Typical *C. montanus*.

[1] *Cmo* = Cercocarpus montanus; *Cle* = C. ledifolius; *Hyb* = *natural hybrid.*

condition and still capable of germination.

Various circumstances made it impossible to continue the study after 1958.

In spite of failure to produce plants by controlled crossing, the supposition remains strong that such crosses occur in nature. Figure 1 portrays the great variation in leaf characteristics of *Cercocarpus* plants collected from a small area near the mouth of Logan Canyon, which appears to support this belief.

Purshia-Cowania Complex

The data obtained from examination of this group are difficult of summarization. Morphological characteristics occur in such a variety of combinations that none is a dependable criterion. As in the *Cercocarpus* complex, gradual inter-gradations can be observed. An array of fruits and leaves illustrating the many gradations found is shown in Figure 2. It will be observed that the leaf characteristics are more erratic than the fruit. Moreover a diversity of leaf form can be observed on different parts of the same plant.

Thomas (1957) was of the opinion that *P. glandulosa* resulted from a cross between *P. tridentata* and *Cowania*. Except for its fruits, in respect to which it most closely resembles *P. tridentata, P. glandulosa* appears very like cliffrose. The material collected near Providence followed none of the three species closely. Individual characteristics most nearly resembled one or another of the species in turn.

Nord (1959) has called attention to that fact that a presumed hybrid between *Cowania* and *Purshia* was collected in Nevada in 1898 by C. A. Purpus. This since has been named *C. mexicana* var. *dubia McMinn.* This is described as having 2 or 3 fruits per receptacle. The material from Providence shows 2 to 6 fruits, although, more "typical" hybrid plants observed have 3 or occasionally 4 fruits.

Figure 3 presents graphically the characteristics found in the Providence material and compares them to the recognized species in this area. Maximum, minimum, and mean values for eight characteristics thought to be of possible usefulness in identifying individual members of this complex were plotted for cliffrose and the two bitterbrushes.

Individual values for these same eight characteristics from selected plants from the Providence area were plotted on the same graph. They tend to fall between the means of cliffrose and antelope bitterbrush although there is great variation. Plant 1161, for example, shows

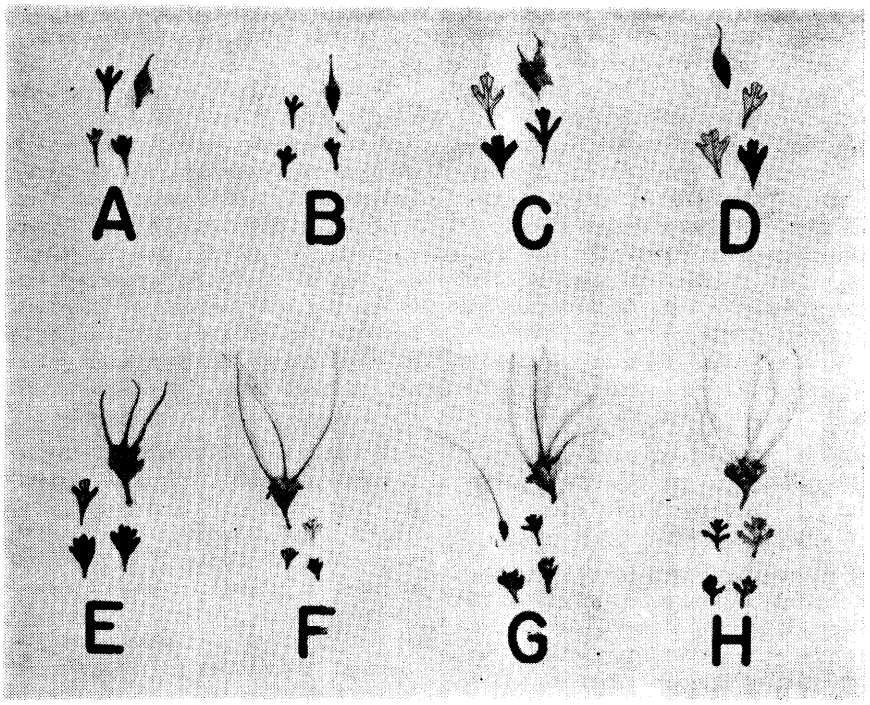

FIGURE 2. Fruit and leaves of the *Purshia - Cowania* complex. A, typical *Purshia tridentata* from Smithfield, Utah. B, *Purshia glandulosa* from Beaver Dam Wash, southwestern Utah. C, Plant 543 near Providence, Utah. Note the twin seeds. D, Plant 589 near Providence. Although one seed predominates, the beak is longer than on typical *P. tridentata* and is slightly pubescent. E, Plant 572, Providence, Utah, with three seeds whose tails are rather long and becoming plume-like. The leaves are broadly lobed with weakly revolute margins and resemble *P. tridentata* leaves. F, Plant 3584, Providence. Long plumes are present but there are fewer seeds than are characteristics of *Cowania.* G and H, From plants on Stansbury Island, the type locality for *Cowania stansburiana.* Note the 7-lobed leaves of H.

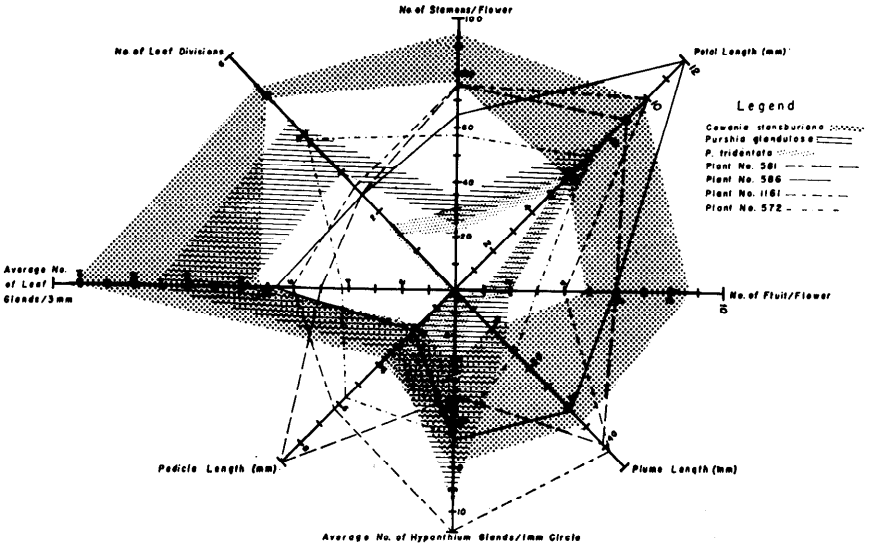

FIGURE 3. Range in values of selected characteristics of *P. tridentata, P. glandulosa,* and *Cowania stansburiana* compared to individual plants found near Providence, Utah.

maximum values for hypanthium glands and plume length but has fewer achenes than cliffrose and all but one of the hybrids shown in the graph. Plant 581 is but moderately glandular, but with respect to leaf divisions and pedicel length it approaches maximum values.

The data obtained from the Providence population do not suggest that we have a true variety, for there is no consistent combination of characteristics that can be recognized. In some instances the foliage characteristics are essentially like those found on *P. tridentata,* while other characteristics may be intermediate or close to cliffrose.

The evidence here would better support the view that the plants under observation are a result of random cross pollination among the parents and hybrids resulting in a wide variety of genetic combinations.

An attempt was made to germinate seeds from hybrid material collected near Providence, Utah, but without success though Plummer (1957) reports having done so.

Data were collected on the palatabilities of these hybrids for deer. Individual plants were identified, tagged, and measured in the fall and again in the spring. No significant differences could be observed between the palatabilities of *Cowania, Purshia tridentata,* and hybrid plants, although differences in palatability have been noted among the recognized species when they occur together in other areas.

Cytological studies are probably necessary to define the true status of these plant complexes.

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