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and wad. The incrustation along the sides of the fissures is iron and manganese from the surrounding rock, which were held in solution by the water and dropped along the line of the flow; this, since the clay has filled the fissures, has been along the sides, between the clay and limestone.

I do not doubt the existence of cretaceous deposits in this part of the state. On the sand banks near the mouth of the Blue Earth river are found bits of lignite that must come from somewhere along either the Blue Earth or Minnesota river. Also fragments of cretaceous corals and teeth of fish in the stream drift show the presence of beds of material belonging to this period not far away, but certainly these beds of white clay must be counted out.

[*Paper II.*]

NOTES ON THE FLORA OF WESTERN DAKOTA AND EASTERN MONTANA
ADJACENT TO THE NORTHERN PACIFIC RAILROAD—*By John*
B. Leiberg.

[Read before the Minnesota Academy of Natural Sciences, March 4th, 1884.]

While in the service of the Northern Pacific railroad company during the past year in the interest of tree culture, I had abundant opportunity to examine the interesting and to some extent peculiar flora of western Dakota, and to a limited degree the eastern portion also, and the eastern part of Montana as far west as the Yellowstone river at Glendive, and to make large and full collections of the same. Copious and interesting notes were made respecting the botanical features of the region, and a few of the more prominent are presented for the consideration of the Academy.

The climate of eastern Dakota, in both rain-fall and temperature, does not appear to present any great variation from that of the prairie region of western Minnesota, except perhaps a somewhat longer winter. The climate of the western portion is very different. The summer is very dry; showers are of rare occurrence; and the temperature varies excessively. Thus in the month of July the mercury rose to 115° Fahrenheit, and fell to 32°. Such great variations cannot fail to modify plant life to a very great extent. The hot, scorching winds that generally accompany the high temperatures quickly dry up all vegetation, except along the

water-courses. The extreme dryness of these hot winds is remarkable. During the great heat which prevailed in the early part of July, I saw the grass on the prairie, which was green and fresh as prairie grass usually is, completely dried up and converted into hay within a period of two hours. As a consequence of this dry weather, we find no annuals in summer. They only appear during the spring, while the ground is still moist. The perennials all have long root-stocks, which penetrate deeply into the ground and enable them to withstand the drouth effectually.

The surface of the country west of the Red river valley is more rolling than in Minnesota, and is found still more so as the Missouri river is approached. Numerous stony knolls and long ranges of rocky, pointed hills mark the ancient glacial moraines. The flora here shows plain indications of the proximity of the dry, treeless plains west of the Missouri; though at the same time the climate is humid enough to permit species of plants to grow and flourish, whose principal habitat is much farther eastward. Here and there alkaline pools appear with their peculiar plants, adding largely to the variety of the flora of this region. Many species are found whose home in the Southwest is at a high elevation, proving that as we go north the increase in latitude compensates for a decrease in elevation.

Scattered over the drift hills in great abundance, and the first flower to appear in spring is *Anemone patens*, L., var. *Nuttalliana*, Gray, attaining a luxuriance of growth never met with in Minnesota. After crossing the Missouri and the western boundary of the glacial drift, this plant wholly disappears. In the moist places of the prairies is found *Ranunculus glaberrimus*, Hook., and around alkaline ponds *R. Cymbalaria*, Pursh, the latter being very abundant west of the Missouri river. Another representative of this genus resembles *R. rhomboideus*, Goldie, but differs from that in its more erect and taller growth and much smaller flowers. It appears to be some undescribed species.

A *Draba*, probably *D. nemorosa*, L., is quite plentiful. Early in the spring, and flowering until late in the summer, we find *Vesicaria Ludoviciana*, DC. *Erysimum asperum*, DC., is abundant as we proceed westward, becoming a very conspicuous plant. Around the alkaline ponds grows a *Nasturtium* near *N. sinuatum*, Nutt. It may prove to be only a variety of this species.

Cleome integrifolia, Torr. & Gr., which is found here and

there in Minnesota as an introduced plant, is first met with in its indigenous state in Pyramid Park near the Little Missouri river. There also, and nowhere else in the territory under consideration, *Cleome lutea*, Hook., was observed. *Polanisia graveolens*, Raf., was frequently noticed along the water-courses, differing somewhat from its character in Minnesota, in having a more clammy pubescence and longer and more lurgid pods.

Viola Nuttallii, Pursh, was met with abundantly, but does not extend to any great distance west of the Missouri river, and was not observed east of Jamestown. *Viola cucullata*, Ait., was not rare in the region covered by the drift, but was confined to the borders of the numerous small ponds.

A *Cerastium* and two species of *Arenaria*, not determined, were very common. One of the *Arenarias* was met with only on the top of the buttes west of the Missouri, forming dense tufts, the short stems closely covered with small rigid leaves giving it a spiny appearance.

A rather common and showy plant was *Malvastrum coccineum*, Gray, the only one of the *Malvaceæ* seen.

Two species of *Linum*, *L. rigidum*, Pursh and *L. perenne*, L., were found. The latter grows very rank, with showy blue flowers, often more than an inch in diameter. The seed-vessels were observed later in the season, and were found to be nearly as large as in the cultivated flax (*L. usitatissimum*, L.) with seeds about half as large, of a shining dark brown color, and apparently containing a considerable proportion of oil. The question arises, whether this wild flax could be improved by cultivation so as to equal in fiber, if not in oil, the *L. usitatissimum*. It is well worth experiment to determine these points, more especially as it is a perennial, while the cultivated flax is an annual.

Polygala verticillata, L., and another species of which no published description could be found, were frequently collected west of the Missouri, extending into Montana.

As might be expected, the *Leguminosæ* were well represented, but a lack of authorities and published descriptions prevented full and complete determinations of the many interesting species collected. Fourteen species of *Astragalus* were observed, among them *A. simplicifolius*, Gray, and *A. triflorus*, Gray. The former was observed only in Montana, on the hills between McClennan and Hodges stations on the Northern Pacific railroad. *Psoralea*

argophylla, Pursh, *P. esculenta*, Pursh, and *P. lanceolata*, Pursh, were noted. The latter possesses the peculiarity of forming at maturity a perfect joint on the stem near the ground. A light wind will then cause the plant to break off and go rolling along in the same manner as happens with *Amarantus albus*, L. (commonly called "tumble-weed") on the prairies of Minnesota. *Psoralea argophylla* and *esculenta* also break off near the ground, but do not appear to form a distinct joint. The separation in these species is effected by means of a constriction on the stem, which cuts off, as it were, the nourishment from the root, and causes the stalk to shrivel at that point, when the least touch or gust of wind releases the plant. On the hills near Mandan, and in no other place along the route, *Petalostemon macrostachyus*, Torr., was collected. Here also *P. Villosus*, Nutt., was quite abundant. *Amorpha fruticosa*, L., and *A. canescens*, Nutt., were both well represented, but a little farther westward they were largely replaced by *A. microphylla*, Pursh. *Oxytropis*, *Desmodium*, *Vicia*, *Lathyrus* and *Hosackia* were found in abundance throughout the territory. *Lupinus perennis*, L., was met with in the valley of the Green river; also an apparently undescribed species of this genus was collected.

Eleven species of *Potentilla* were collected among them *P. Pennsylvanica*, L., and *P. fruticosa*, L., the latter nowhere except in Pyramid Park. Only one species of *Prunus* was seen west of the Missouri river, namely, *P. pumila*, L. Growing abundantly on the rocky buttes was *Chamaerhodos erecta*, Bunge. So far as I know, this plant has not before been referred to this region. Our most common species of strawberry (*Fragaria Virginiana*, Duchesne) abounds east of the Missouri, but is very infrequent farther west. The hot dry weather prevailing during June and July doubtless proves unsuitable for its growth.

A gooseberry (*Ribes*) near *R. Cynosbati*, L., of a low bushy form, thickly armed with long stout prickles, grows on the summit of the dry baked clay hills of western Dakota and eastern Montana. Although growing in these extremely dry localities, it was heavily loaded in the month of July with large ripe juicy fruit, possessing a sweet and agreeable taste. Aside from scattered patches of *Shepherdia*, this was the only native edible wild fruit that was observed along the route after crossing the Missouri.

Hippuris vulgaris, L., rare in Minnesota, is plentiful in every little stream west of the Missouri, provided it is not alkaline and

contains water sufficient to prevent complete evaporation during the dry season.

Of the *Onagraceæ*, *Epilobium palustre*, L., and *E. molle*, Torr., were sparingly found; more common were *Enothera cæspitosa*, Nutt., and *E. albicaulis*, Nutt., the latter extending as far as to Muskoda station east of the Red river. Much more rare was *E. Missouriensis*, Sims. *Gaura coccinea*, Nutt., was very abundant.

Three species of *Cactaceæ*, *Mamillaria vivipara*, Haw., *Opuntia Missouriensis*, DC., and *O. Rafinesquii*, Engelm., were plentiful. *O. Missouriensis* was first observed, in going westward, on the hills around Mandan.

The *Umbelliferae* were mostly represented by species of *Peucedanum*, *Cymopterus* and *Musenium*. Of these only one, *Peucedanum nudicaule*, Nutt., extends as far east as Minnesota.

The *Compositæ*, as might be expected, were numerously represented. Species of *Liatris*, *Solidago* and *Bigelovia* were abundant. Asters were rather rare. *Helianthus lenticularis*, Dougl., (more correctly known as *H. annuus*, L., since it has been shown to be the original of the common cultivated sunflower,) was the only species of this extensive genus occurring at all plentifully west of the Missouri. *Lepachys pinnata*, Torr. & Gr., was wholly replaced by *L. columnaris*, Torr. & Gr., and its variety *pulcherrima*, Torr. & Gr. It is curious to notice the gradual transition to *L. pinnata*, as the Red river valley is approached. A number of species of *Artemisia* were noticed; among others *A. tridentata*, Nutt. (sage-brush), but not extending eastward much beyond Pyramid Park. *Senecio lugens*, Rich., var. *Hookeri*, Eaton, was common everywhere. Species of *Hieracium* peculiar to the far west were found; also *Grindelia squarrosa*, Dunal., which extends east into the edge of Minnesota. *Troximon cuspidatum*, Pursh, common in Minnesota, was replaced by *T. glaucum*, Nutt.; and *Iva xanthiifolia*, Nutt.; by *I. axillaris*, Pursh. Two species of *Gaillardia*, *G. aristata*, Pursh, and an undetermined one were collected. *Antennaria* was represented by *A. dioica*, Gærtn., a rather pretty little plant.

Aphyllon fasciculatum, Gray, of the order *Orobanchaceæ*, was very common on the dry hill-sides, parasitic on the roots of various species of *Artemisia*.

Numerous species of *Pentstemon* and *Castilleja* made up the bulk of the *Scrophulariaceæ*.

Only one of the order *Labiatae* was collected west of the Missouri; this was a species of *Hedeoma*.

Three species of *Echinosperrum*, one *Mertensia*, and three species of *Eritrichium*, were noted as representing the *Borraginaceæ*.

Phlox cæspitosa, Nutt., is first found in going westward near the Missouri river, but only on the summit of the highest and stoniest hills; farther west it covers the ground nearly everywhere.

Asclepias Cornuti, Decaisne, was supplanted by *A. speciosa*, Torr., a closely allied species, rather more handsome though not so tall and robust.

Among the rarer *Chenopodiaceæ*, I collected *Monolepis chenopodioides*, Moq., *Eurotia lanata*, Moq., *Sarcobatus vermiculatus*, Torr. (this only in Pyramid Park), *Salicornia herbacea*, L., and three or four species of *Obione*.

Among the *Polygonaceæ*, *Rumex venosus*, Pursh, and several species of *Eriogonum* were of frequent occurrence.

Shepherdia argentea, Nutt., and *S. Canadensis*, Nutt., commonly called "buffalo-berries," and *Ælæagnus argentea*, Pursh, the silver-berry, abounded along the streams.

A low trailing *Juniperus* was exceedingly common west of the Missouri, growing everywhere upon the sides of the dry rocky buttes.

Allium reticulatum, Fraser, two species of *Zygadenus*, *Smilacina stellata*, Desf., and *Calochortus Gunnisoni*, Watson, this last not extending east of Pyramid Park, and *Yucca angustifolia*, Pursh, make up the list of *Liliaceæ* noted in Western Dakota.

Scirpus maritimus, L., was common around alkaline ponds, together with several undetermined species of *Eleocharis*. Numerous *Carices* were observed, mostly differing from Minnesota species.

The *Graminææ* were much more sparingly represented than one would suppose to be the case. West of the Missouri fully half of the grass consisted of a single species, *Kæleria cristata*, Pers. The remaining half was divided between a dozen other species, such as *Aristida purpurea*, Nutt., an undetermined *Calamagrostis* near *C. stricta*, Trin., *Stipa Mongolica*, Turcz., and *S. viridula*, Trin., *Spartina gracilis*, Trin., *Brizopyrum spicatum*, Hook., *Bouteloua hirsuta*, Lagasca, and *B. oligostachya*, Torr., which two last commonly pass by the name of "buffalograss," *Munroa squarrosa*, Torr., and *Buchloe dactyloides*, Engelm., the true buffalo grass, the last only occurring in scattered patches here and there. Sev-

eral species of *Poa*, *Beckmannia erucaeformis*, Host., *Schedonnardus Texanus*, Steud., *Eriocoma cuspidata*, Nutt., and several species of *Triticum*, complete the list of grasses collected.

Only two species of ferns were observed, a *Woodsia* and *Pellaea atropurpurea*, Link., the latter growing in the crevices of the rocky ledges on the summit of the buttes. A few mosses were seen, and two species of lichens.

The arboreal vegetation was, as might be supposed, very scanty. Aside from the timber on the Missouri river bottoms, only a few stunted willows, cotton-wood, box-elder and June berry were found scattered at intervals along the streams.

A curious feature of the country west of the Missouri, beyond the limit of the drift, was the great number of fossil tree stumps, protruding through the sod. Hundreds could be counted in many places, and in some localities, especially in Pyramid Park, the fossil trunks were found where they had fallen, almost whole and but little the worse for the ravages of time. There is no doubt that during the Cretaceous and Tertiary periods extensive forests flourished in this region; and to judge from the size of the stumps remaining, some of the trees must have been of immense size. Many stumps were seen ten feet or more in diameter, and I heard of others still larger.

This region will yet prove a mine of wealth to the botanist studying our fossil flora. Fossil leaves in great abundance occur everywhere in the Tertiary sandstones and soft Cretaceous clays. In some places the clay beds were originally underlain by seams of lignite, which have been burned, baking the clay above into a kind of brown, red, or yellow brick, which shows perfectly the forms and venation of these fossil leaves. The region is well worth the time and attention of working botanists, both in recent and fossil botany; and will doubtless ere long receive its due share of exploration and study, since it has become so easy of access.

[Paper I.]

AN ANALYSIS OF FILTERED WATER.—James A. Dodge.

The question of the ways and means of obtaining sufficiently pure water for drinking purposes and domestic use in this city, is one that has been several times discussed before the Academy and elsewhere. We must all admit that it is a question of importance.