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UNIVERSITY OF WYOMING.
Agricultural College Department.

WYOMING EXPERIMENT STATION,
LARAMIE, WYOMING.

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Some Native Forage Plants for Alkali Soils.

BY AVEN NELSON.

Bulletins will be sent free upon request. Address: Director Experiment Station, Laramie, Wyo.
Wyoming Agricultural Experiment Station.

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There are herds and flocks on a thousand hills. These are one of the great sources of Wyoming’s wealth. Though events go to prove that we must more and more become an agricultural people, yet for years to come the most remunerative agriculture must be that which finds, in the stock interests of the state, its reason for being. Thousands of horses, tens of thousands of cattle and hundreds of thousands of sheep feed within our vast domain. Can the number now supported be increased? If not, then the stock industry has reached its maximum development.

If, as has been asserted, our ranges will no longer sustain the princely herds of the days of the “cattle kings,” then we are no longer occupying one of the important vantage points of the state’s material greatness. That the methods followed in the management of the stock industry have materially changed admits of no question. The present status has been evolved from the early conditions in which chance and speculation played so important a part. In the early days comparatively few men were able to launch out into so deep a sea or even cared to venture on such a perilous voyage.

Herds numbering thousands of head roamed over hills and plains with no supervision except the semi-annual “round-up” for branding or for “cutting out” those animals fit for market. Furthermore, even this supervision was largely that of the hireling, the owner’s eye being too often absent and his will too often easily evaded.
With no provision for caring for the stock during unfavorable winters (those with heavy snowfall or following a season of drought), whole herds were decimated many times over and the fabulous profits, which had been so alluring, were swept away.

Such experiences have wrought and are still working their own reform. The speculative features are giving place to sounder business principles and the incomes, while less alluring, are far more certain.

The product of this evolution is smaller herds in the hands of many owners, more personal and interested supervision, provision for the care and feeding of stock during inclement weather and individual control of land either by purchase or lease. Are these conditions such as would tend to diminish the stock supporting capacity of the state? It would hardly seem so. The replacing of the bonanza business by everyday prosperity must multiply even the best of the former results.

It may seem at first sight, as if the enclosing of most of the irrigable lands is simply thus to withdraw from the available pasture lands those of greatest worth. Let it be remembered, however, that irrigation increases the productiveness of these lands many fold and the increased product is, in most cases, a direct addition to the stock-supporting capacity of the lands. Not only are the products of these irrigated lands generally made to contribute directly to the support of the stock, but it is forage secured and preserved at a time when the open range furnishes an abundance, and fed out when this resource is no longer adequate. It will be seen that instead of decreasing the amount of stock in the state, the establishment of homes and farms ought to magnify the business in proportion to the increased yield of the lands, and that the profits ought to be enlarged by reason of the decreased losses. Whether we shall actually experience these results or not depends largely upon the way in which we use our resources. A proper appreciation
of the native forage plants and a discriminating, common-sense use of the pasture lands of the state must govern us.

Probably it is true that the quality and kind of native forage is not identical with that of former years, since some species are less able than others to endure the heavy pasturing, the close cropping and the constant trampling to which they are subjected. In over-irrigation and in unwise methods in the application of water we find other causes for the extinction of some species. Indiscriminate flooding drives out many valuable grasses which are replaced by rushes and sedges, less valuable but for the fact that the yield is enormously increased above that of the unirrigated tracts.

If this extinction occurs in soils in which other hardier species do not readily replace them it is a loss that must ultimately seriously affect the total forage resources unless it is met by adequate counteracting influences.

How the range may be kept up to its old value is an important question, but how it may be improved is even more so. These are questions involving so many factors that their full discussion does not fall within the province of this bulletin, but a clearer idea of what is here aimed at may be had if we roughly classify and briefly characterize certain forage areas.

**FORAGE AREAS.**

The distinctive regions, which are utilized for pasture, in so far as native plants are concerned, are three. These each have their season and their peculiar advantages and disadvantages.

**Mountain Areas.**

This term is meant to include all tracts of country lying at an elevation of 8,500 feet or more. Mountain slopes, open or partly wooded, alpine parks, and even the seeming-
ly naked summits become luxuriantly clothed for a few weeks with nutritious grasses. The always abundant moisture ensures a certain crop and the flowing stream is never far to seek for the thirsty cattle. July and August are the safe months in these situations which are of little value later in the year. Early snows soon make the stations untenable and the hard freezes of the lengthening nights convert the succulent grasses into dead mats of little value. Little can be done looking to the improvement of these areas. Here Nature must take her own course and we can only aid her by not taxing her resources too heavily. Overstocking this kind of range, where the climatic conditions are such that mature seed is produced but sparingly under the most favorable conditions, is simply to rob ourselves of our own heritage.

We are further confronted with our responsibility to these areas on account of their relation to the water supply of the plains below. Whether it be Forest Reserve or general public domain we are interested in maintaining the forest cover for the retention of the winter snows and the conservation of the resultant moisture. Heavy pasturing can not fail to ultimately seriously affect the renewal of the forest growth.

**Hill Country.**

Throughout the state at intervals occur ranges of hills, either only partly wooded or wholly denuded. Broad valleys, rounded summits and undulating foot-hills give perfect drainage to these fairly well-watered areas. They may be said to include all those portions of the state lying below an altitude of 8,500 feet, except the plains discussed below. Being well drained, these areas are reasonably free from alkali. In the broader valleys may occur considerable stretches which are capable of being irrigated. In these localities it is possible to materially increase the forage product either by furnishing more favorable conditions for
the native plants or by introducing more productive species. However, these hill lands, as a whole, do not lend themselves readily to any schemes for their improvement. Cultivated and irrigated with difficulty our treatment of them must be protective rather than constructive. Overstocking should be avoided and periods of rest should alternate with periods of use.

This kind of range is, perhaps, in proportion to area, the most valuable that the state affords. Whether it is more desirable as summer or as winter range depends upon its particular location in the state and upon its exposure, factors which decide its relative climatic condition. Areas eminently satisfactory as summer range may be entirely unsuited for winter use on account of heavy snow-fall while other areas which, from lack of potable waters, are quite worthless as summer range may actually fatten great herds during the winter months. The most desirable winter range is not necessarily that of scanty snow-fall but rather one whose topography is such that the snow is, in the main, blown off of the slopes and open areas, forming drifts in the draws and under the brows of the hills. These drifts insure snow and water in abundance for the stock when water in the ponds and creeks is not to be had or is unfit for use.

**The Plains.**

We thus designate any large comparatively level area. The value of plains as grazing lands depends upon many factors, chief among which may be mentioned the amount of rainfall and the character of the soil. These are the determining factors of the character of the vegetation and makes necessary the recognition of two kinds of areas, viz., those which are free, or nearly so, from alkali and those which are heavily charged with it.

**NORMAL PLAINS:** By normal plains it is intended to designate those whose soil has no unusual or detrimental
amount of alkali. The soil may be of varying degrees of fertility and the forage correspondingly scanty or abundant but no problems are connected with these soils and their crops except those that are common to the arid west in general.

Whether such regions are most valuable as summer or winter range is determined by the amount and character of the forage and of the water supply for the stock. In some portions of the state the plains become buried under the early winter snows while in other parts nearly similar plains are swept bare by the winds leaving an open range throughout the year. How to secure from such lands the best possible results must be left to be considered in some future bulletin *

ALKALI PLAINS: The soil in many portions of the state is heavily impregnated with alkali. These tracts occur in some of the more arid portions of the state as extended plains or as extensive, shallow basins; occasionally, as low, wet flats adjacent to streams and lakes, and now often as abandoned strips of a once fertile ranch. The latter are due to the accumulation of alkali carried to the lands by the irrigation waters or leached from the soils of the adjacent slopes. How to secure from such ranch lands profitable crops and from the larger alkali districts, forage of value are questions worthy of consideration.

RELATION OF PLANTS TO ALKALI.†

A question needing full investigation is the relation of plants to alkali or other salts in the soil. Practically all that we know is that some species have adapted themselves to endure or even to thrive in soil containing greater or less

*The management of pasture lands and of the open range must vary in many respects. Little can be done for the improvement of lands which are not under individual control. Data are being accumulated regarding crop and pasture grasses and the treatment that each should have to give the most favorable results.

†This and the next two topics have been in part adapted from the writer’s report upon the Red Desert of Wyoming.
amounts of various salts; that the seeds of most plants will not germinate in alkali soils because they are unable to absorb enough of the denser water of such soils. It has been shown that alkali retards germination or entirely prevents it in most seeds in direct proportion to the amount of the salt present.

Different species even in the same genus behave very differently in this respect; for example, Lambsquarters (Chenopodium album) seeks a soil free from salts, while for the Glaucousleaf Lambsquarters (C. glaucum) there can hardly be too much. If alkali affects a plant injuriously it seems to do so throughout its whole development.

Only a few families of plants contain species which have adapted themselves to a saline soil. Easily first as to the number of species in this respect is the Goosefoot Family (Chenopodiaceae). To this belongs a large number of distinctively alkali plants, such as the Salt-sages, White-sage, Greasewood, Russian-thistle, Australian Saltbush, etc. All of the native forage plants that are tolerant of alkali are contained in about a half dozen families. Besides the one already mentioned the next most important are the Grass family (only a few species) and a few species in the Sedge, the Rush, the Thistle (Compositae) and the Pea families.

**VALUE OF ALKALI PLANTS AS FORAGE.**

The notion that often prevails that the small shrubs and weedy-looking plants of alkali lands have little forage value is an error. Inferior they may be to some of the choicest grasses but they are equal to many of the grasses and sedges that are cut for hay. As winter forage they are far superior to most of the grass-like plants after frosts have

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†For an excellent summary of what is known of the relation of plants to alkali, and of the value of alkali-tolerant forage plants, see Forage Plants for Cultivation on Alkali Soils, by Jared G. Smith, in Yearbook of Department of Agriculture for 1888. The Experiment Station of the University of California has also studied exhaustively many of the questions pertaining to alkali soils and the plants adapted to them.
struck these down. As proof of this note the magnificent results that are attained in the Red Desert* the great winter pasture of Wyoming. If the winters are not too severely cold nor the snow too deep, all kinds of stock not only subsist upon these plants but actually remain in good flesh throughout the winter. These plants are much more succulent than appearances would indicate. Growing on strongly saline or alkaline soils, the Salt-sages and many other plants take up these salts in such quantity that one readily detects them on tasting even a small fragment of a leaf. Stock, feeding upon such plants, secures the necessary amount of salt from the food, so that the salting of stock that must be resorted to during the months when the animals are feeding upon the mountain grasses is wholly unnecessary.

**INCREASING THE FORAGE SUPPLY.**

In the earlier paragraphs of this bulletin, attention was called to the fact that the expansion or even the maintenance of the present stock industry is dependent upon the possibility of increasing the total amount of forage. No attempt will be made to show how this may be done except as to the forage of our alkali lands.† On the large areas of these not much may be hoped for by the expenditure of any ordinary effort or means but nature will here do much to bring about the desired result. According to the best information obtainable from many of our closest observers, the amount of forage produced each year is perceptibly increasing in some of the largest alkali areas of the state. In these localities the forage chiefly depended upon is shrubby in its character. The cutting down to the ground of such vegetation enormously increases the number of annual shoots.

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*For a full discussion of the alkali forage of the Red Desert of Wyoming see the writer’s report to the U. S. Dept. of Agriculture, published as bulletin 13 of the Div. of Agrostology.

†Probably in some future bulletin the character of the forage and the means for its improvement on lands free from alkali may be discussed.
From winter to winter this shrubby vegetation has been browsed down closer and closer to the woody bases of the plants, until now the tender annual shoots are produced in much greater abundance. The effectiveness of this browsing is, of course, dependent upon the region being used as a winter pasture only, giving time for growth and recovery each summer. If we so treat alkali plants of the greater plains that they shall have a chance to increase where they already occur, introduce them into the saline soils where they are not now found and, if possible, irrigate those that will respond to this attention by an increased yield, we shall see a marked difference in the stock-supporting capacity of the state.

Much can be done to make profitable the enclosed lands that originally were alkali lands or have become so through irrigation. Though they are generally considered worthless, yet highly satisfactory returns may be secured from them if they can be successfully seeded to alkali-tolerant plants. The kind of plants introduced will determine whether the crop may best be harvested or left on the ground as winter pasture.

The following brief list contains only such plants as are known to be more or less tolerant of alkali. Each is discussed with respect to this quality and as to its value as forage. Introduced plants that have proven of more or less value in some other places on alkali soils might be given but it is believed that the native forms are quite as likely to give favorable results, under the conditions existing here, as any of the introduced ones.

THE SALT-SAGES.

Among the plants suitable for alkali soils, easily first are the Salt-sages or, as they are sometimes called, the Salt-bushes (Species of *Atriplex*). Many of these are exceedingly nutritious and constitute a large percentage of the for-
age in some of the arid, alkali plains. Some of them are reproduced each year from seed but many of them are perennials with merely a woody base or sometimes the whole plant quite shrub-like. The perennials are more valuable as pasture plants than the annuals, though they are more difficult of introduction, but, when once established, should yield without further attention forage of much value. Of the perennial species the following are of most importance for this state, as judged by their present relative abundance and adaptability to our alkali lands.

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PLATE I.* Nuttall's Salt-sage (*Atriplex Nuttallii* Wats.).

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*I wish to acknowledge the valuable assistance rendered by Mr. A. H. D preparation of the photographs from which these illustrations were made.*
Perennials.

NUTTALL'S SALT-SAGE,—Plate I and Fig. 1, Plate III. (Atriplex Nuttallii.) This is by far the most widely distributed of the Salt-sages, being common throughout the interior arid west. It is less tolerant of alkali than the following species, occurring principally in soils where salts occur in moderate amounts only. It is essentially a plant of the greater plains where it sometimes occurs in the greatest abundance. Especially for sheep it has no superior as winter forage. From its woody base it each year puts out a large number of stems which spread loosely in all directions. These are seldom more than a foot long, are quite leafy below and produce a great abundance of very nutritious seed. Its deep set roots and woody base enable it to endure much hard usage but these characters in connection with its slow growth make it unsuited for any use except permanent pasture. It is difficult of introduction but where well established care should be taken not to destroy it. Seed, however, is readily obtainable.

OSTERHOUT'S SALT-SAGE,*—Fig. 2, Plate III (Atriplex eremicola). This species resembles the preceding in many respects but it has a heavier, harsher woody base, is more erect in habit, grows to about the same size and has probably about the same forage value. The advantage that it enjoys over the preceding is that it is more tolerant of alkali, apparently thriving best on the borders of lakes and ponds where the surface is quite encrusted with the salt. In soils where the preceding will not grow this might be substituted were not the following a far more promising species.

NELSON'S SALT-SAGE,—Plate II and Fig. 3, Plate III, (Atriplex pabularis). Of the native perennials this is the one most worthy of trial as a crop plant. So far it is

*In habit this so much resembles the preceding that no illustration of it as a whole has been introduced.
only known from south-central Wyoming where it occurs in greater or less abundance in the vicinity of alkali lakes and on the banks of similar creeks, e.g., Bitter Creek, in

the Red Desert. Unlike the two preceding, its woody base is almost wholly underground, the numerous annual stems are nearly erect, very leafy and decidedly herbaceous in
character. It also differs from the others in the close, continuous growth that it makes but resembles Osterhout's Salt-sage in that it is at home on the strongest alkali soils. Though best suited for a pasture plant, yet its erect habit and the herbaceous nature of the stems make it possible to harvest a crop of this with the ordinary machinery.

PLATE III. Seeds (technically fruits) of some perennial Salt sages:

BUSHY SALT-SAGE,—Fig. 4, Plate III (Atriplex canescens). This species of Salt-sage is decidedly woody, sometimes a shrub several feet high. Its leaves and abundant seeds are greatly relished by all browsing animals, so
much so that it is being largely exterminated where it is accessible to stock at all times of the year. It is not abundant in Wyoming, belonging rather to a range to the south and west of this state. On account of its shrubby character it can hardly be recommended for introduction.

Annuals.

Some of the annual species are very tolerant of alkali, grow rapidly, often forming plants of great size, and produce seed in the utmost profusion. It is doubtful if the forage value of these is equal to the perennial species and as winter pasture they have little value. On strongly saline soil where nothing else will grow and from which prompt returns are desired these may be properly tried. To secure the best results the crop must be harvested just before maturity in order that the seed may be retained. Of the several species in the state the three briefly describeful below are the most promising.

PLATE IV. Spreading Salt-sage (Atriplex expansa Wats.).
UTAH SALT-SAGE,—Fig. 1, Plate V (Atriplex truncata). This branches rather freely from the base, its branches spreading loosely in all directions and producing a wealth of succulent leaves. It is less tolerant of alkali than the two following but is very generally distributed on the arid, alkaline plains. It is probably more readily introduced than the plants that are native on the more strongly impregnated soils.

SPREADING SALT-SAGE,—Plate IV and Fig. 2, Plate V (Atriplex expansa). Very similar to the last but more freely branched and with much smaller, somewhat triangular leaves. This occurs on soils often quite encrusted with alkali, makes a dense and vigorous growth and yields a large quantity of fair forage which, like the preceding, must be harvested before it becomes dry and brittle.
TUMBLING SALT-SAGE.—Plate VI and Fig. 3, Plate V. *Atriplex volutans*. In this plant we have a typical tumbleweed. It branches so freely and intricately that by autumn it is a dense, subspherical mass. At maturity the slender tap-root becomes brittle and soon breaks, after which the plant is rolled hither and yon by the winds, scattering its seeds at every bound. It does not seem to be widely distributed, being scarcely known except in the alkali basins and on the shores of alkali lakes. On lands that have been abandoned because of progressive accumulation of alkali this may prove to be just the desired plant. If sown thickly it would shade the ground, preventing further rise of the salt, absorbing much of it in its growth and producing at

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PLATE VI. Tumbling Salt-sage (*Atriplex volutans* Aven Nelson). The meter stick lying on top serves to indicate the size of the plant.
the same time a great amount of coarse forage. If harvested a little before maturity and preserved in a silo it would probably yield a superior product.

**WINTER-FAT.**

WINTER FAT.—Plate VII and Fig. 1, Plate VIII. (Eurotia lanata). In this near relative of the Salt-sages (sometimes called Sweet-sage) we have another plant that is tolerant of alkali and of much value as a pasture plant. Though it is widely distributed in the state yet it is not now very plentiful since stock seek it so eagerly that it is becoming exterminated in many places. The numerous herbaceous branches which spring from the woody base are rather densely white hairy and become during the season about a foot long. These are often literally loaded down with the characteristic, white cottony seeds. It thrives on cultivated ground, makes a rapid growth and provides winter pasture of great value, especially so since (so it is said) stock feeding upon this plant are remarkably free from disease on account of its tonic properties.* Since it is not difficult to find small patches in enclosed grounds from which seed may be obtained ranchmen will no doubt find it worth their while to give this valuable plant a trial.

**THREE GRASSES.**

Among the native species of grasses there are very few that can be recommended for cultivation on alkali soils: There are several species that will exist in such soils but only a few that will prove profitable as pasture or crop plants.

INDIAN MILLET.—Plate IX and Fig. 2, Plate VIII (Eriocoma cuspidata). This is not strictly an alkali grass. In fact it will not endure soils containing a very large percentage of salt. It is included here because it is one of the import-

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*Yearbook of the Dept. of Agriculture, p. 547, 1898.
PLATE VII. Winter fat (Erica lanata (Pursh) Moq.).

PLATE VIII. 1. The tips of two branches of Winter-fat. 2. Head of Indian Millet.
ant pasture grasses on the dryer alkaline areas of the interior west. It is one of the bunch-grasses, forming dense tufts from a few inches to a foot or more across. In no region is it so dry and sterile that it will not live but in better soil and with more moisture it becomes even prolific. Often but a few inches high yet under favorable conditions it attains the height of a foot or two. In any case it fruits abundantly and may be easily known by its large, peculiarly branched spreading panicle and large silky seeds. All
kinds of stock relish this plant but horses are especially fond of it and seem do well upon it. It is easily grown from seed as it germinates readily and reaches its best development in loose or sandy soil. It is often adventive in cultivated ground and on the loose slopes of railroad embankments.

SLENDER WHEAT GRASS,*—Fig. 1, Plate XI. (Agropyron tenerum). Among the native grasses of the west there are none that will surpass in value the Wheat-grasses. Many species of these not only grow luxuriantly but represent forage of very high nutritive value. Several species are tolerant of alkali but, as it happens, the one that is best adapted to soils of this character is also in many other respects the most desirable as a meadow grass. Slender Wheat-Grass makes a meager growth in dry

*The Wheat-Grasses are so well known that no illustration is considered necessary except one of the head of this species. By this, it may be distinguished from the other species.
sterile soil, but it responds promptly to all cultural advantages. The writer has seen wonderful results from seeding the ground to this grass, and this, too, where the soil was strong with alkali and the water used for irrigation was far from the best. It forms a close uniform growth that yields as much per acre as an average field of Timothy. Since it

thrives best with a very moderate amount of water (it will not endure flooding) no more profitable grass can be found for saline areas of limited water supply. While not seeding very freely, the requisite amount for sowing can easily be obtained after the first crop has been harvested. It is easily thrashed out in a machine or may be flailed out if no better method is at hand. Seed of this grass is now on the market.

ALKALI MEADOW-GRASS.—Plate X and Fig. 2, Plate XI (Puccinellia airoides). Here we have a grass that is at home on the salt encrusted margins of ponds and lakes
and on wet efflorescent flats where other grasses are wholly wanting. In such situations it grows luxuriantly, making a crop of much value but for the difficulty of harvesting it. Though of less nutritive value than some other grasses yet if cut in its prime it would make tolerable hay. Browsing

animals greedily devour it but often it grows in boggy, inaccessible places. On abandoned alkali flats which can be flooded early in the season but which can be entered later with horses and mower this should be a profitable crop.
Forage Plants for Alkali Soils.

It produces a fair amount of seed but unless harvested promptly, as it nears maturity, much of this is lost. Even as a pasture grass it has little value after it has reached maturity.

**BULRUSHES.**

Though there are several Rushes and Bulrushes that occur in alkali soils and have some slight forage value, yet there is but one known to the writer that is sought out by stock when other feed is abundant. This is the TUBER BULRUSH,—Plate XII, and Fig. 3, Plate XI. (*Scirpus paludosus*). It never reaches maturity if it is accessible to cattle. They will wade about for it in places where they are in imminent danger of becoming mired. Like the grass last described above it will thrive best where the alkali is the densest. Even on recently dry lake beds, covered inches deep with the white salt, this species still develops apparently uninjured. Its best development is attained in alkali marshes that become dry late in the season. In such situations, if stock be kept out, it makes a dense, uniform growth and attains a height of 18 to 24 inches. Leaves are produced in abundance and the head-like cluster of spikelets are so richly supplied with large plump seeds that it is an easy matter to collect quarts of them by hand in a few hours. Though the seeds are retained by this plant most remarkably well yet none are more easily thrashed out and cleaned than this.

To secure perpetual returns from lands so thoroughly filled with alkali as to be worthless as regards other crops seems more than possible if seeded to this. Being an herbaceous perennial of the most persistent character it should maintain itself indefinitely where it is once introduced. Each year’s new stems spring from the tubers produced the previous year at the end of short underground stems, and by this character and mode of development this species may easily be recognized.