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**PLANTS AS INDICATORS OF GROUND WATER**

BY

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In Sulphur Spring Valley, Ariz., is found an alkali-resistant bush commonly called burweed and identified as a species of *Suaeda* (*Dondia*). It grows in the belt of shallow ground water and alkaline soil immediately surrounding the barren playa, in association with Mexican salt grass, and also in clumps at the margin of the playa where the surface is otherwise destitute of vegetation. In three localities of *Dondia* investigated in Sulphur Spring Valley the depth to the water table at a low stage ranged from 4 to 7 feet. In one locality, where the depth to the water table was not determined but was estimated to be 15 feet, this species was found, though not as the dominant vegetation.<sup>72</sup>

Two other species of alkali-resistant plants that indicate ground water were mentioned by Mendenhall<sup>73</sup> as growing in California—lowland purslane (*Sesuvium portulacastrum*) and wild heliotrope (*Heliotropium curassavicum*), locally called "Chinese pusley." The lowland purslane grows in moist soils and indicates ground water but usually water of poor quality. The wild heliotrope is described by Coulter<sup>74</sup> as occurring along the seacoasts and also on saline soils in the interior. Mendenhall states that it grows only in moist soils, but as it has strong alkali-resistant powers the ground water on which it feeds may be brackish.

#### YERBA MANSA

Yerba mansa, a perennial herb which somewhat resembles the plantain weed in appearance has been listed as a ground-water plant in southern California by both Lee<sup>75</sup> and Thompson.<sup>76</sup> Lee states that it formerly grew in association with salt grass in the valleys of the western slope of San Diego County, Calif., where the water table commonly stood within 5 feet of the surface. Thompson observed it in the vicinity of Newberry Spring, in the Mohave Desert region, where the water table is only 3 or 4 feet below the surface.

#### RABBIT BRUSH AND RELATED SPECIES

One of the most conspicuous of the ground-water indicators in Nevada, Utah, and adjacent regions is the well-known desert bush commonly called rabbit brush or broom sage. The principal ground-water species of rabbit brush (*Chrysothamnus graveolens*) is a shrub with slender, whiplike branches that have small, narrow leaves.

<sup>72</sup> Meinzer, O. E., and Kelton, F. C., op. cit. (Water-Supply Paper 320), pp. 172-181, 184, 186.

<sup>73</sup> Mendenhall, W. C., op. cit. (Water-Supply Paper 224), p. 20.

<sup>74</sup> Coulter, J. M., Manual of the botany of the Rocky Mountain region, from New Mexico to the British boundary, p. 258, 1885.

<sup>75</sup> Ellis, A. J., and Lee, C. H., Geology and ground waters of the western part of San Diego County, Calif.: U. S. Geol. Survey Water-Supply Paper 446, p. 110, 1919.

<sup>76</sup> Thompson, D. G., op. cit. (Water-Supply Paper 578).

In late summer it is made conspicuous by numerous small heads of yellow flowers which resemble those of golden rod.<sup>77</sup> In the Mohave Desert region, Calif., *Chrysothamnus mohavensis* was observed by Thompson<sup>78</sup> as a ground-water plant. Rabbit brush has been described as a ground-water plant in Big Smoky,<sup>79</sup> Ralston,<sup>80</sup> Clayton,<sup>81</sup> and Steptoe<sup>82</sup> Valleys, Nev.; in Tooele Valley<sup>83</sup> and Sevier Desert,<sup>84</sup> Utah; and in Owens Valley<sup>85</sup> and the Mohave Desert region,<sup>86</sup> Calif.

It is one of the most common plants in the shallow-water areas of Big Smoky Valley. It prefers the parts of these areas that have some drainage but also grows in very alkaline soil and is a fairly reliable indicator of shallow ground water. The zone of dominant rabbit brush is in a general way bordered on the inside by the salt-grass zone and on the outside by the greasewood zone. In seven localities of rabbit brush that were investigated the depth to the water table at a low stage ranged from 2.5 to 12 feet, and in another locality the depth was estimated to be 14 feet. In all eight of these localities the rabbit brush was associated with salt grass, and in all except one it was also associated with greasewood. In two of the localities it was associated with sagebrush (*Artemisia tridentata*), which does not depend on ground water. The alkali in the soil of a few of the localities that were tested ranged from 0.20 to 3.15 per cent and averaged a little over 1 per cent.

In the Sevier Desert and some other tracts of shallow ground water in western Utah rabbit brush grows in close relation to greasewood but generally on somewhat better-drained and less alkaline soil. On some of the low ridges formed by abandoned river channels the greasewood is largely displaced by rabbit brush, and some abandoned channels can be traced long distances by such bands of yellow-topped brush winding through the monotonous expanse of greasewood. In Tooele Valley, where rabbit brush grows in association with alkali sacaton and salt grass, the alkali content of the soils that were tested is only very moderate. A considerable excess of moisture over that needed to prevent wilting suggests the presence of the capillary fringe and the existence of the water table probably within 10 feet of the surface. In studies made in Steptoe Valley,

<sup>77</sup> Kearney, T. H., and others, op. cit., p. 406.

<sup>78</sup> Thompson, D. G., op. cit.

<sup>79</sup> Meinzer, O. E., op. cit. (Water-Supply Paper 423), pp. 95, 98, 100, 159-161.

<sup>80</sup> Idem, p. 125.

<sup>81</sup> Idem, p. 145.

<sup>82</sup> Clark, W. O., and Riddell, C. W., op. cit., p. 39.

<sup>83</sup> Kearney, T. H., and others, op. cit., pp. 406, 407.

<sup>84</sup> Meinzer, O. E., op. cit. (Water-Supply Paper 277), pp. 24, 110.

<sup>85</sup> Lee, C. H., op. cit. (Water-Supply Paper 294), p. 77; The determination of safe yield of underground reservoirs of the closed-basin type: Am. Soc. Civil Eng. Trans., vol. 78, pp. 238, 250, 1915.

<sup>86</sup> Thompson, D. G., op. cit.

Nev., the conclusion was reached that in general rabbit brush occupies tracts where the depth to the water table is between 8 and 15 feet.

Small individuals of rabbit brush or of a plant resembling rabbit brush are widely distributed over the alluvial slopes far above the water table. In Tooele Valley the species *Chrysothamnus marianus* occurs in the shadscale association far above the water table and almost certainly without any relation to it. Further investigation is needed to determine to what extent the species *Chrysothamnus graveolens* parts company with the water table. Quite without such an investigation, however, there is generally little difficulty in determining the localities where the luxuriant and abundant individuals of rabbit brush are true indicators of shallow ground water.

The rayless goldenrod (*Bigelovia hartwegii*) appears to behave much like the rabbit brush, and the writer may have confused these two species in his observations. Apparently both have a tendency to occupy ground on which the native vegetation has been destroyed by grazing or cultivation, and both will grow in dry situations as small plants but will make a notably ranker growth where ground water is within reach.

#### ARROW WEED, BATAMOTE, AND JACATE

Arrow weed (*Pluchea sericea*) is a tall, straight-stemmed shrub that seldom branches and grows in rather dense thickets. Its wood was used by the Indians to make arrows.<sup>87</sup> It is reported to be a ground-water indicator in the Mohave Desert region, California, by Thompson,<sup>88</sup> and in the Salton Sea region, California, by Brown,<sup>89</sup> who states that although it is a reliable indicator of ground water it is likely to grow where the depth to the water table is several feet and possibly as much as 25 feet. Usually, however, a heavy growth signifies water within 5 or 10 feet of the surface. Thompson noted it growing abundantly along the flood plain of Colorado River near Needles, where the depth to water was only a few feet. Brown states that arrow weed is common along dry arroyos where there is a shallow subsurface flow and in basins where ground water is near the surface. It also grows freely beside pools and running streams.

The batamote bush (*Baccharis glutinosa*) is regarded by G. E. P. Smith as an indicator of ground water. In a letter he makes the following remarks in regard to it:

There are several other plants which I think you should list. One of them is the batamote, of which there are three varieties. While it will grow in my

<sup>87</sup> Aldous, A. E., and Shantz, H. L., op. cit., p. 113.

<sup>88</sup> Thompson, D. G., op. cit. (Water-Supply Paper 490-B), p. 98; also Water-Supply Paper 578.

<sup>89</sup> Brown, J. S., op. cit., p. 113.

was about 9 feet deep, and the capillary water rose only to a level 3 feet below the surface, but some salt grass was growing in this place. Up the valley from this point the evidences of shallow water gradually disappear. Five miles above Warm Spring the ground in the stream valley was dry, but the vegetation consisted of big greasewood, the tall saltbush (*Atriplex torreyi*), and a small amount of rabbit brush. These plants are somewhat ambiguous as indicators. They probably draw on the ground-water supply, but may owe their presence to floods, the evidences of which were very distinct in the stream valley. A few miles farther upstream these species give way to *Atriplex confertifolia*, which predominates also on the dry bench lands.

Since the investigation in Ione Valley was made, much has been learned in regard to the behavior of ground-water plants, and it now seems altogether probable that the greasewood and rabbit brush at the locality 5 miles above Warm Spring feed on ground water and that the saltbush does likewise.

The occurrence of *Atriplex torreyi* in Clayton Valley is described as follows:<sup>97</sup>

Outside of this zone in the part of the valley south of the playa there is a zone in which iodine weed, big greasewood (*Sarcobatus vermiculatus*), the tall shrubby saltbush (*Atriplex torreyi*), and the common spiny saltbush (*Atriplex confertifolia*) are associated. \* \* \* Outward from this area, in the direction of the mountains, first the iodine weed and then the big greasewood and *Atriplex torreyi* disappear or become scarce, while the common saltbush (*Atriplex confertifolia*), often called shadscale, becomes dominant. Over the extensive gravelly and arid tracts of the middle and upper parts of the alluvial slopes this saltbush maintains its supremacy.

#### GREASEWOOD

The shrub known as big greasewood (*Sarcobatus vermiculatus*) is one of the most conspicuous and widely distributed of the desert bushes in Nevada and Utah and in adjacent States, especially to the north. According to Coulter<sup>98</sup> it is "common in the Great Basin, and to the upper Missouri, headwaters of the Platte, and southward." It should not be confused with the creosote bush (*Covillea tridentata*), which is commonly though incorrectly called greasewood in southern California and in Arizona, nor with the seepweed (*Dondia*), which is also sometimes called greasewood. It is an erect scraggy, leafy bush, 1 to 8 feet high, and has a vivid green color that contrasts strongly with the gray hues of shadscale and sagebrush. (See fig. 8.)

Greasewood was not at first regarded as an indicator of ground water, because to a large extent it grows on land that lies some distance above the water table. The information now at hand, however, makes it practically certain that greasewood habitually

<sup>97</sup> Meinzer, O. E., op. cit. (Water-Supply Paper 423), p. 145.

<sup>98</sup> Coulter, J. M., op. cit., p. 312.

sends its well-developed taproot to considerable depths to reach the water table or the overlying capillary fringe, and that it is a true

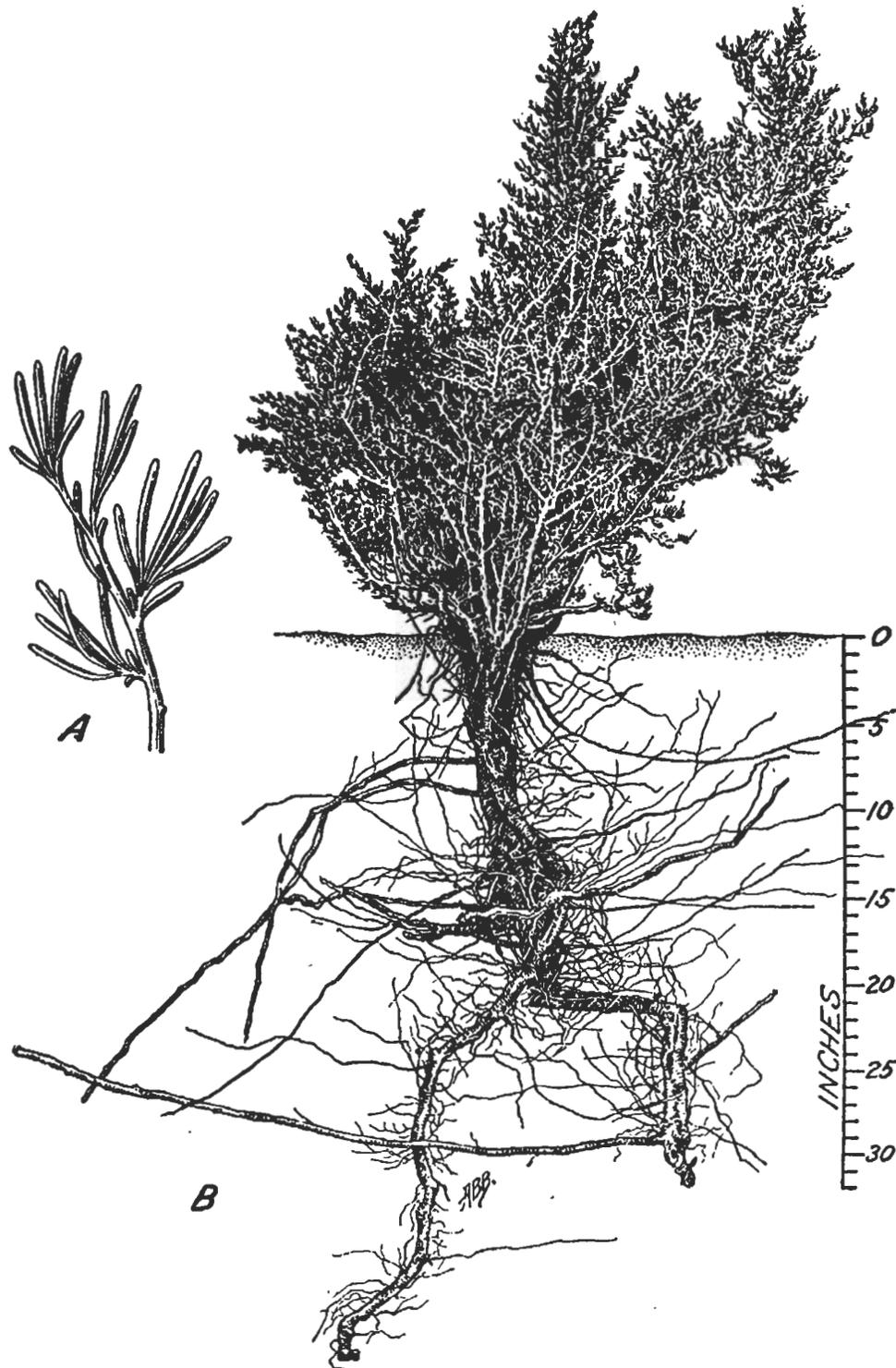


FIGURE 8.—Big greasewood (*Sarcobatus vermiculatus*). A, Detail showing the narrow, rather fleshy leaves; B, a plant, showing the excellent root development. The large, deeply penetrating taproot is characteristic of the species. (After Kearney, T. H., and others, op. cit., fig. 10)

ground-water plant not only where the water table is very near the surface but also in its favorite position surrounding a shallow-water

tract. It is, thus, one of the most trustworthy of all ground-water indicators. It has been recognized as such an indicator in many western valleys, especially in Nevada and Utah. In their recent publication Aldous and Shantz<sup>99</sup> state that the species is limited to subirrigated alkali lands throughout the West.

In some places the big greasewood spreads meagerly to upland tracts that are wetted by storm waters, but it should not be confused with the little greasewood (*Sarcobatus baileyi*), which is not at all a ground-water plant. The little greasewood is commonly associated with shadscale (*Atriplex confertifolia*) on arid slopes and plains that lie too high above the water table to be influenced by ground water. Its appearance is extremely dry and lifeless, especially during the long autumn drought.

In Big Smoky Valley, Nev., the big greasewood is abundant in the shallow-water areas, in great mounds on the barren playas (pl. 4, C), in the sand hills in or near the shallow-water areas, and in a belt between the shallow-water areas and the extensive upland areas of shadscale and little greasewood, generally where the depth to the water table is less than 50 feet. (See fig. 9.) An interesting occurrence is on the mounds in the flat, barren, clayey, alkaline, and periodically submerged playa. These mounds have a sandy soil that was captured by the greasewood from the wind-borne materials. They have been gradually built to their present large dimensions by this process of wind deposition. The development of the mounds has produced favorable conditions for the greasewood, and the growth of the greasewood has tended to preserve and further develop the mounds.

In 19 localities of big greasewood that were studied in Big Smoky Valley the greasewood occurred alone in 3 localities and was associated with rabbit brush in 9, with salt grass in 7, with shadscale in 6, with sagebrush in 4, with *Atriplex torreyi* and iodine weed in 2 each, and with willow in 1. It was, of course, associated with the salt grass in the localities of shallowest ground water and with the shadscale chiefly in the upper part of the greasewood zone or somewhat above the zone of dominant greasewood.

The conditions as described for Big Smoky Valley agree closely with those found in Tooele Valley, Utah, which are set forth as follows:<sup>1</sup>

The area occupied by the greasewood-shadscale association forms an interrupted belt across the valley between the areas occupied by the shadscale association and by the grass flats, respectively. It also covers the low ridges and hummocks which alternate with the basinlike depressions and flats near the shore

<sup>99</sup> Aldous, A. E., and Shantz, H. L., op. cit., p. 110.

<sup>1</sup> Kearney, T. H., and others, op. cit., pp. 400-405.