nershed P-13, yet these two soils are vastly different in textural characteristics. The similarity in rate of water-intake for these two soils may, in part, be explained by the dry condition and severe soil cracking present on the Clayey range site at the time of test. The rate of water-intake as determined for the Sandy range site is in line with previous studies on soils of sandy texture in this rainfall belt and with vegetation in comparable range condition.

This study has shown that differences in rate of water-intake between soils is not a function of surface texture only. Dense sub-soils as in Panspots range sites and thin surface soils over shale parent materials can inhibit the rate of water-intake, especially after the surface soil becomes saturated as in the second 30 minutes of water application. Surface cracking is important in determining the amount of water absorbed by the soil during the forepart of a runoff-producing storm.

**Summary**

During the summer months of 1957 and 1958, water-intake studies were conducted on instrumented rangeland watersheds in the 10-14 inch precipitation belt near Newell, South Dakota.

Data from four range sites on four watersheds showed that water-intake rates were correlated with range sites, as mapped by SCS, where the range condition class was comparable. With Good condition class, the water-intake during the first 15-minute period of the 1-hour test was high even on thin or fine-textured soils. However, the rate of intake declined much more rapidly on such sites in later periods of the test except on thick well-structured clays which maintained a rate comparable to a sandy loam.

The effects of surface conditions such as texture, cracking, and amount of cover are important factors but during prolonged rainfall subsurface features becomes important in determining the amount of water absorbed during the storm event.

**LITERATURE CITED**

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There are a great many approaches to the improvement of sagebrush ranges. The purpose is to reduce sagebrush and other undesirables and increase good grasses and other valuable forage plants. Common methods used in northeastern California are: plowing and seeding, burning and seeding, burning alone, spraying alone, and sometimes burning, plowing and seeding, or spraying, plowing, and seeding. Another possibility is spraying to kill the sagebrush and drilling seed of desirable forage species directly into the stand of dead sagebrush. The cost of plowing is eliminated. Unlike plowing, discing, or burning, the spraying and drilling technique is characterized by minimum disturbance of vegetation and soil. In some cases this can be an advantage. Dead standing sagebrush will catch more snow, improve temperatures, reduce frost heaving, reduce wind velocity at the soil surface, and reduce erosion. The abrasive action of windblown soil on plant seedlings has been reported (Lyles 1960). Native perennial grasses are not destroyed as with plowing. Rocky ground can be seeded by this method. Likewise, there may be benefits from drilling without other soil disruption, depending on the soil involved. Soil crusting, reduced infiltration, and erosion can be averted. It also provides a firm seedbed for direct drilling. These possible manifold advantages are difficult to measure and will vary with soil type and climate. The technique has not been widely used because the heavy-duty planting equipment necessary for operation in the dead brush has been lacking. Now, however, this two-step low-erosion-hazard range conversion program is possible because of two pieces of machinery—agricultural aircraft and the range drill (Hull 1957, 1958). Approximately 5,200 acres of sagebrush in Idaho has been treated by this method at an average total cost of $5.00 per acre.

Sagebrush in northeastern California can be killed with aircraft application of 2,4-D when plants are susceptible. Two pounds active ingredient of 2,4-
D ester (2,4-dichlorophenoxyacetic acid) properly applied to sagebrush by airplane during the active growing period will give 95-100 per cent kill if soil moisture is sufficient for brush growth (Cornelius 1955, 1958). Most years there is sufficient soil moisture. Spraying of sagebrush is accepted as a common practice in the study area, and is widely used by ranchers and public land managers. Thus step number one of this two-point conversion is readily accomplished. The remainder of this paper deals with the second step of the conversion—the establishment of wheatgrasses in the stand of dead sagebrush.

The effectiveness of direct drilling of wheatgrasses is inversely proportional to weed production or competition. Weed competition or production of resident annual plants in arid sagebrush country is extremely variable from season to season, being primarily a function of weather and soil moisture.

Methods and Results

The study area, two miles northeast of the town of Likely, Modoc County, California, is commonly referred to as table land and usually grows big sagebrush (Artemisia tridentata), cheatgrass (Bromus tectorum), squirrel tail (Sitanion hystrix), Sandberg bluegrass (Poa secunda), and red-stem filaree (Erodium cicutarium). Annual precipitation averages 12.5 inches, though seasonal totals vary widely. The elevation is 4500 feet. The growing season is short and variable. The cheatgrass may germinate as early as October. Grazable growth, however, may not appear until May of the following year, though it may start as early as February in a warm wet spring. In all years, the annual grasses are dry by the end of June. Winter temperatures may fall below zero.

The soil is classified as Yancy slightly gravelly loam. The A horizon is 0-4 inches deep and is a gray brown slightly gravelly loam of pH 6. The B1 horizon is located at 3-8” depth and is a slightly gravelly clay loam. The B2 horizon is located at 8-18” and is a brown to dark brown clay of pH 7. Below this is an indurated layer several inches thick which is silicci cemented.

Crested wheatgrass (Agropyron desertorum), intermediate wheatgrass (A. intermedium) and pubescent wheatgrass (A. trichophorum) seed was drilled into sprayed sagebrush in four successive seasons. The resulting wheatgrass stands were sampled by the stocked quadrat system described by Hyder (1954). Ratings of excellent, good, etc. were applied as suggested by Hyder for this rainfall zone. Fifty percent or better stocking of one-square-foot quadrats was rated excellent, 40-50 percent good, 25-40 percent fair, 10-25 percent poor, and 9 percent or less as failure. Only the area between sagebrush plants was sampled. The drill openers rode up and over sagebrush plants, resulting in no planting in these areas. Measurements before spraying indicated that only 12 percent of the ground was covered by sagebrush.

During years of adequate spring rainfall the area between the sagebrush plants is covered by weedy annuals, primarily cheatgrass. In seasons with low spring rainfall this interspace is largely bare ground. The measure of competition was total herbage production (mostly cheatgrass), measured on adjacent areas cleared of brush.

The first seeding germinated in the spring of 1955, a year when the interspaces were essentially bare. Competition from resident annual plants was considered about median in the spring of 1955. The establishment of pubescent wheatgrass was excellent.

Competitive conditions during 1956 were similar to 1955. Again cheatgrass production was about median for the area. An excel-
Table 1. Result of drilling directly into sprayed sagebrush.

<table>
<thead>
<tr>
<th>Date of Seeding</th>
<th>Yield of resident annuals (pounds oven dry/acre year of establishment of wheatgrasses)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9-17-54</td>
<td>210</td>
</tr>
<tr>
<td>11-2-55</td>
<td>240</td>
</tr>
<tr>
<td>4-4-57</td>
<td>970</td>
</tr>
<tr>
<td>10-23-57</td>
<td>90</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Species seeded</th>
<th>Pubescent wheatgrass</th>
<th>Mixture of crest-ed, pubescent and scent and grass</th>
<th>Intermediate wheatgrass</th>
<th>Pubescent wheatgrass</th>
<th>Crested wheatgrass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent stocking of wheatgrass plants June 1960</td>
<td>65</td>
<td>81</td>
<td>13</td>
<td>7</td>
<td>12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rating of wheatgrass stand.</th>
<th>Excellent</th>
<th>Excellent</th>
<th>Poor</th>
<th>Failure</th>
<th>Poor</th>
<th>Excellent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Hyder 1954</td>
<td>50-100%</td>
<td>40-50%</td>
<td>24-40%</td>
<td>fair</td>
<td>10-25%</td>
<td>poor, 9% or less failure.</td>
</tr>
</tbody>
</table>

Lent stand of a mixture of pubescent and intermediate wheatgrasses resulted.

The third seeding was rated poor. Production of resident annuals was 970 pounds of dry matter per acre, several times that of the previous two years. A multiple increase in ground cover (mostly cheatgrass) competed seriously with the seeded species. The interspaces between brush plants were well covered with cheatgrass.

This was the only seeding of the four reported made in spring. Lack of success of this seeding was not attributed to season of seeding. Spring seedings have consistently proven to be more reliable than fall seedings and produce equally as good stands in this area.

Stand establishment was excellent again on the fourth seeding. Cheatgrass production was 90 pounds, the lowest of the four years studied. Because of the large amount of cheatgrass seed produced the previous season, a dense stand of cheatgrass started between the brush plants. Most of the cheatgrass died before reaching one inch in height. It is interesting to note that under these conditions pubescent and intermediate wheatgrasses established poorly whereas crested wheatgrass produced an excellent stand.

**Discussion and Conclusion**

Wheatgrasses were successfully established following the killing of sagebrush with 2,4-D with a minimum of disturbance to the site. Seed was planted between dead sagebrush plants with a rangeland drill. Sagebrush was not removed.

Establishment was excellent in years when production of the associated resident annuals was high. Median production of resident annuals is about that experienced during the first two years of this study. It therefore appears that drilling wheatgrass seed directly into an area of dead sagebrush is a good risk in the area studied.

**LITERATURE CITED**


