Wind Erosion Curtailed by Controlling Mesquite

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Abstract

A sand-dune mesquite area with very little interdunal vegetation was treated aerially one to three times with 2,4,5-T at 0.56 kg/ha in an oil:water emulsion. Four and five years after the initial treatment, the amount of blowing soil was evaluated using sandtraps located at various distances from the boundary between sprayed and unsprayed mesquite. The amount of wind-blown particles was greatly reduced on the area chemically treated to control mesquite. During the windy season the amount of blowing soil in the unsprayed area was more than 15-fold greater than at 180 m into the sprayed area. Intermediate amounts were measured between the boundary and 180 m into the treated area.

Extensive areas of rangeland in the southwestern United States and northern Mexico are infested with honey mesquite [*Prosopis juliflora* (Swartz) DC. var. *glandulosa* (Torr.) Cockerell]. Historical records refer to much of the rangeland in New Mexico now supporting mesquite as grassland with vast and continous expanses of grama *(Bouteloua)*. Mesquite was present along drainages and in small isolated areas on the mesas (Dick- Peddie 1966). Where the mesquite was growing on sandy soils, sand dunes typically developed around the mesquite plants.

The area infested by mesquite has increased rapidly since the introduction of large herds of cattle in the late 1800's. The mature seed pods of mesquite are relished by livestock. However, most of the seeds are not digested, and they readily pass through the digestive tract (Fisher et al. 1959). Apparently, these seeds are scarified while in the digestive tract as they germinate readily when moisture and temperature are favorable. Livestock have served as a very effective mechanism for the distribution of mesquite seed on rangeland.

Mesquite is an inefficient user of water when soil moisture is adequate (McGinnes and Arnold 1939), yet it is extremely drought tolerant (USDA 1937). As mesquite becomes established, the lateral roots grow rapidly in all directions (Fisher et al. 1973) and take up soil moisture that would otherwise be used by herbaceous plants. Selective grazing and utilization of herbaceous vegetation by livestock, plus drought and competition for soil moisture, causes a depletion of herbaceous plants on these areas.

The potential for wind erosion on a bare soil surface is much greater than for a soil with vegetation. Also, the jetting effect around the edges of scattered shrubs causes the wind velocity at the ground surface to be greater than the average wind velocity in the open (Schwab et al. 1971). As a consequence, large acreages of sandy rangelands have been transformed to sand dunes where mesquite has become established. During windy periods, these sandy sites are a major source of air pollution from blowing dust.

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Workers in Arizona, New Mexico, and Texas found in the early 1950's that mesquite stands could be reduced significantly by spraying with 2,4,5-T [(2,4,5-trichlorophenoxy) acetic acid] (Fisher 1959, Valentine 1960). Clipping studies by Herbel and Gould[1] in 1963–1967 showed that perennial grasses increased significantly after stands of mesquite were reduced by spraying with 2,4,5-T. The rate of recovery for grasses depended upon the degree of mesquite control, the degree of grass stand degradation before treatment, and the amount and distribution of rainfall. Preliminary observations in 1971 suggested that soil stabilization was occurring in sprayed areas of severely eroded, sand-dune mesquite before the grass stand had improved sufficiently to protect the soil. This study was conducted to quantify the erosion occurring on 2,4,5-T-treated and untreated areas infested with mesquite.

Methods and Materials

The study was conducted on the Jornada Experimental Range approximately 35 km north of Las Cruces, N.M. The study area originally was grassland which became infested with mesquite. The soil in the area is an Onite-Pentura complex. Onite is a member of the fine-loamy, mixed, thermic family of Typic Haplargids, and Pintura is a member of the mixed, thermic family of Typic Torrispsamments. The range site is classified as sandy. The Onite soil is deep and well drained, and is formed in alluvium between dunes. Typically the surface layer is loamy fine sand about 12 cm thick, the subsoil is sandy loam about 38 cm thick, and the substratum is sandy loam to a depth of 150 cm or more. Pintura soil is deep, excessively drained, and was formed in eolian materials on dunes. The surface layer typically is loamy fine sand about 15 cm thick overlying fine sand to a depth of 150 cm or more. The soil blowing hazard of both soils is very high. The sandy surface soil has blown into dunes up to 2.5 m in height around mesquite plants. Between the dunes are sparse stands of yucca (*Yucca elata* Engelm.) and broom snakeweed (*Xanthocephalum sarothrae* (Pursh) Shinners]. Scattered plants of fourwing saltbush [*Atriplex canescens* (Pursh) Nutt.] are associated with mesquite plants in the dunes. The area supported a very good stand of black grama [*Bouteloua eriopoda* (Torr.) Torr.] before 1940 (Buffington and Herbel 1965), but the black grama has disappeared and the main grass species occurring on the area was mesa dropseed [*Sporobolus flexuosos* (Thurb.) Rydb.]. The grass plants were very sparse, e.g., the herbage production over a 4-year period averaged less than 4 kg/ha.

The climate of the Jornada Range is typical of the arid phase of the semidesert grassland, with an average annual precipitation of 22.5 cm at the Jornada Experimental Range headquarters from 1915 to 1970. The precipitation is extremely variable. Most winter moisture comes as low-intensity rains or occasionally as snow. About 55% of the precipitation occurs in July through September as localized thunderstorms of high intensity. Evaporation averages 235 cm annually. The average maximum temperature is highest in June when it averages 36° C, and is lowest in January at 13° C. Wind movement is usually greatest in April and May, and least in

[1]Herbel, C.H. and W.L. Gould. Unpublished data.

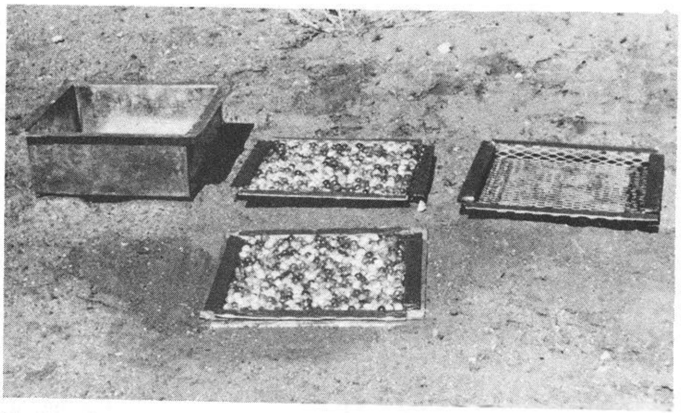

Fig. 1. *The component parts of a sandtrap (metal pan, tray made from expanded and rerolled steel, and tray filled with marbles) in the background and a sandtrap in place in the foreground.*

December. The average wind velocity in the spring months is 14.8 km/hr. High velocity winds that produce blowing dust are not uncommon in any month, but occur more often in the spring.

An area measuring approximately 550 × 1200 meters was sprayed with 2,4,5-T at 0.56 kg/h in June 1968. The area was divided into plots measuring 60 × 1200 m, and these plots were resprayed with 2,4,5-T at the same rate one or two additional times with 1- to 4-year intervals between spray treatments. Mesquite control was determined by evaluating the percent of dead stems 27 months after treatments were applied. Mesquite control varied from 48 to 84%. The long axis of the sprayed area was oriented in a north-south direction which is nearly normal to the prevailing high velocity winds during the windy season. The area immediatley west of the sprayed area had never been treated to control mesquite. The prevailing winds are from the westerly quadrant.

In February 1972, sand traps were installed at the border between the sprayed and unsprayed areas, and at approximately 30, 75, 120 and 180 m eastward from the border into the sprayed area. Three sand traps were set in representative sites in the interdunal areas at each location. The sand traps consisted of metal boxes measuring 30 × 30 × 15 cm with a screen tray made from expanded and rerolled steel set in the top of the boxes (Fig. 1). The trays were of proper depth to hold two layers of marbles. The sand traps were placed in wood frames set into the soil such that the top of the traps and upper surface of the marbles were flush with the soil surface. Soil moving by wind action fell through the layers of marbles and was accumulated in the metal boxes. The metal tray and marbles prevented the soil from blowing out of the boxes. The soil in each sand trap was collected weekly, or more often if necessary, from February 22 to May 22, 1972. The soil was air dried, sieved, and the various fraction weighed. The test was repeated in a similar manner in 1973, except that the sand traps were located at the border between the sprayed and unsprayed areas and at 90 and 180 m east and west of the border.

Results

The relative difference in wind erosion in March, 1972, on the untreated and sprayed areas is evident in Figure 2. These photos were taken at locations less than 200 m apart. The two sites were similar in appearance before spraying. Deposition and rippling of wind-blown soil on the leeward side of dunes and scouring of the interdunal areas were severe in the untreated area (Fig. 2A). The sparse cover of plants and plant litter from the previous season was sufficient to resist severe wind erosion during the windy season of 1972 on the sprayed area (Fig. 2B).

The amount of wind blown soil caught at weekly intevals in sand traps located at various distances from the border between the unsprayed and sprayed areas in 1972 is shown in Figure 3. The amount of soil collected at the edge of the unsprayed area was significantly greater ($P<.01$) than at any other location. Also, the amounts collected at 30 and 75 m from the edge of the unsprayed area differed significantly from each other and from the amounts collected at 120 and 180 m. More soil was collected in some weeks than in others because of differences in wind velocity and duration.

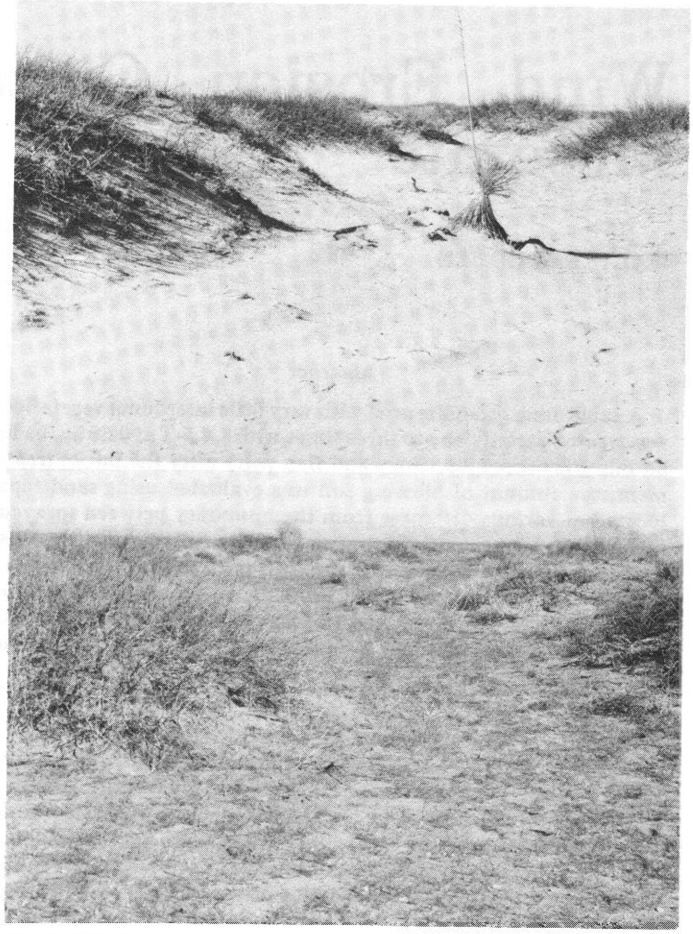

Fig. 2. *Wind erosion in March, 1972 on (A) an unsprayed mesquite-dune site and (B) an adjacent area sprayed with 2,4,5-T in 1968 for mesquite control.*

The ratio of the amounts of soil collected at the various distances from the unsprayed area, using the quantity at 180 m as unity was 15.7 (boundary): 7.0 (30 m): 3.6 (75 m): 1.8 (120 m): 1 (180 m).

The amount of soil collected at weekly intervals in 1973 at the various locations is presented in Figure 4. The amounts collected at the boundary between the sprayed and unsprayed areas and at the two locations (90 and 180 m) in the unsprayed area were not significantly different, but they were significantly ($P<.01$) greater than the amounts collected at comparable distances from the boundary into the sprayed area. The ratio of the average amounts of soil collected in the unsprayed areas and at the boundary as compared to the amounts collected at 90 m (location D) and 180 m (location E) into the sprayed area, using the quanity at location E as unity, was 18:3:1.

The amounts of soil collected in 1973 were much less than amounts collected at comparable locations in 1972. In both years the periods of greatest accumulation were during periods of high wind velocity. The amount of blowing soil during the 2 years was indirectly related to the rainfall and herbaceous growth during the summer growing season prior to the year of collection and to the winter precipitation during the period of collection. The rainfall for June through September in 1971 and 1972 was 111 and 210 mm, respectively. The summer rainfall in 1972 was great enough to produce significant forb growth in the interdunal areas of the

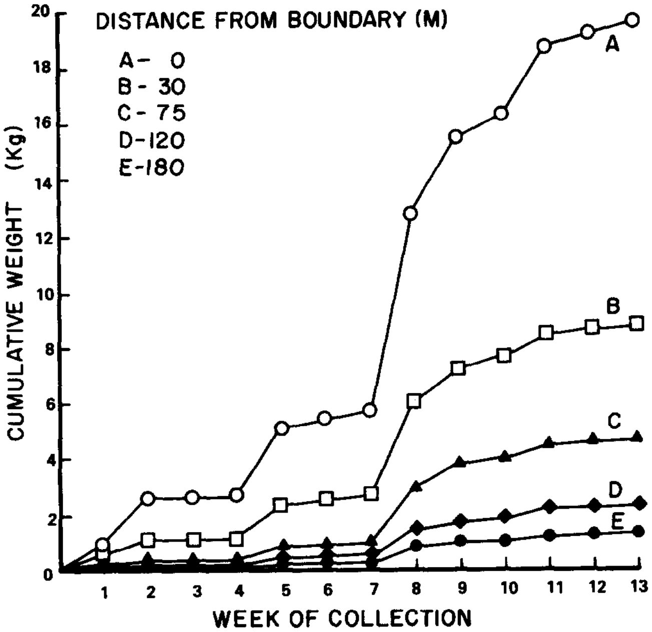

Fig. 3. *Average cumulative weight per pan of wind blown soil collected in 1972 in sandtraps located in the sprayed area at various distances downwind from the boundary between untreated and 2,4,5-T-treated areas of mesquite.*

unsprayed areas as well as in the sprayed areas, while in 1971 there were few forbs in the unsprayed area. The precipitation from December through April was 37 mm in 1972 and 91 mm in 1973. The growth of winter annuals during the winter of 1972–73, while mesquite plants were dormant, was similar in the sprayed and unsprayed areas. However, the low winter precipitation in 1972 permitted very little growth of winter annuals, so the soil was more subject to wind erosion than in 1973. The total miles of wind at the Jornada Experimental Range headquarters for February through May was 6,198 in 1972 and 6,168 in 1973.

The average accumulative amount of soil and the particle size distributions of the blowing soil that was collected in the sand traps at the various locations are presented in Tables 1 and 2. In 1972 the sand traps located at the boundary between sprayed and unsprayed

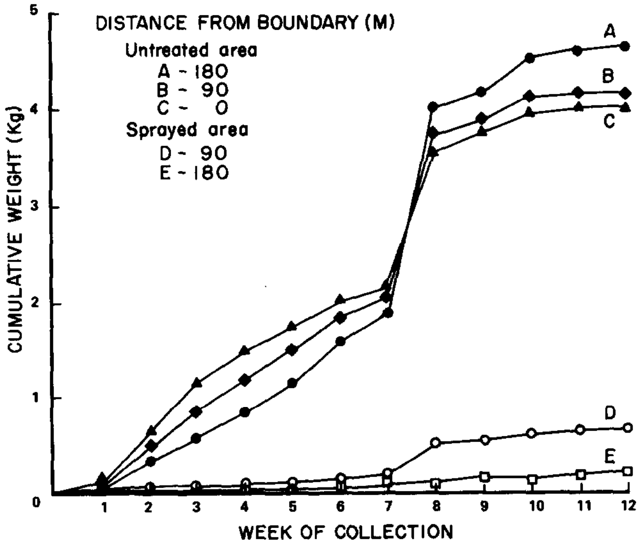

Fig. 4. *Average cumulative weight per pan of wind blown sand collected in 1973 in sandtraps located at the boundary, or 90 and 180 m from the boundary in untreated and 2,4,5-T-treated mesquite.*

Table 1. Average particle size distribution (percent by weight) of wind-blown soil collected in sandtraps at various distances downwind from the boundary between untreated and sprayed mesquite over a 13-week period in 1972.

Distance from boundary (m)	Percent of soil remaining in sieve — Sieve opening (μ) 380	180	140	74	<74	Soil weight in sandtrap (gm)
0	21.3	61.9	7.0	8.7	1.1	19,868
30	17.1	61.0	9.5	10.9	1.5	8,836
75	15.9	57.2	8.2	15.1	3.6	4,567
120	11.1	58.3	9.5	17.0	4.1	2,247
180	7.9	64.0	7.6	16.3	4.2	1,265

area had the highest percent of soil particles larger than 380μ and the percentage of particles of this size decreased as the distance from the boundary increased. Conversely, the percent of soil particles passing through 100-mesh and 200-mesh screens (smaller than 140 or 74μ) increased as the distance from the boundary increased. The results in 1973 were quite similar, i.e., there was a lower percentage of soil particles that were larger than 380μ and a greater percentage of particles smaller than 140 or 74μ in the sprayed area than in the untreated area or at the boundary between areas.

Soil particles are transported in wind by suspension, saltation and surface creep. In the unsprayed area there was very little herbaceous material between sand dunes, so the wind velocity at the soil surface would be greater than it was in the sprayed area where plant residues were more abundant between the dunes. Fungal hyphae were abundant in the upper 4 cm of soil in the area with a cover of plant litter, but were sparse in the untreated area. Fungal hyphae are important in binding soil particles (Swaby 1949) and apparently some of the stability to wind erosion on the sprayed area was the effect of soil microflora. The amount of soil carried by suspension should have been reduced as the distance from the boundary into the sprayed area increased because part of the suspended material settled out and was not replenished from the surface of the sprayed area. Consequently, the amount of fine particles in the traps decreased as the downwind distance increased. The lower load of suspended material would also reduce air pollution by dust.

The amount of soil moved by saltation and surface creep would be much greater on a bare soil than on one partially protected by plant residues. The soil moving by saltation and surface creep from the unsprayed area encroached upon the plant debris in the sprayed area, but as the distance from the boundary increased, the amount of soil moving by these processes decreased. Consequently, the total amount of soil collected decreased as the distance into the sprayed area increased, and the percentage of large and small particles changed because of the large reduction in large particles as the distance into the unsprayed area increased.

Some wind erosion occurred in the sprayed area because of the death of the mesquite. Three or four years after the mesquite was killed, the stems deteriorated and provided less protection to the

Table 2. Average particle size distribution (percent by weight) of wind-blown soil collected in sandtraps at various distances from the boundary between untreated and sprayed mesquite over a 12-week period in 1973.

Distance from boundary (m)	Percent of soil remaining in sieve — Sieve opening (μ) 380	180	140	74	<74	Soil weight in sandtrap (gm)
180–untreated	22.9	61.6	7.7	6.3	1.5	4,616
90–untreated	21.2	59.7	9.5	7.3	2.3	4,165
0	19.0	65.8	7.5	6.1	1.6	4,016
90–sprayed[1]	10.7	64.6	11.0	10.9	3.7	675
180–sprayed[1]	10.4	60.6	10.8	12.5	5.7	231

[1]Downwind from untreated area

top and sides of the dunes. As a result, the dunes were reduced in height and the soil from the dunes was deposited in the litter between dunes. Probably, most of the larger soil particles collected in the sand traps at the 90 and 180 m distance from the boundary of untreated and sprayed areas came from the dunes that were being reduced in height.

Summary and Conclusions

Grass stands are depleted and dunes develop on sandy soils in the semiarid Southwest when mesquite invades the area. These sand dune areas are a major source of air pollution. Under favorable moisture conditions, annual and perennial species of plants will reinvade the site when the mesquite stand is reduced sufficiently.

In a study undertaken to measure the amount of blowing soil in a mesquite-infested, sand-dune area, sandtraps were placed at various distances from the boundary of a 2,4,5-T-treated and untreated portion of the area. The soil collected in the sandtraps during the windy sessions of 1972 and 1973 was measured weekly. During a 3-month period in 1972, the amount of collected soil decreased dramatically with distance from the boundary of the untreated area into the treated area. The amount of blown soil at 30 to 180 m from the boundary varied from 50% to 6% of the amount at the boundary. In 1973 the amount of soil collected in the untreated area at 90 or 180 m from the boundary did not differ from the amount collected at the boundary, but the amounts at comparable distances into the sprayed area were 83 and 94% lower, respectively, than in the unsprayed area.

The particle size distribution of soil collected in the untreated (or boundary) areas showed a higher percentage of large particles ($>380\mu$) and a lower percentage of small particles ($<74\mu$) than in the sprayed area. The percentage of large particles decreased as the distance into the sprayed area increased. There was an increase in the percentage of small particles as the distance downwind into the sprayed areas increased, but the amount of all sizes of particles decreased as the distance downwind increased. These data show that the chemical control of mesquite on sandy sites can reduce wind erosion and air pollution from blowing dust.

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