in 1961 and found them to be effective as well as inexpensive.

Construction

Both of Isaac White's windbreaks were built with a dragline to accommodate approximately 100 head of cattle. Each is 150 feet long east and west with two wings 75 feet in length that project toward the south. The wings were placed at a 45° angle on one structure and at a 90° angle on the other.

The windbreaks and wings were built to a settled height of six feet with side slopes of 1.5:1 and a top width of six feet. This design gives protection against winds that may blow from the northwest or northeast (Figure 1 and 2). After two year's experience Mr. White believes the windbreak that has wings projecting at a 90° angle is the most effective.

The borrow pits which provided the earth taken for construction were located on the windward side. These pits also served as reservoirs for storing fresh drinking water near the windbreak.

Location

Louisiana marsh ranges are relativley flat. They are covered with water periodically throughout the year. However, there are some elevated places or ridges that water does not cover. These areas are good sites for constructing earthen windbreaks. Also, if there is a choice, the structure should be located where it will serve the greatest acreage without excessive travel by the cattle.

If ridges are not available, it is possible to build up an area a foot or two high for a distance of 30-40 feet out from the main structure on the leeward side. This is necessary to provide drainage as well as a high, dry place for more cattle to stand or lay down.

Approximately 1,000 cubic yards of earth are required for each windbreak. Figuring the cost of earth moved at 25 cents a cubic yard, each earthen windbreak cost Mr. White $250.00. This cost, amortized at five percent for ten years, represents an average annual cost of 32 cents per animal protected.

Summary

Earthen windbreaks provide cheap and effective protection for cattle against cold winds and driving rain or sleet on Louisiana marsh ranges during the winter months.

When properly located, windbreaks are an aid to distribution of livestock over the entire range. This results in better and more uniform utilization of the forage.

These earthen windbreaks can be tied into a system of cattle walkways on some marsh ranges making both facilities more valuable as range practices during the winter grazing season.

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SPRAY PENETRATION IN SCRUBOAK WITH HELICOPTER APPLICATION[1]

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Tests conducted during Operation Firestop in 1954 showed that spray penetration of heavy brush was aided considerably by the downdraft of the helicopter rotor. The tests were preliminary and tentative but they did investigate a field that is now becoming quite important. Although herbicidal treatment of forest and range lands for brush control or vegetation manipulation is becoming common, hand spraying and mechanized ground spraying is just too expensive except for special purposes. Spraying by aircraft seems to offer the only economical means of covering such areas.

The helicopter offers certain advantages over fixed-wing aircraft for spraying vegetation. It is highly maneuverable, can operate at low speeds and at low elevations (thus minimizing spray loss), and has the aforementioned effect of the rotor downdraft aiding penetration.

Equipment and Procedures

The study was made in the coastal mountains of southern California on the Cleveland National Forest. The study area was located just east of the Camp Pendleton Marine Base in a heavy stand of pure scruboak (*Quercus dumosa* Nutt.). The individual plants were from ten to 14 feet high. The stems were crowded and mostly within a few feet of each other. The crowns formed a dense, unbroken canopy of foliage. The canopy layer was generally uniform in depth and leaf density.

We used a small Bell helicopter with an agricultural spray boom and chemical side tanks as described by Akesson and Harvey. Diaphragm type spray jets gave instantaneous on and off control of the spray. The low rate of application of this equipment made it necessary to go over the area repeatedly.

The spray compound we used was an aromatic oil with a viscosity of 37.2 Saybolt Universal Units at 100° F. and a gravity

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[1] *Arizona Agricultural Experiment Station paper No. 362.*

[2] *Recently developed helicopters have greatly improved hovering ability for a much wider range of atmospheric conditions.*

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Table 1. Spray penetration in Scruboak with helicopter application.

A-Line — Foliage Canopy Observation Levels (East ↑, West ↓; Slope 45%)

	Ground Level	Halfway to Ground	Top of Canopy
+50 ft.	60%	35%	80%
+40 ft.	50%	50%	100%
+30 ft.	60%	90%	100%
+20 ft.	80%	100%	100%
+10 ft.	30%	90%	90%
0	75%	50%	100%
−10 ft.	30%	50%	100%
−20 ft.	25%	15%	80%
−30 ft.	10%	15%	30%
−40 ft.	1%	10%	10%
−50 ft.	1%	2%	3%

Line of Flight →

B-Line — Foliage Canopy Observation Levels (East ↑, West ↓; Wind Direction; Wind Speed 5-8 mph Uphill)

	Ground Level	Halfway to Ground	Top of Canopy
+50 ft.	10%	20%	50%
+40 ft.	30%	40%	80%
+30 ft.	60%	90%	100%
+20 ft.	60%	70%	100%
+10 ft.	50%	50%	95%
0	100%	100%	100%
−10 ft.	75%	75%	100%
−20 ft.	80%	75%	95%
−30 ft.	50%	50%	50%
−40 ft.	50%	75%	90%
−50 ft.	1%	5%	10%

value of 19.6, American Petroleum Institute standards. For comparison, a sample of a commercial diesel oil used in spray mixtures and analyzed at the same time showed a viscosity of 37.7 SU at 100° F. and an API gravity value of 32.0.

The study plot was laid out on a 45 percent west facing slope. The helicopter single line of flight was marked with red flags tied high in the foliage so they could be easily seen from the air. This flight line ran parallel to the contour lines of the slope for a distance of 340 feet. The beginning and end of this line were marked by wide, caterpillar-cleared firebreaks.

Perpendicular to the marked flight line and extending 50 feet up and down the slope from the flight line, two 100-foot lines were measured out in ten-foot intervals; lines "A" and "B" (Table 1). At each of these ten-foot intervals, three, eight by ten-inch sheets of white paper were placed at three different levels in the brush canopy as follows: one sheet on the ground; one sheet at a point estimated to be midway between the top of the canopy and the ground; and the third as near to the top of the canopy as possible. In all line locations, measurement, and paper placement procedures, we made an effort not to disturb the canopy foliage. The paper sheets were so spaced as to minimize any possible "shading effect" from one paper being placed over another and were placed to offer a level flat surface to spray droplets coming from above.

The helicopter flew along the marked line at elevations of 25 to 30 feet above the foliage and sprayed 43 gallons of chemical. A spraying overlap was noted, of approximately 30 feet, at each end of the flight line which increased the length of the area sprayed. The elevation of the test area and the atmospheric conditions existing at the time of the experiment made it impossible for the helicopter to take full advantage of its hovering ability.[2] This and the low rate of application of the spray equipment made it necessary to make 17 passes in order to apply all the aromatic oil. A stop watch was used to check the spraying time which was three minutes. This represented the total time spray was seen coming from the helicopter.

Immediately after the helicopter finished spraying, two men entered the spray zone from each end of the flight line and recorded the percent of area stained by oil droplets on the sheets of white paper. Observers then exchanged zones of observation and recorded the data again. The two sets of data were checked against each other to obtain an estimate of visual error and variation. When stain coverage was under five percent, estimates were made to the nearest 1 percent. Over a period of time the stained areas enlarged; therefore, later precise checks could not be made. In future experiments of this type, it would be desirable to obtain a photographic or other permanent record of the stained sheets for more precise analysis.

Results and Conclusions

The greatest variation between two individuals in visual estimate results was five percent. This variation existed on only seven sheets of the 66 checked. On sheets having stained areas of five percent or less, some variations of one or two percent were noted. The data recorded then gave a good portrayal of the spray penetration obtained in this experiment (Table 1).

The agitation of the brush varied with the altitude of the helicopter. In some current practices in applying herbicides for brush control, spraying is limited to small sprouts rather than dense, mature brush. The aircraft are flown at speeds greater than hovering speed, to apply the desired low volume of material at a reasonable cost. Under these conditions, air currents from the rotor blades are not of importance in spray distribution and in penetration of the spray material into the plant crowns.

Spray penetration at all three levels in the brush canopy in our test was greatest in the area above the line of flight with the highest being recorded on the plus side of "A" line (Table 1). This higher penetration on the uphill side of the flight line was attributed to the following:

1. The uphill-oriented wind currents of five to eight miles per hour caused the main body of spray to shift uphill. These currents were also partially deflected into the foliage by the helicopter rotor to give an additional side-foliar disturbance which was stronger on the uphill side closer to the helicopter rotor.
2. Also, because the uphill side of the sprayed area was closer to the helicopter rotors, more vertical canopy disturbance resulted on this side from rotor-generated downdrafts.

The greater foliar disturbance on the uphill side of the flight line was observed visually and also was indicated by the higher spray penetration on the uphill area (Table 1).

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