of tillers the first week in July. This date coincides with the time at which the reproductive culm was reaching its maximum length.

Conclusion

Tillers of blue grama develop from axillary buds that are located at the node of each phytomer. The axillary bud is partially enclosed in a specialized leaf sheath (prophyllum). The development of the axillary buds and tillers was delayed when the plant was maintained under artificial short-day photoperiods.

The increase in temperature associated with the natural-day greenhouse as compared to the control resulted in tiller development four weeks earlier in the season. With the combination of lower temperatures and controlled photoperiod there was an additional one week delay of tiller development. The major increase in tiller development was associated with the mid-June dates which coincided with the elongation of the reproductive culm.

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Ground Markers Aid in Procurement and Interpretation of Large-Scale 70 MM Aerial Photography[1]

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Highlight

Butcher paper, surveyor stakes, lath strips, plastic letter-number codes, paper plates, and drop-panel markers were all useful for marking range ground features, providing strict flight-line control, and interpreting resultant aerial photographs. All markers were both highly detectable and resolvable at the largest scale of 1:600. All markers remained visible, yet some became less resolvable, at the smaller scales of 1:2400 and 1:4600.

Five test sites were selected to evaluate the usefulness of large-scale 70 mm color and color infrared aerial photography to detect and identify features in the range environment. These areas were located in various vegetation types: (1) mixed grassland-shrub types within the Harvey Valley Range Allotment of the Lassen National Forest in northeastern California, (2) mountain grassland type of the Black Mesa Experimental Forest and Range in southwestern Colorado, (3) mixed shrub type in the Corral Creek area of Middle Park in northwestern Colorado, (4) ponderosa pine-bunchgrass type of the Manitou Experimental Forest in southcentral Colorado, and (5) open pinyon-juniper type with a shrubby understory near McCoy in northwestern Colorado.

Flight lines for each study area were flown at approximately 300 to 2,300 ft above the terrain to procure photographs between the scales of 1:600 and 1:4600. Lengths of the flight lines varied between 250 and 3,000 ft.

To assure photo coverage of specific areas, and to provide control for photo interpretation and measurement, ground markers were used to: (1) guide the aircraft, (2) provide precise scale determination, and (3) assure positive identification of ground features potentially detectable on the aerial photographs.

The markers provided a means of determining the exact location and subsequent positive identification of items seen in the aerial photographs. These pre-marked range features, as viewed in the photographs, were used: (1) for comparative identification of marked to unmarked items, (2) to develop photo interpretation keys, (3) to train photo interpreters, (4) to administer photo interpretation tests to judge the usefulness of the photographs for detection and identification of specific range features, (5) to develop photogrammetric techniques, and (6) to determine the limits of resolution for various ground markers and range features.

The work reported here describes the kinds of ground marking techniques used, their usefulness, and points out the detectability and resolvability of the markers as seen on the resultant aerial photographs.

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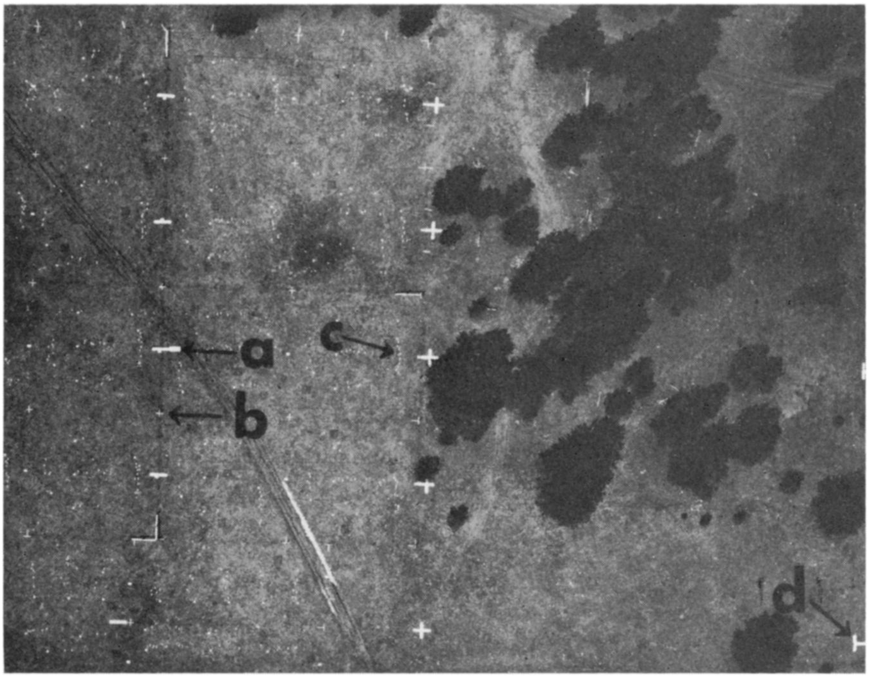

FIG. 1. Black and white photo made from 1:2400 scale 70 mm color aerial transparency. Photo shows: (a) dash-type flight-line marker . . . note letter-number code which appears immediately below dash, (b) 3-foot lath cross, (c) group of range feature arrows on a 20-foot vegetation transect . . . note paper plate immediately above group, (d) T-type flight-line marker. Resolution is decreased in copy photo.

It should be recognized that this intensive marking was designed to facilitate research objectives and evaluate techniques, but would not be applicable or practical in an operational range or wildlife habitat resource inventory. Such marking would be an integral first step, however, in designing and initiating such an inventory.

Ground Markers

All flight-line markers were located in a straight line through the center of an area where aerial photo coverage was desired. Principal markers consisted of 1.5 × 10 ft strips of white polyethylene butcher paper in the form of a "T" at the beginning and end of each flight line (Fig. 1). These indicated direction of aircraft travel, and were guides to the aerial photographer to begin and end photography. Paper crosses were placed at measured intervals, usually 100 ft from the "T," to provide control for photo scale determination. Other markers in the form of dashes were placed along the line to assure aircraft orientation. The number of flight-line markers depended on the desired photo scale. For the largest scale photography, they were no more than 600 ft apart. With smaller scale photography, and hence higher elevation of the aircraft above the terrain, they could be spaced at greater intervals due to the increased field of view of the pilot and the photographer.

Red florescent drop-panels (28 inches × 6 ft) were substituted for the white butcher paper when snow conditions prohibited use of white markers. Red panels were also used to avoid confusing the pilot when flight lines were close together, parallel, or when a slightly different flight line or scale was desired over the same area. Red panels or white flags were placed in selected trees for aircraft orientation when trees obscured parts of the flight line from observation at a distance by low-flying aircraft.

Range features were marked on the ground prior to a photo mission to provide positive identification in the aerial photographs. Wood surveyor stakes (1 × 2 × 18 inches), pieces of lath (1½ × 12 inches), white paper plates, or letter-number codes made from white paper were used. The wood markers were painted white, yellow, or orange so they could be easily detected and distinguished from other features in the aerial photographs.

The surveyor stakes were used to indicate vegetation and soil surface characteristics or line transect locations. Vegetation features marked included: individual or groups of healthy and decadent plants, ungrazed and

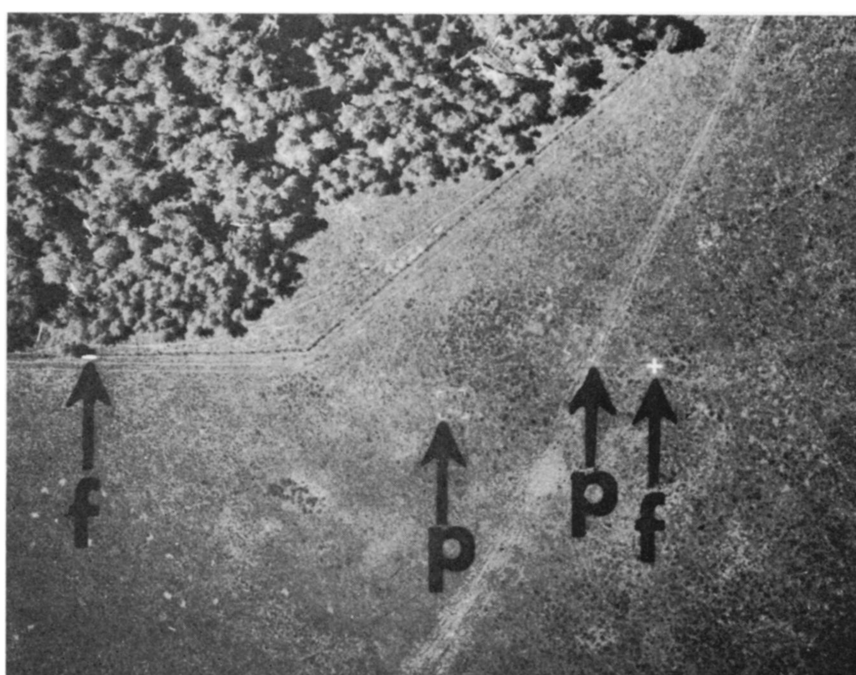

FIG. 2. Black and white photo made from 1:4600 scale 70 mm color infrared aerial transparency. Photo shows: (f) dash-type and cross-type flight-line markers, and (p) 4-foot lath used as plot corners (some resolution lost in copy photo).

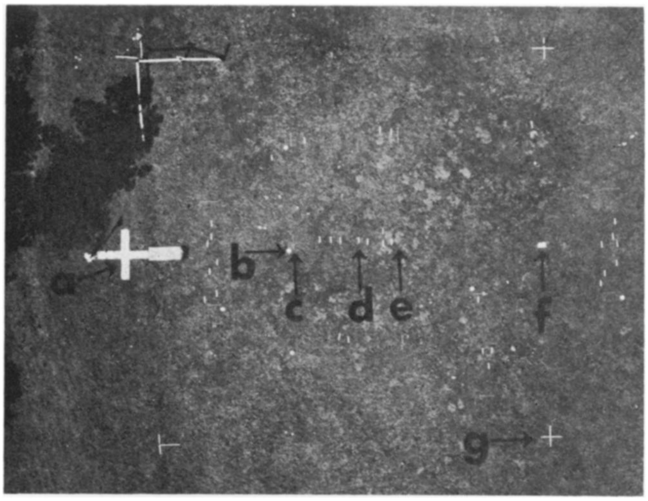

Fig. 3. Black and white photo made from 1:600 scale 70 mm color aerial transparency. Photo shows: (a) cross-type flight-line marker . . . note shadow of flagmen, (b) 9-inch paper plate delineating start of vegetation transect, (c & e) 3-foot lath delineating zero and end, respectively, of 20-foot vegetation transect, (d) ground feature arrow, (f) 12-inch letter-number code . . . A2 . . . (resolution lost in copy photo), and (g) 3-foot lath cross for cultural treatment boundary.

grazed plants, and plants with unusual growth forms. Surface features marked included: rodent holes and mounds, soil casts from gophers, ant hills, rocky areas, noticeably wet areas, deer pellet groups, cow droppings, large animal tracks (cattle and deer), soil auger holes, and dead deer.

Longer lath strips (4 to 8 ft) were used to indicate the corners and sides of rectangular plots defining specific areas for relating ground truth to photo interpretation and measurements (Fig. 2). The plots were used for density counts, mapping, line-intercept measurements, and determining shrub heights on aerial photos. Wood lath crosses (1½ × 12 inches or 1½ inches × 3 ft) were also used to indicate widespread features such as areas of cultural treatment, heavy rodent activity, colonies of annual plants, or plant utilization, without specifically pointing to individual items or plants (Fig. 3).

Pointed lath and surveyor stakes layed flat on the ground were used to locate vegetation transects. White, 9-inch paper plates were attached to those stakes at the start of the transects to indicate the zero end for photogrammetric studies (Fig. 3). Paper plates were also used to identify plot centers and plot corners.

Range feature markers (surveyor arrows) should be positioned so the pointed end does not fall beneath the plant crown when viewed vertically. Also, arrows should be oriented so that, at the estimated time of photography, the sun's angle will be perpendicular to the length of the arrow. This increases shadow detail and allows for greater reliability in determining which end of the stake is pointed.

Large letter-number codes (12 inches) cut from white plastic shelf paper and stapled to heavy cardboard-like material for backing were used to identify land areas that had been seeded, fertilized, or treated with herbicides. These coded markers were anchored to the ground in the appropriate treatment area to provide positive identification in the aerial photographs (Fig. 3).

Cylindrical objects of known heights and with visible surface areas detectable in the aerial photographs were used to estimate height of shrubs.

To insure that all ground markers are photographed if the aircraft drifts, markers should be positioned near the center of flight lines, or at least away from the extreme peripheral portions of flight lines.

Flight-line marker locations and plots used for subsequent photo missions were marked with flagged steel pins or steel fence posts to assure relocation at the next flight date.

All ground markers must be anchored in some fashion to avoid movement by animals, wind, or water. Rocks were used to weight the butcher paper; nails were driven through the wood markers into the ground. The nails were left in the ground following removal of the arrows to provide for relocation of the arrow positions for subsequent photo missions.

It is necessary that flight-line and ground-truth markers be established as close to the proposed day of the flight as possible, and inspected immediately prior to the photo mission. Markers should be removed as soon after the flight as possible so as not to damage the vegetation or litter the area.

Resolution of Markers

All ground markers were both detectable and resolvable at the largest scale of photography, 1:600 (Fig. 3). At a scale of 1:2400, the letter-number codes were still detectable, but resolution of individual letters and numbers became less clear so that some were difficult to read. The surveyor arrows were detectable, but it was difficult to resolve the pointed end of the arrow at the smaller scales. All other markers had good resolution at the smaller scale of 1:2400 (Fig. 1).

At the smallest scale, 1:4600, the letter-number codes and the arrows were detectable, but resolution of individual letters and numbers was lost. Flight-line markers, paper plates, and the longer lath strips remained detectable with good to fair resolution (Fig. 3).