containing mild strains of virus causing no symptoms. Later, if freedom from all viruses seems desirable, proven stocks may possibly be freed through nutrient agar cultures of microscopic stem tips. Tip cultures of Easter lily plants have been produced, but freedom from virus and superiority of the cultured stocks have not yet been proven.

Pathogen-free stocks (i.e. free from fungi and bacteria) were obtained by culturing single bulb scales in test tubes on nutrient agar. Plants derived from a single carefully chosen bulb were kept in a separate group (clone). Unblemished bulb scales from a bulb were selected, trimmed top and bottom with a sharp knife, treated at 125°F for 30 minutes in water containing 1 in 200 parts of formaldehyde, cooled rapidly, surface-sterilized 2 or 3 minutes in 1 in 10 hypochlorite solution, and placed under sterile conditions in tubes (slants) of potato-dextrose agar gel. If any organism, pathogenic or not, was left on or in the scale, it became visible by growing onto the agar gel. All such scales were discarded. At first the yield of sterile scales was 0 to 50 per cent. When bulbs developing from sterile scales and planted in sterilized soil were again scaled and cultured, the yield went up to 80 or 90 per cent sterile.

Scales cultured

Thousands of scales were cultured, grown in pots, and pathogen-free plants were sent to northern California and grown in the field. The cultured plants were the first foundation stocks. They inspired growers to choose the best bulbs from their own fields, treat them with hot water and pesticidal dips, scale them, and plant the scales directly in the field. These produced bulbs of moderate size, excellent in health and conformation. Starting bulb stocks from scales of chosen and treated bulbs has become the routine commercial method for maintaining healthy Easter lilies. This method can only be applied to healthy bulbs; scales from infected bulbs rot in the ground or produce infected and unthrifty plants.

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VEGETATIVE MAPPING

with false-color infrared aerial photography

. . . and comparison with black and white

DONALD T. LAUER

This study was made to determine the extent to which the species composition of timber stands and other types of vegetative cover could be interpreted from high-altitude, small-scale, vertical Ektachrome Infrared Aero photographs. Comparisons were also made between interpretations of conventional black-and-white panchromatic aerial photography—used extensively throughout the world by agriculturalists and foresters—and those derived from color infrared photography (a false-color tri-emulsion layer reversal film type originally developed for military purposes). Results indicate that while color offers only a slight increase in interpretation accuracy (at an added cost) over black and white, other factors involved may be even more significant. These include considerable savings possible in man hours and labor costs through the possibility of faster and less fatiguing analysis by the interpreters.

THE 1,460-ACRE AREA used in this study is a woodland-chaparral-grassland forest within the California coastal range in close proximity to the University of California, Berkeley campus. Predominant vegetation types are: (1) *Sequoia sempervirens* (coast redwood), (2) *Pinus attenuata* (knobcone pine), (3) *Pinus radiata* (Monterey pine), (4) *Eucalyptus globulus* (blue gum eucalyptus), (5) mixed hardwood (big leaf maple, madrone, buckeye, coast live oak and California bay), (6) chaparral (coyote brush and chamise), and (7) annual grasslands.

Coast redwood

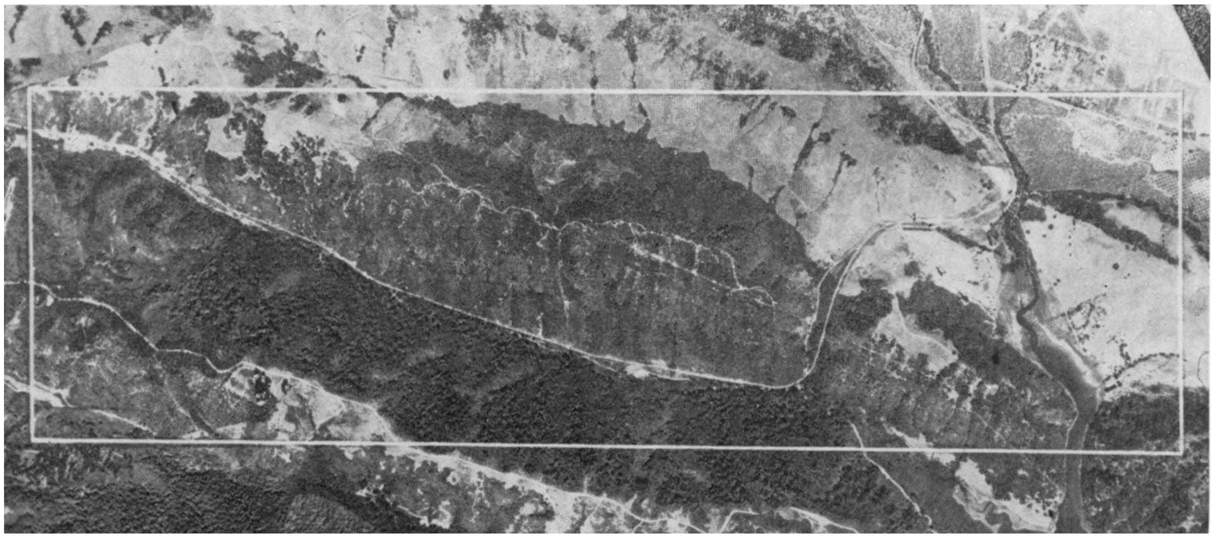
Lumber from coast redwood that is produced in the northern coastal counties of California is the mainstay of the economy of that region. Valuable stands of redwood grow in large pure stands principally on the alluvial flats and lower side slopes of the drainage networks. The timber producers within the area are concerned with obtaining accurate inventory data about the location, distribution and number of these important timber stands. This study may lead to a rapid and accurate means of inventorying redwood in this region of California.

Monterey pine, knobcone pine and eucalyptus are less commercially important than redwood, but serve as valuable forest cover types, improving the water retention capacity of watershed lands throughout the arid western United States. Range managers and cattle ranchers are continually seeking accurate survey data on the location and extent of major vegetation cover types (grassland, brushland, and timberland) in the areas they must manage.

Procedures

Optimum photographic specifications were determined for the region and a

PANCHROMATIC FILM,
WRATTEN 12 FILTER
Photographic Scale:
1/32,000



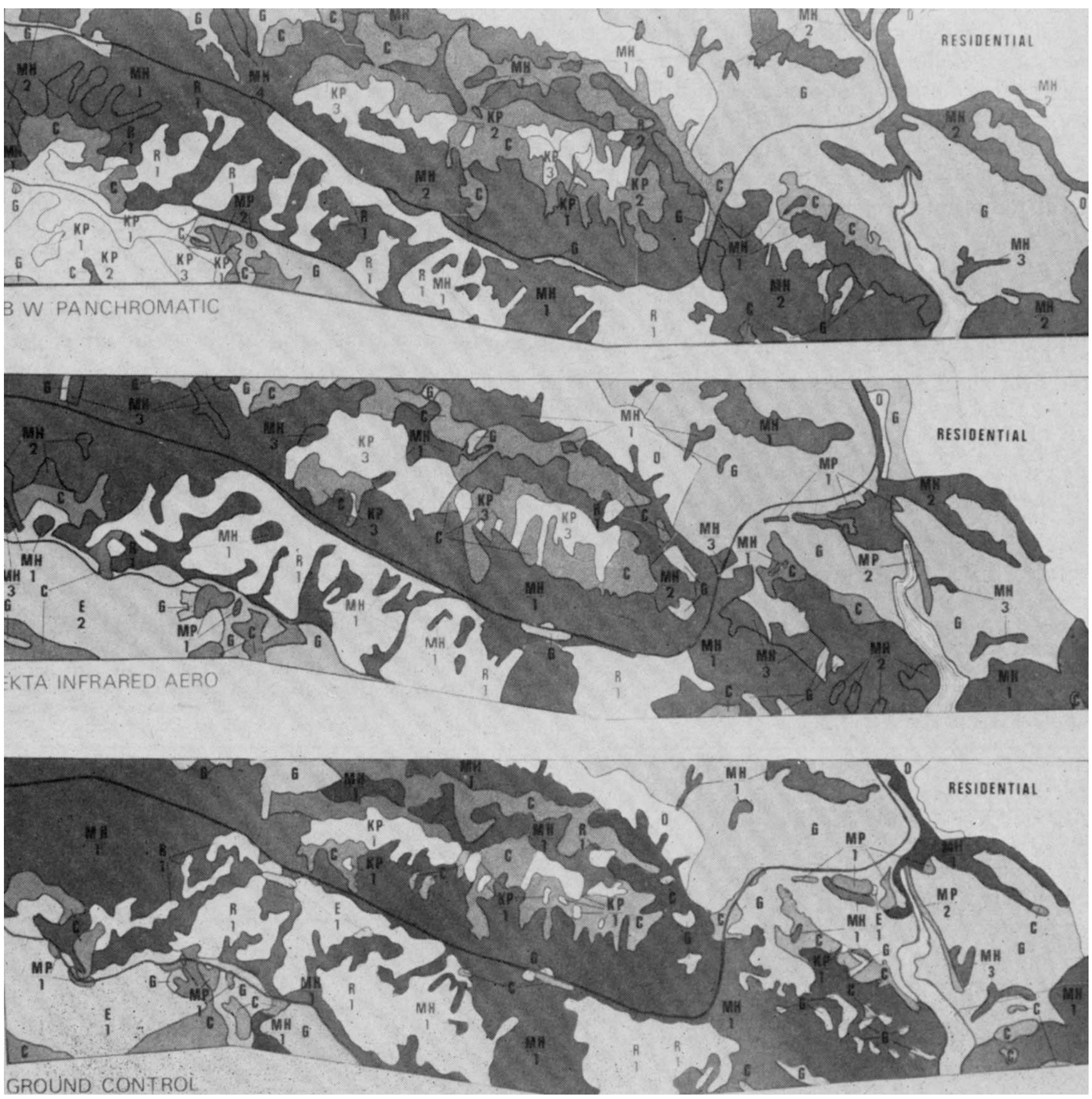
The study area is outlined above on a black-and-white panchromatic aerial photograph. The 1,460 acre area is covered with the following vegetative cover types: Monterey pine (15.5 acres), knobcone pine (33 acres), redwood (199.5 acres), eucalyptus (87 acres), mixed hardwood (653 acres), chaparral (185 acres) and grassland (287 acres).

Key to Vegetation Types (Numerator)

R = Sequoia sempervirens (redwood)
KP = Pinus attenuota (knobcone pine)
MP = Pinus radiata (Monterey pine)
E = Eucalyptus globulus (blue gum eucalyptus)
MH = Mixed hardwood (maple, madrone, buckeye, bay, oak)
C = Chaparral (chamise, coyote brush)
G = Grassland
O = Orchards

Key to Density Class (Denominator)

1 = Dense (80+%)
2 = Semidense (50–80%)
3 = Open (20–50%)
4 = Very open (5–20%)
5 = Unstocked (5–%)



The top two annotated maps are a summary of the information derived from photo interpretation of each of the two film-filter combinations used in this test (i.e., panchromatic-Wratten 12 and Ekta Infrared Aero-Wratten–15). Each map was compared with a third map (the ground truth map shown at the bottom of this figure) to determine the relative accuracy of timber stratifications and individual tree species identifications on each film-filter combination. A quantitative expression of the results of this test will be found in tables 1 and 2.

Cessna 180 aircraft was used to obtain the following photographs of the study area: (1) in the fall seasonal state—showing maximum foliage coloration differences between species, (2) at midday, high sun angle—assuring minimum shadow density, (3) with six-inch focal length Wild RC 8 metric cameras—providing maximum image resolution, (4) at maximum flying altitude (scale 1/32,000)—making possible small-scale coverage, and (5) with Plus-X Aerographic film with a Wratten 12 filter and Ektachrome Infrared Aero film with a Wratten 15 filter—the two film-filter combinations being tested (see photo).

"Ground truth"

On the ground, a 100 per cent "ground truth" survey of the timber resource was made, with the aid of large-scale aerial photography. In this ground survey, with which photo-interpretation results were compared, timber type boundaries were accurately delineated, a delineation based on stand composition and stand density.

The interpreter of the photographs showed proper motivation, patience, good judgment, a capability for deductive reasoning, and high acuity for the perception of tone, color and image sharpness. Since he had no experience in forestry, was not familiar with the study area and had not been involved in the field checking, there was little possibility of bias. The interpreter was trained for his task solely through the use of a photo interpretation key.

The information obtained by photo interpretation was compiled in the form of planimetric maps (see photo). To eliminate map compilation errors, a photogrammetric instrument called the Kail plotter was used to plot planimetric detail. With the aid of a dot-grid overlay system, each map was compared with the ground truth map for the same area—thereby enabling a quantitative analysis to be made (see tables 1 and 2).

Results and conclusions

Probably the most satisfying conclusion drawn from this study was that the photo interpretation key, used as the sole source of training and reference material, provided the interpreter with a means of mapping vegetation in an area completely unfamiliar to him. For the 1,460 acres analyzed, he misinterpreted the identity of the predominant vegetative cover type of only 332 acres on panchromatic photographs and only 151 acres on Ektachrome Infrared Aero photographs. Thus, if an interpreter has proper motivation and skill, if photography is flown to proper specifications, and if an adequate photo interpretation key is made available, accurate vegetation surveys can be made without using the expensive and time-consuming ground survey techniques.

Ekta infrared

These results show that Ekta Infrared Aero photographs provided the interpreter with significantly more information than conventional black-and-white panchromatic photographs, especially for locating, identifying, and distinguishing between forest types with similar image characteristics (i.e., Monterey pine, knobcone pine, eucalyptus, and redwood).

Slightly better

One might prematurely conclude that although color infrared photography gives slightly better results (compared with black-and-white photography), the slight increase in interpretation accuracy would not offset the added cost of making the color photographs. However, besides providing more accurate results, the analysis of color infrared photography required approximately 25 per cent fewer man-hours of interpretation time than black-and-white photography. Considering high labor costs, this factor is extremely important, especially since salaries dominate the costs of large survey jobs. When interpreting color photos, the interpreter more quickly recognized image characteristics and more rapidly identified the species composition. Consequently, much less time was devoted to pondering over difficult decisions. With this combination of advantages, the interpreter is far less likely to be fatigued. Since interpretation accuracy decreases rapidly as fatigue increases, the total gain from the use of color infrared photography, particularly on large projects, may be even greater than is indicated here.

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TABLE 1. TIMBER TYPING ON SMALL SCALE AERIAL PHOTOGRAPHY

PANCHROMATIC FILM; WRATTEN 12 FILTER; SCALE 1/32,000. Figures in darkest rectangles indicate accuracies achieved, as expressed in both acreages (numerator) and percentages (denominator). Figures in other rectangles indicate errors made. In the total area of 1,460 acres, 1,128 acres were correctly identified, giving an overall accuracy of 77%.

COVER TYPE	TOTAL AREA	IDENTIFIED AS: MH	MP	E	KP	C	R	G
MIXED HDWD.	653	547.5/85%	0/0%	0/0%	11/1%	47.5/7%	30/5%	17/2%
MONT. PINE	15.5	9/58%	1.5/10%	0/0%	3/19%	0/0%	0/0%	2/13%
EUCALYPTUS	87	0/0%	0/0%	0/0%	85/98%	0/0%	2/2%	0/0%
KNOB. PINE	33	1/3%	0/0%	0/0%	26/79%	6/18%	0/0%	0/0%
CHAPARRAL	185	24.5/13%	0/0%	0/0%	5/3%	143/77%	0/0%	12.5/7%
REDWOOD	199.5	64.5/32%	0/0%	0/0%	0/0%	0/0%	135/68%	0/0%
GRASSLAND	287	8.5/3%	0/0%	0/0%	0/0%	3/1%	0/0%	275.5/96%

TABLE 2. TIMBER TYPING ON SMALL SCALE AERIAL PHOTOGRAPHY

EKTA INFRARED AERO FILM; WRATTEN 15 FILTER; SCALE 1/32,000. Figures in darkest rectangles indicate accuracies achieved, as expressed in both acreages (numerator) and percentages (denominator). Figures in other rectangles indicate errors made. In the total area of 1,460 acres, 1,309 acres were correctly identified, giving an overall accuracy of 89%.

COVER TYPE	TOTAL AREA	IDENTIFIED AS: MH	MP	E	KP	C	R	G
MIXED HDWD.	653	577.5/88%	0/0%	1/0%	11/2%	29.5/5%	29/5%	5/0%
MONT. PINE	15.5	5/32%	7/45%	2.5/16%	0/0%	0/0%	0/0%	1/7%
EUCALYPTUS	87	0/0%	0/0%	83/95%	0/0%	1.5/2%	2.5/3%	0/0%
KNOB. PINE	33	.5/1%	0/0%	0/0%	31/94%	1.5/5%	0/0%	0/0%
CHAPARRAL	185	20.5/11%	0/0%	1/0%	9.5/5%	147/79%	0/0%	8/4%
REDWOOD	199.5	11.5/6%	0/0%	0/0%	0/0%	0/0%	188/94%	0/0%
GRASSLAND	287	6/2%	1/0%	0/0%	0/0%	4.5/2%	0/0%	275.5/96%