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P. O. BOX 245
BERKELEY, CALIFORNIA 94701



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ABSTRACT: Daily progression of shadows cast by red and white fir trees in forest stand openings is illustrated by vertical aerial photographs made on the summer solstice at 2-hour intervals from 7 a.m. to 5 p.m. The aerial photos show shade patterns in three irregularly - shaped, natural stand openings and two different widths (3-chains and 5-chains) of clearcut strips. Illumination measurements are reported to aid interpretation of shadow patterns.

RETRIEVAL TERMS: shading (protective) (-seedlings); seedling survival; natural regeneration; forest clearcutting; photogrammetry; light; *Abies concolor*; *Abies magnifica*.

OXFORD: 236.3:231:221.1:587:111.211:174.7 *Abies concolor*:174.7 *Abies magnifica*.

Tree Shadow Patterns and
Illumination Measurements
within clearcut strips and irregular
openings in a true fir forest

DONALD T. GORDON

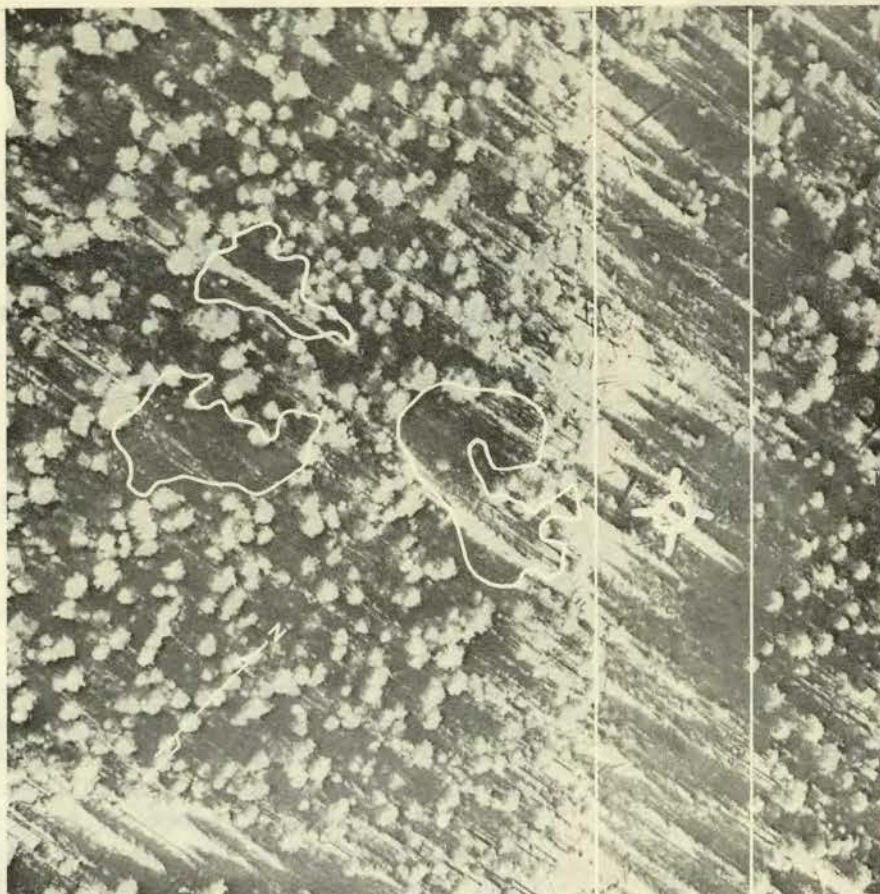
Do tall fir trees at edges of clearcut stands provide as much shade for seedlings as we usually think they do? Probably not--but apparently enough to help seedlings survive. More seedlings become established near cutting edges than at some distance from them. This was one of the findings in a recent study of factors that affect natural seedling establishment of white fir (*Abies concolor* [Gord. & Glend.] Lindl.) and red fir (*A. magnifica* A. Murr.) in clearcuttings in northern California.¹

Two factors may be responsible: (a) more sound seeds fall near the cutting edges, where (b) shade from the uncut timber is most prolonged. And shade seems to help seedling establishment. The finding created the problem of resolving the relative importance of amount of seed fall and the amount of shade in natural regeneration of fir. The problem is not solved, but this note reports two methods of evaluating shade, or its antithesis, illumination.

Theoretical shade diagrams for cutting edges are often drawn, but they usually demonstrate only four variables: tree height, sun elevation, sun azimuth, and horizontal distance. They are useful for general concepts, but have limited value for relatively refined studies because shadow patterns cast by edge trees are complex. And the patterns vary because of tree size, shape, spatial distribution, and crown density or perviousness to light.



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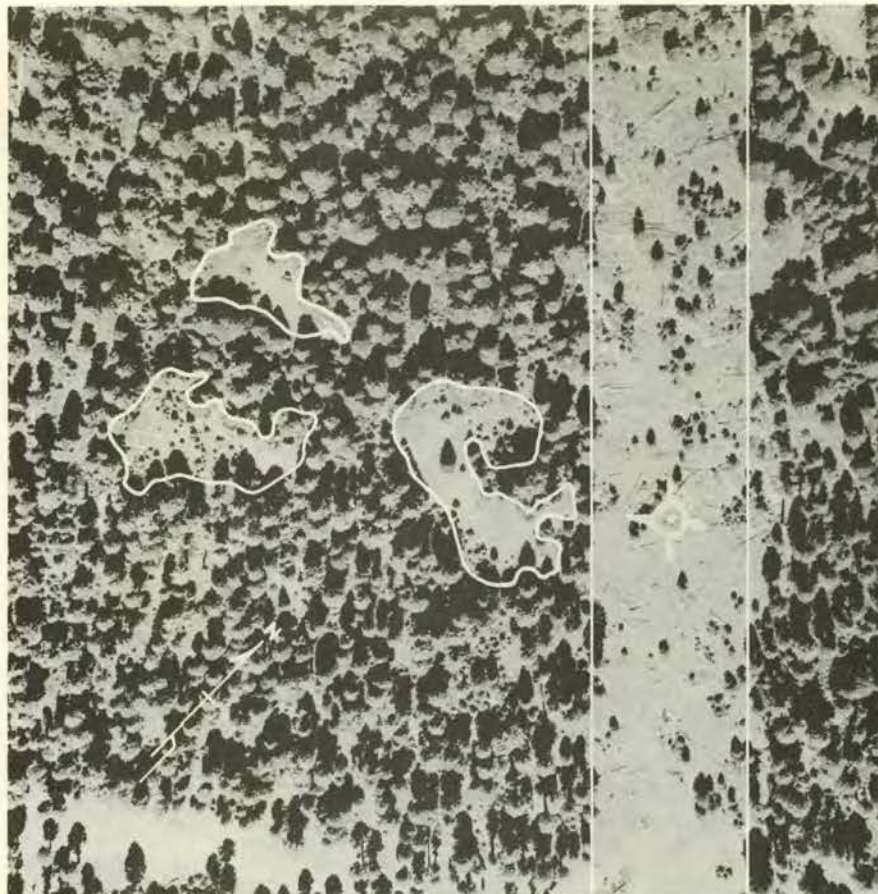


7 a.m P.S.T.

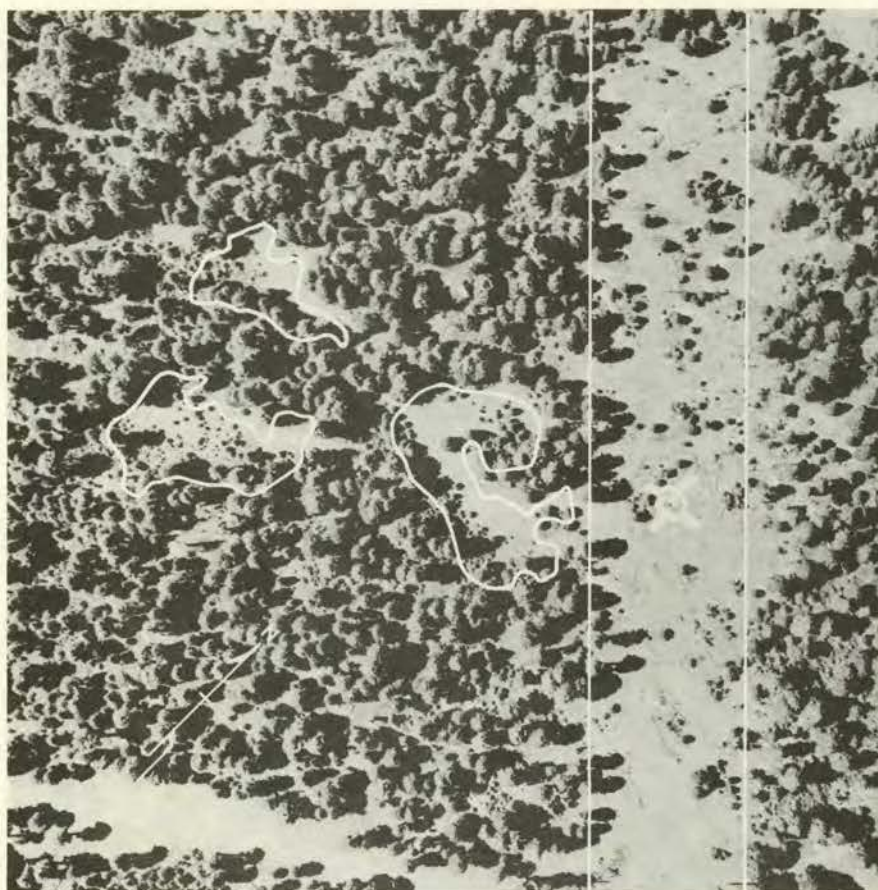


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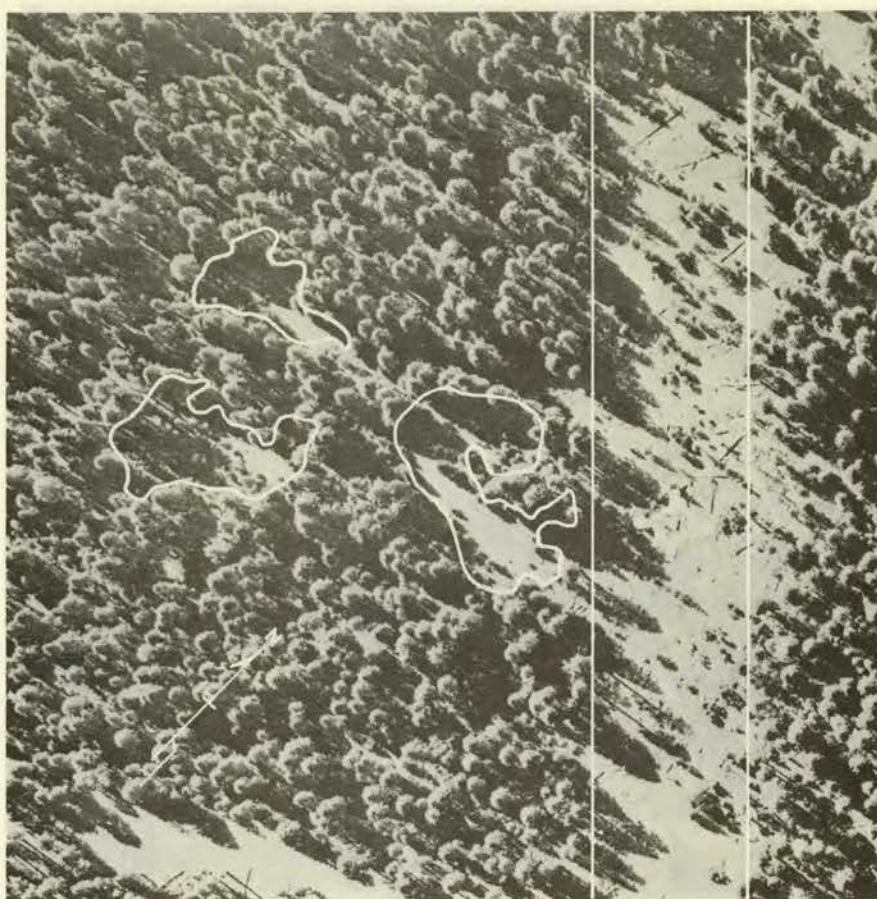
Figure 1.--Three-chain strip and natural openings in stand.
Photographed at 2-hour intervals beginning at 7 a.m., P.s.t.



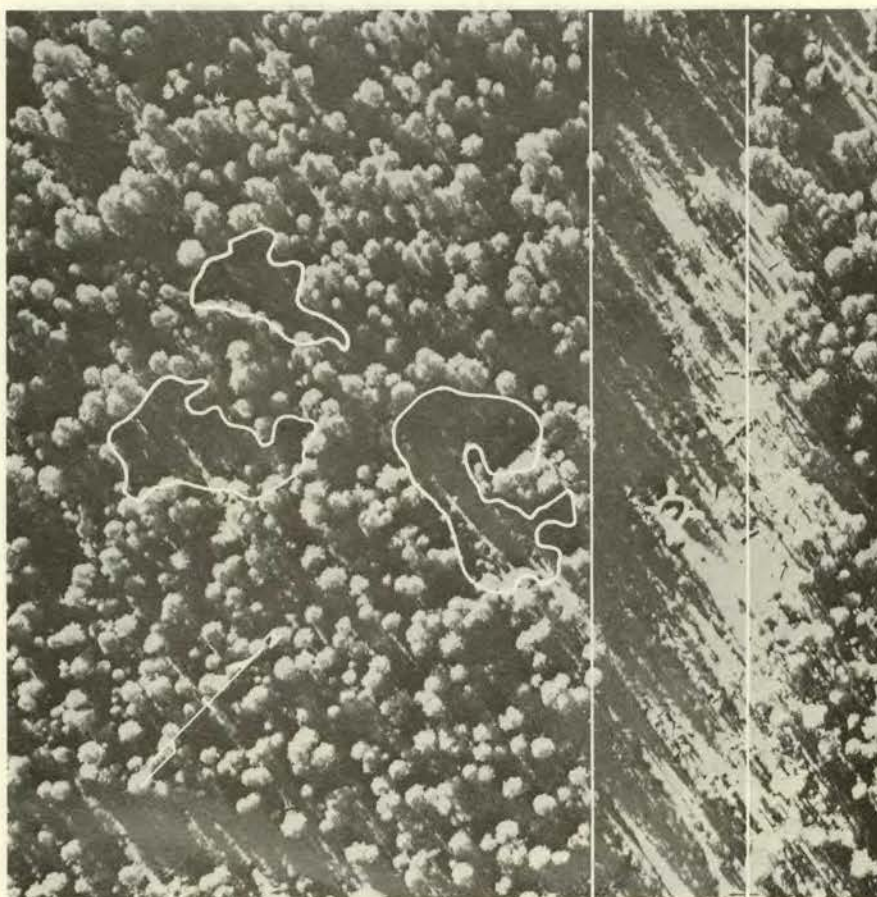
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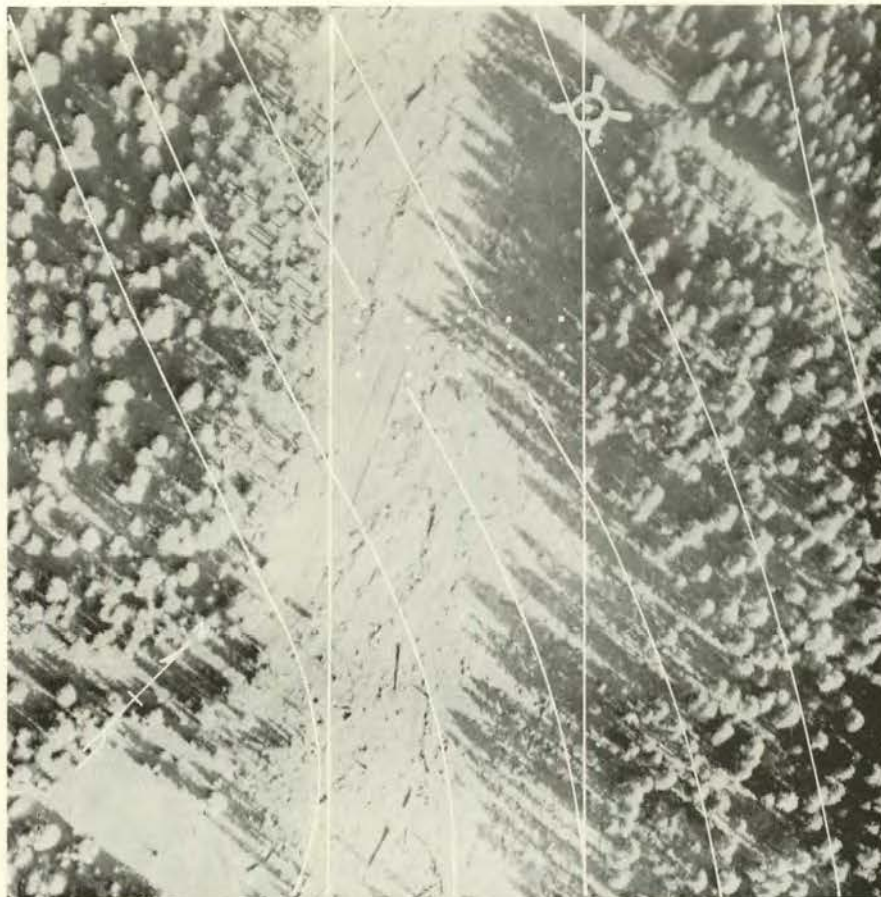
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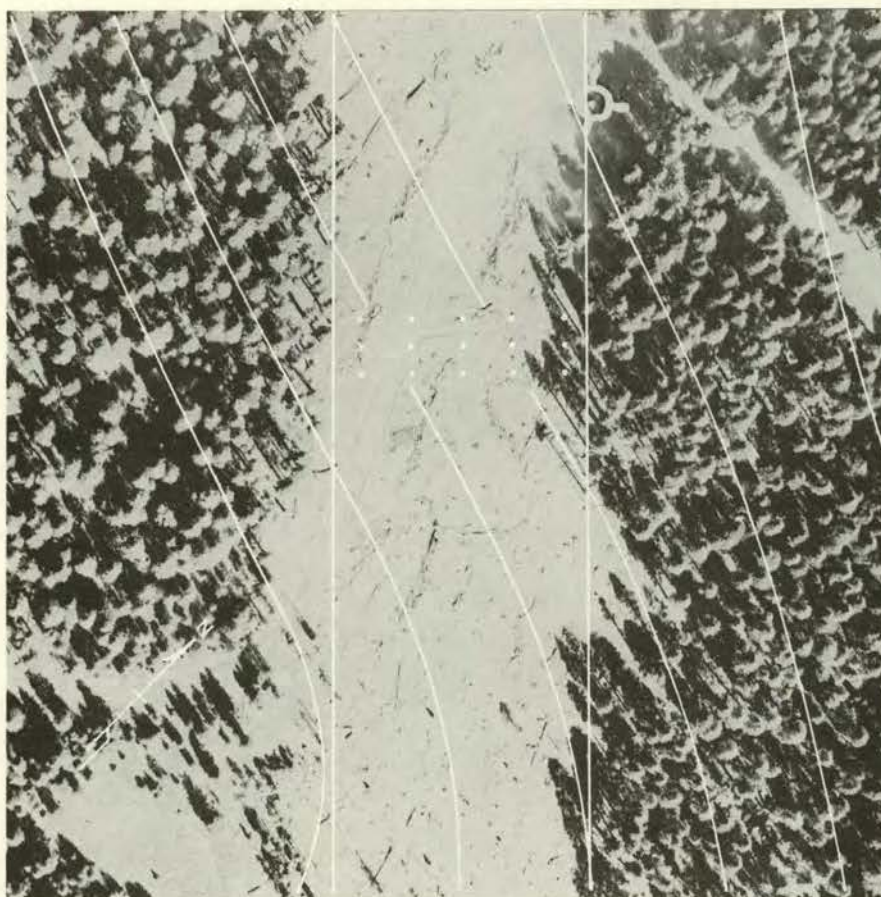
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5 p.m. P.S.T.

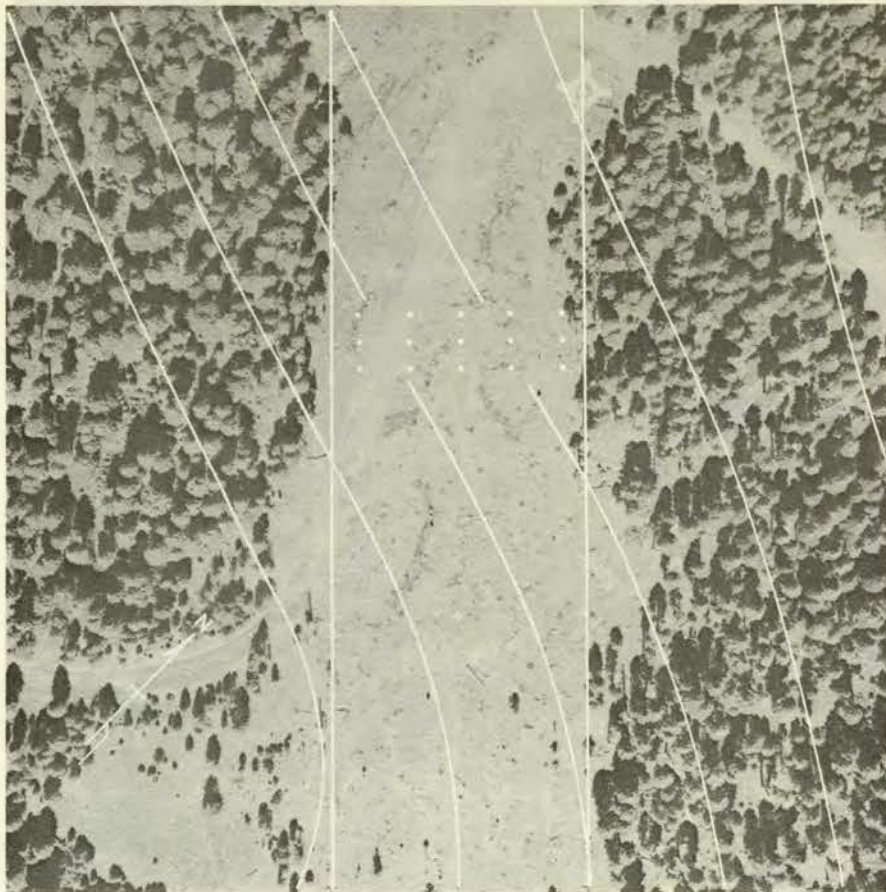


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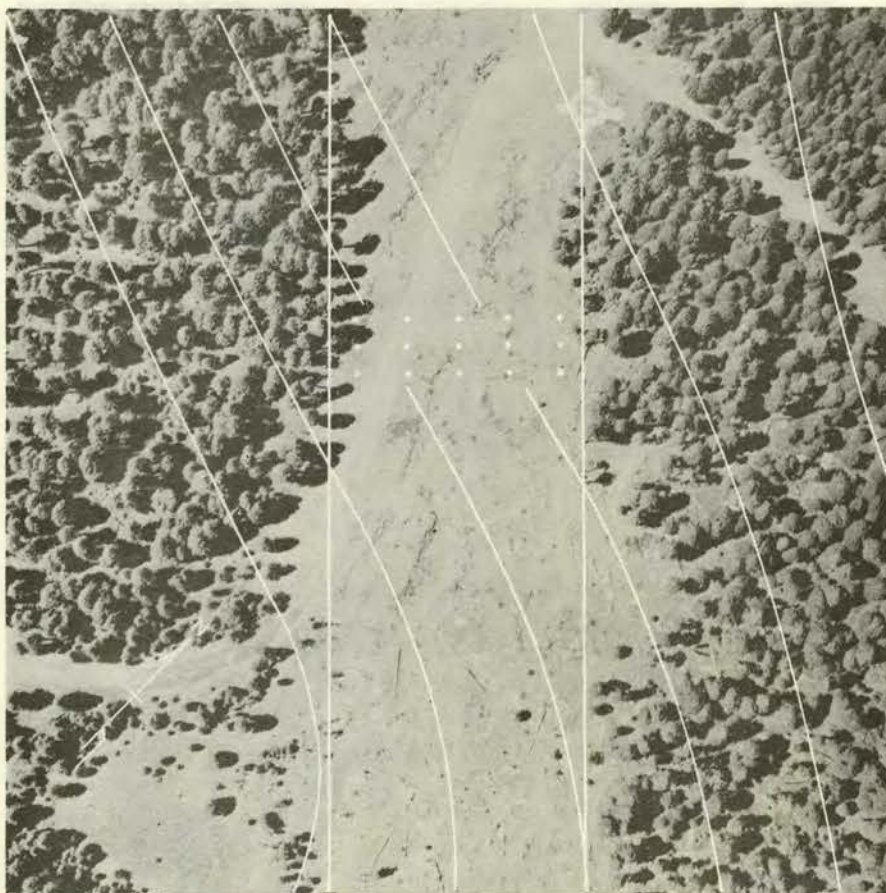


9 a.m. P.S.T.

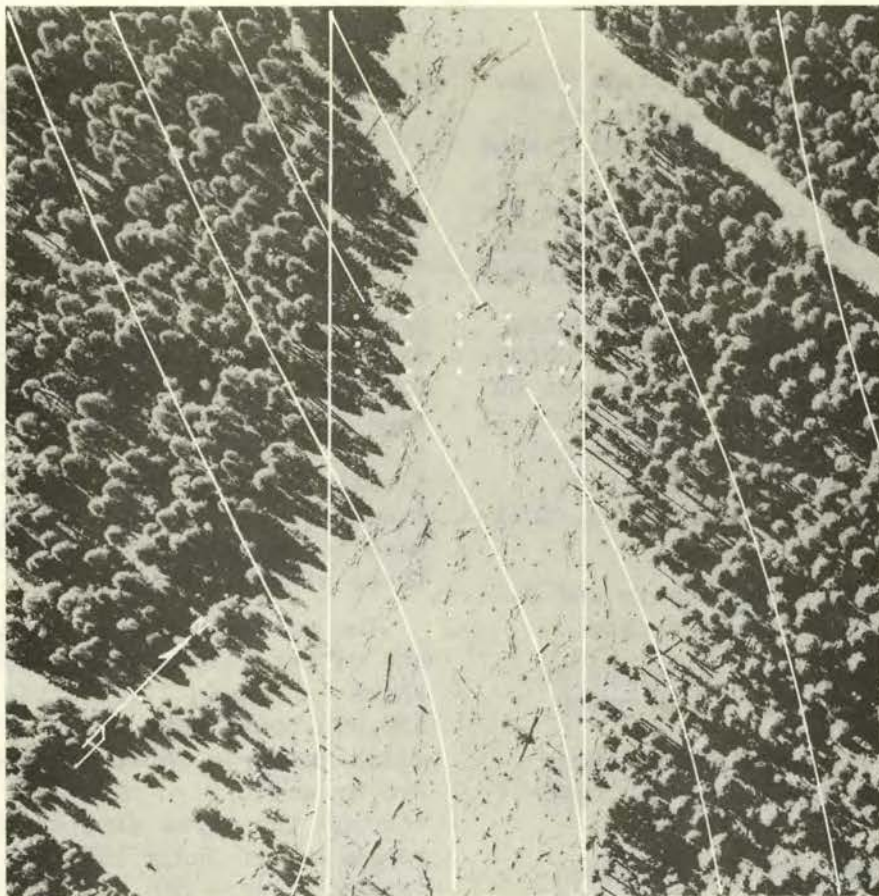
Figure 2.--Five-chain strip, photographed at 2-hour intervals beginning at 7 a.m., P.s.t. Dots show sampling points in illumination study. Contour interval: 20 feet.



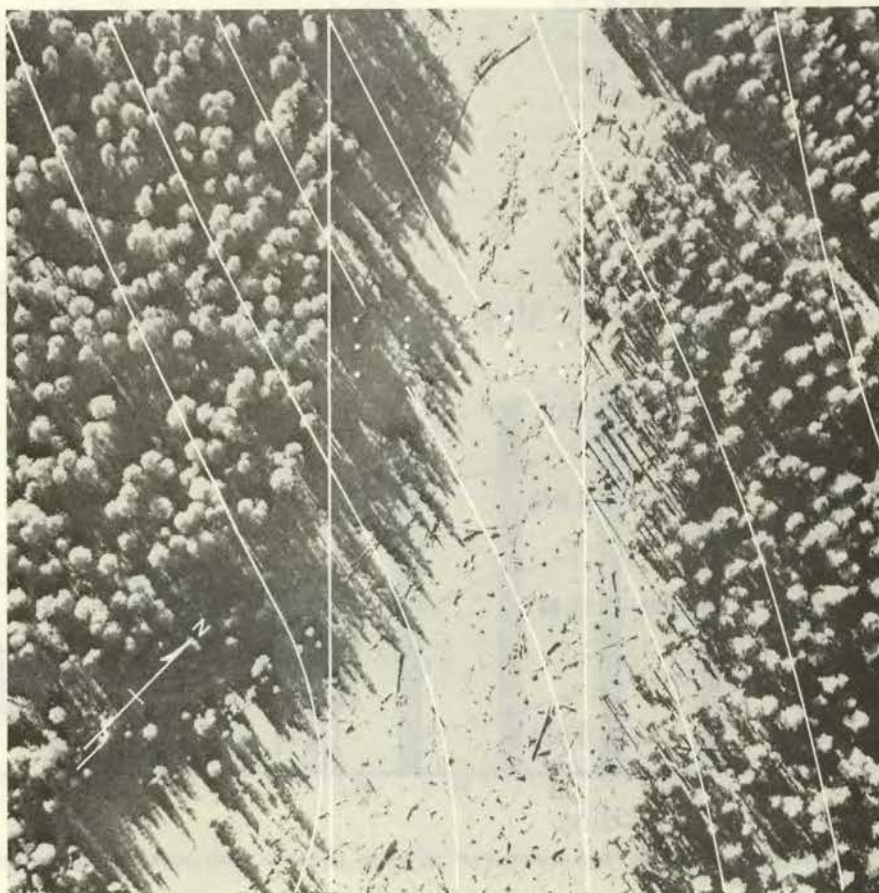
11 a.m. P.S.T.



1 p.m. P.S.T.



3 p.m. P.S.T.



5 p.m. P.S.T.

During the regeneration study I obtained a series of vertical aerial photographs on June 22, 1964, at 2-hour intervals from 7 a.m. to 5 p.m., P.s.t. (figs. 1, 2). At this time of year the sun is at maximum elevation (73°), and tree shadow lengths at noon are minimal.

Enlargements of some of the photos are reproduced in this note for comparison. The study areas pictured are on the Swain Mountain Experimental Forest, latitude $40^\circ 26'$ north, longitude $121^\circ 05'$ west, at 6,200 feet elevation, about 10 miles north of Westwood, California.

Annotations for the 3-chain and 5-chain wide strip photos indicate:

1. Parallel surveyed boundaries of cutting strips, oriented NW-SE.
2. Generalized boundaries of three irregularly-shaped natural openings near the 3-chain strip.
3. Contour lines for the 5-chain strip and vicinity. (Slopes for the 3-chain area face north to northeast and are gentle--mostly less than 10 percent--but topographic detail is unavailable).

4. Locations of sample points for an illumination study within the 5-chain strip.

Easily seen in the tree shadow portions of photos, particularly those for 7 a.m., are such features as sunflecks and variations in crown, such as: (a) perviousness to light, (b) absolute size and shape, and (c) relative size. But the most obvious observation is the relative lack of shade on clearcut strips during the day. To get proportionately longer periods of shade for seedbeds, artificial openings would have to be narrower than shown, given trees of equal height.

The pure fir timber stand at either end of the illumination study location shown in figure 2 would yield about 150,000 board feet per acre (Scribner gross volume)--about maximum yield for red or white fir. Movement of sunlight through the three-dimensional crown arrangement of these 150-foot-tall trees causes shadows and sun flecks to shift rapidly across the ground. Movement of tree foliage by wind adds another variable to the complex. The photo sequences, although unique, can suggest only

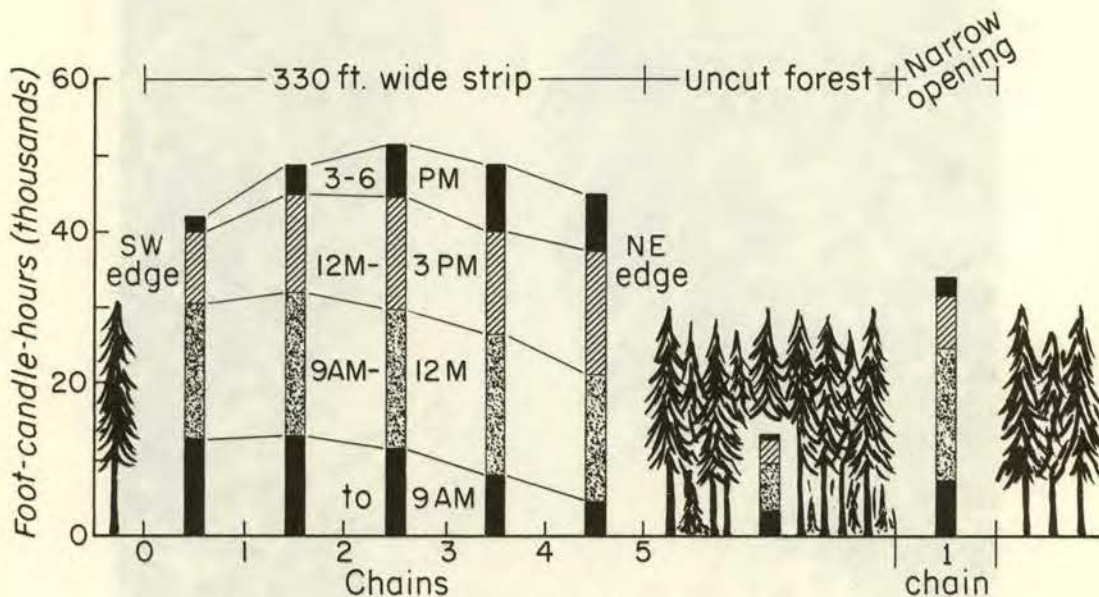


Figure 3.--Illumination was measured within forest openings and beneath a dense overmature stand.

periodic fragments of the total shadow-play during a day.

Another step toward understanding the effects of sunlight and shade was taken as a means of interpreting shadow patterns in the aerial photographs. On July 8, 1965, I measured cumulative illumination during 3-hour periods, using the benzene-anthracene technique.² Data were derived for points across the 5-chain wide strip, within a narrow stand opening, and beneath a dense overmature fir stand (fig. 3).

Trees at the edges of the 5-chain strip influenced illumination within the strip less than expected. The

total daily illumination at the southwest edge was about 80 percent of that at the center of the strip. Therefore, until we have more information, it is not possible to state conclusively all the effects shading by uncut edges of tall, dense fir forests has on seedling establishment--only that it seems to increase it.

FOOTNOTES

¹Gordon, Donald T. *Influence of several factors on natural regeneration of white and red fir.* (MS. in preparation.)

²Dore, W. G. *A simple chemical light meter.* Ecology 39(1):151-152, illus. 1958.

The Author

DONALD T. GORDON is doing research in the silviculture of Sierra Nevada forest types, with headquarters at Redding, Calif. Native of Oxnard, Calif., he was educated at the University of California, Berkeley (B.S. in forestry, 1939), and joined the U.S. Forest Service in 1940. He became a member of the Station's research staff in 1946.

