Pacific Southwest Forest & Range Experiment Station

P. O. BOX 245
BERKELEY, CALIFORNIA 94701

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White Fir Stands Killed by Tussock Moth

. . . 70-mm. color photography aids detection

STEVEN L. WERT   BOYD E. WICKMAN

ABSTRACT: The use of large-scale 70-mm. aerial photography proved to be an effective technique for detecting trees in white fir stands killed by Douglas-fir tussock moth in northeastern California. Correlations between ground and photo estimates of dead trees were high. But correlations between such estimates of lesser degrees of tree damage--thin tops and topkill--were much lower; increased training of interpreters could improve these correlations.

RETRIEVAL TERMS: Douglas-fir tussock moth; *Hemerocampa pseudotsugata;* white fir; *Abies concolor;* aerial photography; photo interpretation; photogrammetry; remote sensing; insect damage; defoliation damage; California.

OXFORD: 453--145.718 *Lepidoptera*; 174.7 *Abies concolor* (794): 587.

The Douglas-fir tussock moth *(Hemerocampa pseudotsugata* McD.) has caused widespread damage to white fir (*Abies concolor* [Gord. & Glend.] Lindl.) timber stands in the West in recent years. Wickman[1] found that mortality losses alone in heavily defoliated stands can reach 11,000 board feet per acre after 2 years of insect feeding. Other damage included 1,000 board feet per acre of growth loss, and 12 percent of the trees topkilled. Recurring outbreaks are of serious concern to forest managers trying to produce sawtimber and Christmas trees, and to protect recreation areas.

Research foresters and entomologists at the Pacific Southwest Station have joined forces in designing a survey method to determine the extent and severity of white fir damage following defoliation. They decided to use an aerial survey technique combining large-scale 70-mm. aerial photographs and 0.2-acre ground plots. Large-scale 70-mm. aerial photography was selected for two reasons: (a) defoliation and mortality in white fir stands in this case was difficult to determine accurately on small-scale photographs; (b) use of 70-mm. mat allows interpreters to view film stereoscopically in an uncut roll. Larger format films must be cut apart to view stereoscopically. The small format can be stored and handled much more conveniently.

An infestation on the Modoc National Forest in northeastern California was selected as a study area. Portions of the study area were properties of the Shasta Forest Company.[2] Here the insect has caused varying degrees of damage over 80,000 acres of white fir forest type. Three separate sites were chosen for photography (fig. 1).

Each site had experienced a different intensity of defoliation and tree mortality:

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Toms Creek--Light defoliation; mixed conifer to pure white fir stands; second-growth and mature trees; terrain nearly level.

Roney Flat--Medium defoliation; mixed conifer to pure white fir stands; mostly pole-sized second growth; terrain moderate.

Stowe Reservoir--Heavy defoliation; pure white fir stands; second-growth and mature trees; terrain moderate.

Obtaining photography. During the last week in July 1966, flight lines were superimposed over portions of three strip plots previously established on the ground by the forest entomologist. The strip plots consisted of a single white fir tree every chain on a N-S or E-W bearing. Ground markers were placed at the ends of the flight line strips and feed sacks were placed on tree tops at the ends of the lines to aid in photography and navigation.

Anscochrome[3] D/200 color film was exposed in a 70-mm. Mauer aerial camera from an Aero Commander 500-B airplane especially equipped for aerial photography. Large-scale (1:1,584) vertical aerial photographs were taken over each of the three flight lines.

Collection of ground data. The processed rolls of film (color transparencies) were delivered to the field crew to collect ground data. The data were gathered from trees along the existing strip plots. We would begin at the end of a flight line, walk along the strip to the first numbered line tree, and record the d.b.h., height, and crown condition of the tree. If the tree had been killed by the tussock moth, we estimated the year of death. By viewing the film strip on a portable light table (fig. 2), the field interpreter could locate each tree on the film and circle the image with red ink. He marked the number of the tree next to the circle. And he repeated this procedure for each line tree (numbered trees at 1-chain intervals) on the strip. A total of 190 line trees was marked on the film strips.

In addition, rectangular 0.2-acre plots (1 by 2 chains) were located lengthwise along the strips at 8-chain intervals (fig. 3). Each tree on the plot that was visible on the photographs and 2 inches d.b.h. or larger on the ground was circled onto a clear acetate overlay placed on the film, and assigned a number. The d.b.h., height, and tree crown condition were recorded for each tree on the plot and noted whether it was visible or not

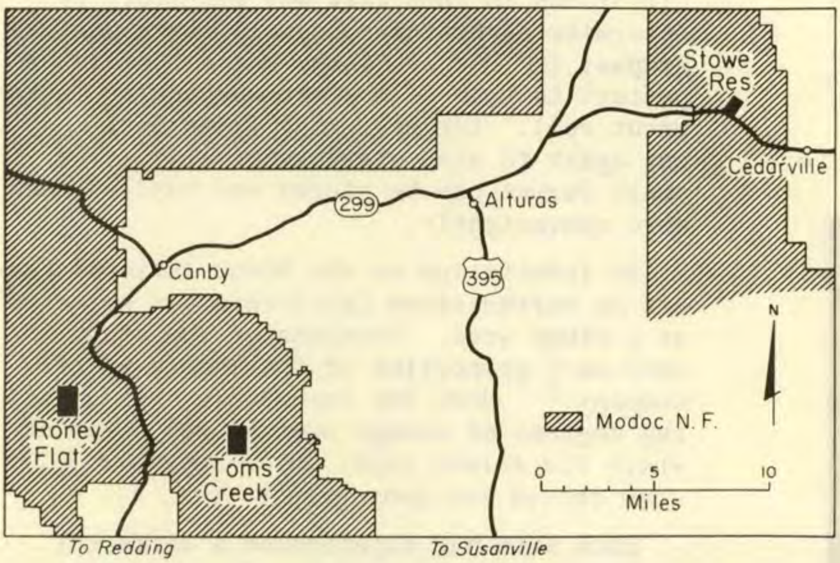

Figure 1.--*Three sites on the Modoc National Forest, northeastern California, were selected to study white fir mortality by aerial photography: Toms Creek, Roney Flat, and Stowe Reservoir.*

Figure 2.--*Portable light was used to view aerial films taken over a flight line. The photo interpreter marked the location of trees on the film.*

visible on the aerial photographs. The plot corners were pinpricked on the film to delineate the boundaries for future interpretation. This procedure was repeated for all plots. Nineteen 0.2-acre plots were examined on all three study locations.

Additional data were taken outside but next to the plot boundaries. Other tree species were recorded and marked on the film. This information was used to train interpreters for species identification within the plots.

Office photo interpretation. Four individuals[4] of varying backgrounds and photo interpretation experience served as the photo interpreters. Their experience was as follows: (a) a research forester with 20 years experience in forest photo interpretation, (b) a forest entomologist with several years experience in military intelligence photo interpretation, (c) a forest entomologist with relatively little experience in photo interpretation, and (d) a forestry student with classroom instruction in photo interpretation.

Training aids were assembled to bring the interpreters to a common level of knowledge. They consisted of several ground slides and sample strips of 70-mm. color film in pine-fir timber stands. When the interpreters felt sufficiently confident, they were given a species identification test from portions of the study areas. The test was designed to check the interpreter's ability to distinguish white fir from associated tree species.

The men were then asked to interpret the aerial photographs of the line trees and also the 0.2-acre plots. For the 190-line trees known

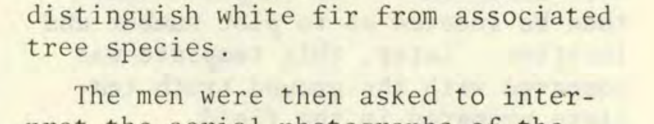

Figure 3.--*Rectangular plots 1 by 2 chains were set up along the flight strips at 8-chain intervals to collect data on trees and their condition.*

Table 1.--*Simple correlations (r) of photo interpretation to ground observations of tree conditions, by interpreters and plots*

Tree condition	0.2-acre plots		Strip plots	
	Interpreter		Interpreter	
	Experienced	Inexperienced	Experienced	Inexperienced
Live tree	0.84	0.87	0.84	0.87
Dead tree	.97	.98	.95	.94
Topkill > 6 ft.	.35	.50	.54	.22
Topkill < 6 ft.	.79	.72	--	--
Thin foliage	.64	.70	.44	.33

to be white fir and already circled and numbered on the transparencies, the interpreters were to determine only the tree crown condition. Tree crown condition is defined as being dead or alive; if alive whether the crown needle complement is thin or normal and how much topkill is present, if any. Topkill was expressed in feet of dead top.

For the 19 rectangular 0.2-acre plots the interpreters were asked to record the tree crown condition of all visible white fir trees on the plots. Other species would not be recorded by the interpreter. However, the interpreter had to first determine if a tree on the plot was in fact a white fir. He would also prepare a clear plastic template and delineate and number all white fir or groups of white fir onto the template with india ink. The template would then be indexed as to plot number and location. Later, this template was compared with the ground truth template prepared in the field.

During interpretation of both the line trees and plot trees the men recorded the time required to make interpretations.

Data Analysis

A regression analysis determined the correlation of photo interpretation to field observation in each category of tree condition (table 1).

We found that interpreters were able to detect dead white fir on the plots and the line trees with a high degree of accuracy. The relative experience of the interpreter did not seem to be a significant factor. The photo interpretation training for this particular study apparently brought the four interpreters to a common proficiency level.

Interpreters' estimates of other categories of tree condition did not show strong relationships. Correlations between their photo and ground estimates of topkill and thin foliage were low. Apparently they did not receive enough training in the recognition of these categories.

A computer program[5] analyzed errors made by interpreters among all trees examined. Data from one of the interpreters were incomplete, but, the other interpreters provided complete data from three experience levels (table 2; fig. 4).

Discussion

Over-all, the technique used for detecting white fir mortality seemed successful. We could not find any significant difference between interpreter accuracy on the line trees and accuracy within the plots. In both cases, the number of dead white fir was interpreted correctly more than 90 percent of the time. We believe that the number of errors in interpretation can be reduced by more extensive training of the photo interpreters. And we are convinced that we could not have obtained as good results on photography of any smaller scale. This is particularly true for interpreters identifying the proper tree species and measuring topkill and thin crowned trees.

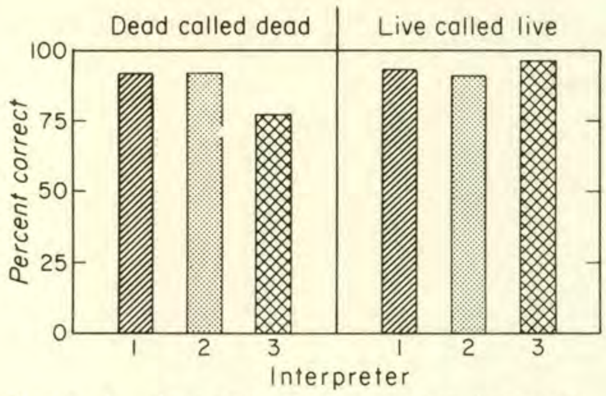

Figure 4.--*Accuracy of three photo interpreters in determining live and dead white fir trees.*

A photo interpreter devoting full time to interpretation was able to complete the work in about 10 man-days. Interpreters averaged 1.39 min. (83 seconds) per tree observed. The time required ranged from 0.94 min. to 1.80 min. per tree for all interpreters.

Conclusions

The strong points in favor of the technique used in this study are these. Mortality correlations in all cases were high. Time required to make evaluation on aerial photography would be minimal compared to a similar evaluation made on the ground. And interpretation accuracy did not seem to be affected by photo interpretation experience when sufficient training was provided.

On the other hand, more training could have been given interpreters in recognizing top-killed and thin-foliaged crowns. The size of the plots selected (1 by 2 chains) was difficult to work in the field. And excessive numbers of trees on some plots made template comparisons (PI to ground) difficult; some valuable data were lost in these cases.

On the whole the strong points outweighed the weak ones. Most of the shortcomings can be overcome by slight revisions in procedure and by more training.

Table 2.--*Errors in interpreting tree crown conditions in 190 line-trees, by three photo interpreters*

Tree crown condition	Interpreter		
	No. 1	No. 2	No. 3
	No. errors		
Normal crowns, top-kill called thin	2	4	2
Normal crowns, called thin	25	25	5
Normal crowns, called thin and top-killed	1	1	1
Normal crowns, called top-killed	0	0	4
Thin crowns, called top-killed	7	5	8
Dead crowns, called live	2	2	8
Live crowns, called dead	9	13	8

FOOTNOTES

[1]Wickman, Boyd E. *Mortality and growth reduction of white fir following defoliation by the Douglas-fir tussock moth.* U.S. Forest Serv. Res. Paper PSW-7, Pacific SW. Forest & Range Exp. Sta., Berkeley, Calif. 15 pp., illus. 1963.

[2]We wish to thank the Shasta Forest Company for supplying study sites and field help.

[3]Trade names and commercial products or enterprises are mentioned for information. No endorsement by the U.S. Department of Agriculture is implied.

[4]We thank Robert C. Aldrich, Clarence J. DeMars, and Richard H. Smith of the Pacific Southwest Forest and Range Experiment Station, and Eric Janes of the University of California, for their help in photo interpretation.

[5]We thank Richard O. Anderson for his assistance in designing the computer program.

The Authors

STEVEN L. WERT, a research forester, is assigned to the Station's remote sensing research unit in Berkeley, Calif. A native of Fort Wayne, Ind., he holds forest management degrees from Pasadena City College (A.A. 1960), Utah State University (B.S. 1963), and Oregon State University (M.F. 1966). He joined the Station in 1966. BOYD E. WICKMAN, a research entomologist, was formerly with the Station's forest insect research staff. He is now assigned to the Forestry Sciences Laboratory, Pacific Northwest Station, Corvallis, Ore.