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Field Evaluation of Small-Scale Forest Resource Aerial Photography*

Experienced professional field forest resource managers considered scales smaller than 1:24,000 unacceptable for standard data collection.

Abstract: *Economic considerations prevent most forest land managers from obtaining conventional black-and-white medium-scale (circa 1:15,000-1:20,000) forest aerial photography at adequate intervals. Were smaller-scale photos comparably useful, the savings in procurement and interpretation costs could be used for more frequent overflights.*

Forested portions of Minnesota were flown with black-and-white infrared at scales of 1:15,840; 1:24,000; and 1:31,680 and with color infrared at scales of 1:31,680 and 1:80,000. Trained cooperators who analyzed the photographs under field-use conditions with high quality viewing equipment considered black-and-white forest photography at a scale of 1:24,000 marginally acceptable at best, and judged scales smaller than 1:24,000 unacceptable for the resource management applications involved. Overall, good quality summer black-and-white infrared 1:15,840 scale photography was preferred, but many user-cooperators were enthused about the potential of small-scale coverage as a supplement to, not a replacement for, conventional medium-scale photography.

Color infrared transparencies provided more information than black-and-white prints of equivalent scale, but were considered overly cumbersome for day-to-day use under existing field office conditions.

Introduction

A growing problem in aerial photography applications to forest management in many parts of the U.S. is the lack of funds for obtaining the proper type(s) of photo coverage at adequate intervals in time. A frequently suggested approach to reduced forest photo procurement cost is the use of smaller photo scales (Latham and McCarty, 1972; Lauer and Benson, 1973; Ulliman, 1975). As a case in point, 1:31,680 scale photo coverage in lieu of 1:15,840 scale over a given area would require about 75 percent fewer prints. Such a print number reduction would be reflected in substantially lower costs of acquisition, purchase, storage, handling, and interpretation. However, this would not be a logical substitution if it were

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accompanied by any significant reduction in interpretable information quantity and quality (Nash, 1963). A preliminary study by Ulliman and Meyer (1971) under laboratory conditions suggested the possibility of using smaller scales of summer infrared black-and-white forest photography without serious information loss. This investigation subjected their idea to a field test by experienced cooperators.

Study Area Locations

In order to provide results useful to a large number of forest photography users in the Lake States, a study area with a wide diversity of typical vegetation types—Itasca County, Minnesota—was selected (Figure 1). Secondary sites were chosen in Becker and Mahnomen counties in order to sample slightly different types of areas. Whereas Itasca County typifies the sub-boreal forest of northeastern Minnesota, Becker and Mahnomen are representative of the drier western prairie border counties.

Aerial Photography

The principle objective of this study was to determine the degree of acceptability, to field practitioners, of summer infrared black-and-white infrared photography at a scale, or scales, smaller than the conventional 1:15,840. As Figure 1 and Table 1 indicate, recent 1:15,840; 1:24,000; and 1:31,680 scale coverage was obtained over the study areas. Although all of the 1:24,000 and 1:31,680 scale black-and-white photography was flown in the period 1972-74, only the 1:15,840 over Becker and Mahnomen counties was flown during the same period. In Itasca County, due to problems of weather and flight scheduling, the 1:15,840 scale was not flown in the 1972-74 period and existing 1966-69 coverage had to be utilized as a basis for comparison. This posed no problem insofar as the field cooperators were concerned because of their familiarity with the area and their ability to select representative locations and cover types which had undergone negligible change since photography.

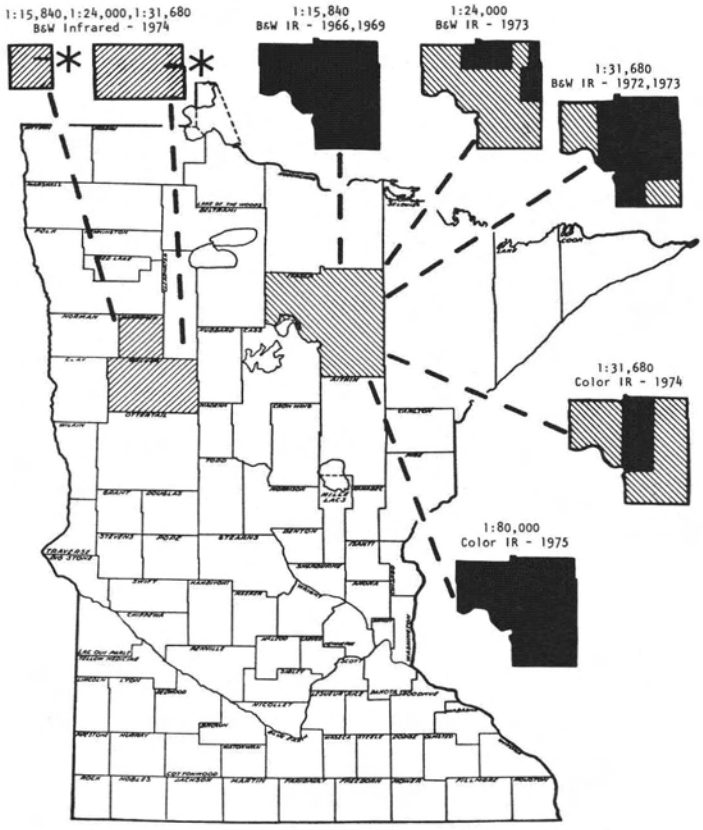

FIG 1. Aerial photography employed in the study.

TABLE 1. CHARACTERISTICS OF PHOTOGRAPHY TESTED.

County	Dates	Film & Filter[1]	Scale	Contracting Agency	Field Cooperators Agency	Field Cooperators Individual
BECKER	Sept 1974	Aero IR 2424 Wratten 12	1:15,840 1:24,000 1:31,680	MinnDNR UMinnCollFor UMinnCollFor	MinnDNR	Baumgartner & Rupert
MAHNOMEN	Sept 1974	Aero IR 2424 Wratten 12	1:15,840 1:24,000 1:31,680	MinnDNR UMinnCollFor UMinnCollFor	MinnDNR	Rodewald & Kresien
ITASCA						
· Entire County	Jul-Aug-Sept 1966 July 1969	Aero IR 2424 Wratten 12	1:15,840 1:15,840	ItascaCy USFS	USFor Serv MinnDNR	Goldie & Goltz[2] Tarbell, Licke, Nixon, Tornes, Mooty, Pierce, & Stenlund[3]
· North Central	Aug-Sept 1972 Jul-Aug 1973	Aero IR 2424 Wratten 12	1:31,680	UMinnCollFor	ItascaCy IRRRB BlandinPapCo	Marshall Kobs, Lauber, Johnson & Olson Peterson, Morrow & Hanson
· North Central and Northeast	Aug-Sept 1973	Aero IR 2424 Wratten 12	1:24,000	UMinnCollFor	RajalatimbCo BoiseCascadeCorp SoilConsServ	Ringold Hubbard, Olson & Cutler Nyberg & Sharp
· North Central	Sept 1974	Aero Ektachrome IR, Wratten 12	1:31,680	UMinnCollFor	USForServ MinnDNR ItascaCy IRRRB	Goldie & Johnson Tarbell, Cass, Nixon & Tornes Marshall Lauber
· Entire County	Aug-Sept 1975	Aero Ektachrome IR, Wratten 12	1:80,000	UMinnCollFor	BlandinPapCo	Peterson, Morrow Hanson

[1] Wratten 12 equivalent used.
[2] Both forest management and forest soils specialists involved.
[3] Both forest and wildlife management specialists involved.

A secondary purpose of the study was to expose as many cooperators as possible to training and applications experience in the use of color infrared photography and, subsequently, solicit their reactions to it. To this end, a sizable portion of Itasca County was flown with color infrared at a scale of 1:31,680 in 1974 and the entire county was flown at a scale of 1:80,000 (i.e., "quad-centered") in 1975.

STUDY DESIGN, PROCEDURES

USER-COOPERATOR SELECTION AND TRAINING

Because of the intense interest and degree of use of forest aerial photography, a large number of capable cooperators volunteered their services, including users in forestry, wildlife management, and soil science in both public and private sectors of forest land management.

Despite their experience in photo interpretation, additional training in preparation, handling, and viewing and use of the various types of photography was essential. This was accomplished at each cooperator's home station on an individual basis to the degree necessary. Additionally, periodic visits to cooperators served to answer questions and maintain the quality and scope of the evaluations.

PHOTO INTERPRETATION EQUIPMENT, INTERPRETATION AIDS

Although most of the cooperators use aerial photography on a near-daily basis, viewing equipment usually consists of a pocket stereoscope and marginal office working conditions (Figure 2). In order to assure the best possible viewing conditions and consistency, each cooperator was provided with suitable viewing equipment and lighting (Figure 3). For the cooperators involved in viewing the 9×9-inch CIR transparencies, a specially equipped light table was also provided.

In addition to vegetation cover type and condition class delineation, most users frequently perform distance measurements and calculate areas. To provide comparative tests of these functions between photo scales, area dot grids and aerial photo rulers designed for all scales to be tested were furnished.

FIG 2. Typical viewing station encountered in the field offices of project cooperators—often crowded, noisy, and poorly lit.

FORMS OF AERIAL PHOTOGRAPHY TESTED

The 9×9-inch prints were printed to the same contrast level on double weight semi-matte paper. Glossy prints also were provided but rejected as unsuitable, primarily because pencil annotations could not be made on the glossy surface.

The color infrared 9×9-inch transparencies were cut, sleeved, and labelled before delivery to the cooperators. All cooperators involved in this portion of the study were given thorough instruction and assistance in handling, viewing, and detail delineation.

To the extent appropriate to their particular work, each cooperator performed specific tasks on the different scales of photo coverage:

- Vegetation cover type and condition class mapping.
- Area measurement.
- Distance measurement.
- Planning (e.g., road layout, timber sale design, fire planning).

DESIGN OF TEST QUESTIONNAIRE

All too often, photo interpretation tests are conducted under laboratory or pseudo-field conditions with interpreters who lack the experience and on-the-ground management applications knowledge, typical of the average professional field user. Although such tests lend themselves to various experimental designs capable of producing quantitative results bearing a high degree of statistical credibility, the final results often may not be meaningful in real world terms.

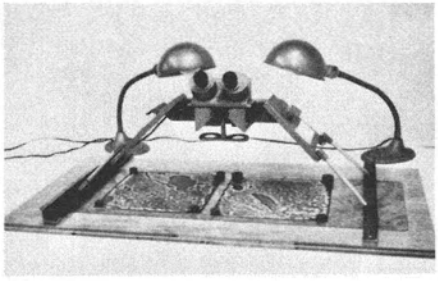

FIG 3. Equipment provided each cooperator for photo evaluation: mirror stereoscope with 3× binoculars, railtype viewing table, metal viewing board with magnets, and individually adjustable lamps.

Because of the diverse biological nature of the scene subjects under analysis by the skilled forest resource photo interpreter, individual subjective judgment based upon experience is his (the interpreter's) most powerful tool in the information extraction and management decision process. As a consequence, this study was designed from the outset to ascribe ratings to the various photo types under evaluation on the basis of the professional judgment of experienced, skilled forest cooperators. A highly structured, quantitatively based assessment was a logistic impossibility under the circumstances and, even if it were, there was no known reliable way in which it could adequately reflect the most useful photo quality evaluator (i.e., individual experience). Consequently, completion of a narrative evaluation based upon the following items was requested from each cooperator at the termination of his work:

Background information.

- Agency/firm, location, management objectives.
- Types, source, and adequacy of photography used.
- Interpretation equipment and facilities.
- Interpreter background.

Test photography evaluation.

- Attitude toward test photography—before and after.
- Comparison of tonal contrast and image qualities.
- Effect of viewing equipment and light quality.
- Summary of reaction to black-and-white photography scale variations.
- Impact of mandatory small-scale photography use.
- Color infrared transparencies.

RESULTS

USER-COOPERATOR PROFILE

On the average, the cooperators use 1:15,840 scale summer black-and-white infrared photography primarily for the purpose of forest resource inventory and management planning.

The typical user has a professional re-

source management background, including two college-level courses in aerial photo interpretation and eight to ten years of on-the-job interpretation experience.

All cooperators felt the need for more frequent photo coverage, and considered the tonal contrast and image detail quality of black-and-white forest aerial photography to have declined significantly in recent years. Additional research in aerial photography and photo interpretation was deemed desirable, along with additional training sessions, in order to improve the interpreter's ability to identify and classify forest vegetation.

TEST PHOTO EVALUATIONS

It was intended that each cooperator perform sufficient operations with the test photography to arrive at a sound judgment of preference supported by specific reasons. A summary of average cooperator reactions follows:

(1) *Attitude toward smaller scales of black-and-white photography.* Quite negative at first, but became more positive as they grew accustomed to it and began to visualize possible applications.

(2) *Tonal contrast and image quality of smaller-scale black-and-white photography.* Considered much superior to the 1:15,840 scale control photography. Apparently, although the test photography was acquired under typical commercial job conditions and standard contract specifications, the close supervision afforded its procurement apparently resulted in better quality photography than had been accomplished on the previously flown control photography.

(3) *Stereo perception, vegetation and soils classification, and measurement tasks.* (a) although the cooperators generally found more vegetation and/or soil detail visible on the smaller scales than anticipated, there were problems in delineating and labelling small features; (b) distance and area measurement accuracy declined with scale decrease; (c) useful, relative relief perception was attainable with all scales, some feeling they could visualize relief better with the smaller scales; (d) adequate navigation and location accuracy could be accomplished down to a scale of 1:31,680, but at 1:80,000 it became difficult or impossible to achieve; (e) timber volume estimate accuracy declined significantly with photo-scale decrease; (f) timber sale boundaries could be outlined fairly well but area estimates of adequate accuracy were impossible with scales smaller than 1:24,000; and (g) fire planning operations and preliminary road and trail location favored small-scale photography because minute detail was unnecessary and it was helpful to view large areas.

(4) *Time required.* An average of three to four mandays per cooperator. In general, for equivalent tasks, interpretation time increased as the scale decreased.

(5) *Improved viewing equipment and lighting systems.* Readily accepted by all users, who agreed that a mirror stereoscope was essential for viewing smaller-scale photography (greater magnification, wider field of view). It was also agreed that proper lighting was more important than had been generally realized.

(6) *Reaction to smaller scales of black-and-white photography. Favorable.* (a) the larger ground area covered by fewer photographs resulted in better large-area perspective and fewer photos to prepare, view, and carry; (b) less problem in matching detail from photo-to-photo; especially good for road and trail layout; (c) less expensive to procure; (d) broad cover types were more easily and quickly delineated; (e) general patterns of relief were more evident over large areas; and (f) broad soil patterns often were easier to discern. *Unfavorable.* (a) field use limited by inability to study small (important) features without sophisticated viewing equipment; (b) sufficiently accurate measurements not achievable; (c) adequate resource detail often lacking, even with great magnification; (d) necessary detail sometimes visible, but could not be delineated due to space limitations; and (e) one out of four experienced more eyestrain.

(7) *Impact of mandatory use of small-scale photography.* Availability of a sophisticated viewing and lighting system would be an absolute requirement. Additionally, the following undesirable adjustments in interpretation methods and procedures would be necessary: (a) the current minimum type area of 1-2 acres would have to increase to 5-10 acres for 1:24,000-1:31,680 scale photographs, and to 10-30 acres for 1:80,000, depending upon the cover type; (b) minimum linear measurements would increase from the current 0.5 chain on 1:15,840 scale photographs to 1 chain for 1:24,000-1:31,680 scale photographs, and to 5 chains for 1:80,000 scale; (c) ability to discriminate cover type species mixtures, size classes, and stocking would decrease significantly with scale decrease; (d) ground navigation, spot location, and area measurement accuracies would decrease significantly with scale decrease; (e) some system of enlarging the small-scale-generated cover type maps

would be required for field use; and (f) the amount of field checking would increase as the photo scale decreased, at least for the important vegetation and/or habitat types.

(8) *Color infrared transparencies vs. black-and-white prints.* Color infrared transparencies at scales of 1:31,680 and 1:80,000 subjected to various applications tests by a number of cooperators resulted in the following reactions: (a) initially, some found the unnautral colors an obstacle to interpretation, but less a problem as they worked with the film; (b) although, to them, a surprising amount of information was available even on the smaller-scale color infrared, it was difficult to capitalize upon it due to problems of delineation and field checking; (c) eyestrain was not greater than normal, except for one interpreter; (d) mental fatigue was a serious problem for several users; (e) considerable effort with undisturbed concentration was necessary to interpret the smallest scale, a condition hard to achieve in many field offices; and (f) in lieu of matte acetate and pencils used with black-and-white contact prints, clear film overlays and inking pens are necessary for interpretation of film transparencies, a situation found to be difficult and inconvenient and which produced a product difficult to transfer with available mapping equipment and facilities.

In summary, most of the cooperators unreservedly preferred conventional black-and-white photography. Although they could clearly see more detail with color infrared transparencies of equivalent scales, they indicated color infrared would be more palatable if available in the form of color prints which retained the high information level noted on the color infrared transparencies. The substantially higher cost of procurement of the color infrared also posed a deterrent to its favorable consideration.

Summary

The overwhelming preference for a photography type/scale combination was 1:15,840 scale summer black-and-white infrared. A scale of 1:24,000 was determined to be less desirable than 1:15,840, but might be substituted as a matter of necessity providing the overall quality was exceptionally good. A few photo interpretation tasks can be accomplished equally well (or better) with a scale of 1:31,680 as with 1:15,840, but a scale of 1:80,000 is much too small for the majority of required resource management applications.

Color infrared transparencies had the advantage of greater clarity and increased information than was noted on equivalent scales of summer infrared black-and-white photography. However, since aerial photo use is essentially a day-to-day operational function for most field resource management personnel, color infrared transparencies were considered difficult to employ due to the need for specialized facilities and equipment in viewing, interpretation, detail delineation and mapping, and related difficulties in field checking. To this must be added the cost differentials in procurement and use of color infrared photography.

Acknowledgments

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