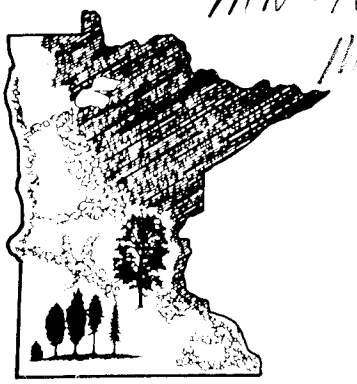

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SPECIFICATIONS FOR IMPROVEMENT OF TONAL CONTRAST QUALITY IN B&W SUMMER INFRARED FOREST AERIAL PHOTOGRAPHY*

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ABSTRACT

The recent shift to low contrast negatives, electronically dodged and printed, has seriously impaired tonal quality of medium-scale Lake States B&W infrared forest aerial photography. Comparisons of various combinations of camera filter/film exposure-development/paper contrast grade showed that a Zeiss C filter/underexposed-overdeveloped film/medium contrast grade paper print combination provided significant improvement in tonal quality.

Introduction

Over the past decade, increasing numbers of Lake States forest managers have expressed concern over the continuing deterioration in quality of B&W summer infrared forest aerial photography. This type of photography has been, and will continue to be, the standard medium for forestry purposes in the Lake States for some time to come. Although image detail has remained good, or even improved, tonal quality (i.e., tonal difference between features) has declined significantly. This is a serious matter since tone is a primary key in vegetation identification and classification in the diverse conifer-hardwood forest complexes of the Lake States.

In an attempt to identify the source(s) of deteriorated tonal quality, representatives of the USDA Forest Service's North Central Forest Experiment Station, the Minnesota Department of Natural Resources, Division of Forestry and the University of Minnesota, College of Forestry met with representatives of a major aerial survey firm in December, 1975. They concluded that forestry photography tonal quality had, in fact, deteriorated significantly over the past decade primarily as a result of overall technological changes in the aerial photography industry.

To a large degree, these photo characteristic changes have been the result of a shift in comparative aerial photography business volume from vegetation resource photography to engineering purpose photography. Photogrammetric purpose photography stresses reduction in tonal contrast and shadows, while maintaining the greatest possible image detail. By exposing and processing the film to produce a relatively thin (low contrast) negative rather than the relatively dense (high contrast) negative formerly sought for forestry purposes, this is accomplished. Further reduction in tonal contrast occurred when manual print dodging and exposure on variable contrast papers was replaced with automated electronic dodging and printing. The electronic printer's scanning technique automatically passes more light through the denser portions of the negative and less light through the thinner portions. The results, even when using variable contrast printing papers, are low contrast prints whose only desirable attribute, from the vegetation interpreter's standpoint, is their comparatively low cost - i.e., electronic printing methods can produce about 800 prints/man/day, as contrasted to 130-150 prints/man day by hand processing methods.

Because of the almost total change in materials, equipment, laboratory methods and labor costs during recent years, it is no

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longer possible to return to traditional hand processing methods. This research was undertaken to determine what could be done within the current state-of-the-art to significantly improve image tonal qualities of forest aerial photography.

Test Site Location, Description

A 1x10-mile site in Itasca County, Minnesota was chosen and flown in July 1976. The strip contained the greatest possible variety of forest vegetation and topographic situations: upland and lowland conifers and hardwoods, hills, flat uplands, marshes, swamps and lakes. Recent, accurate cover type maps were available. The entire country had been commercially flown in 1975 under contract to the Department of Natural Resources Division of Forestry. Although flown by a reputable firm with excellent equipment, and processed under high quality commercial laboratory conditions, the photography exhibited the usual serious lack of conifer-hardwood tonal contrast. These photographs, already in field use, were used as the control for the study.

Aerial Photography, Film Processing, Printing

The goal of the project was to perfect a commercially practical (repeatable) technique for producing negatives capable of offsetting the neutralizing effects of the electronic printer upon final print tonal contrast. Several possibilities were considered: (a) utilization of a Wratten 15 (deep yellow) filter in lieu of the conventional Wratten 12 (minus-blue) filter, so as to increase conifer-hardwood reflective differences; and (b) manipulation of exposure to vary overall relative film density, and subsequent variation of development techniques, to control the density range of the film (ASP 1968, Nielsen 1974).

Although Wratten filter series transmittance characteristics (EKCo. 1972) are generally used as a standard of reference for selecting filters for aerial photography, metric camera manufacturers such as Wild and Zeiss have filters designed specifically for their cameras which do not necessarily have transmittance characteristics precisely identical to the Wratten series. As a consequence, most forest photography contracts specify "..a Wratten 12 filter, or equivalent.." to insure use of the manufacturer's filter closest to the Wratten designation. Since this study employed a Zeiss metric camera and filters, the comparative transmittance characteristics of Wratten 9, 12, 15 and 16 filters (EKCo. 1972) were plotted on a filter transmission diagram for the Zeiss filters (Figure 1). Note that the Zeiss C curve is close to the Wratten 12, but that both the Wratten 15 and 16 transmission curves fall between the Zeiss C and D. Zeiss C and D filters were selected for the test since they most nearly approximated the Wratten 12 and 15.

The test flights were designed to exploit the fullest possible range of effects of camera filter, film exposure and processing. The film was processed to manufacturer's specifications according to the specific exposure levels used.

Sample stereoscopic pairs of negatives were selected from each Filter/Exposure-Development combination and printed on the EK Kind 1594 paper contrast grades most appropriate for the negatives: Grade 2, low contrast; Grade 4, medium contrast; and Grade 5, high contrast - totaling 14 different Filter/Exposure-Development/Paper Grade combinations. The comparative characteristics of the 1975 Control Photography and the 1976 Test Photography are summarized in Table 1.

Design of Evaluation Test

Inspection of prepared sample stereograms by experienced interpreters indicated only the three following Filter/Exposure-Development/Paper Grade combinations gave acceptable tonal quality:

Test Combination 1 - Zeiss C/Film Underexposed and Overdeveloped/Paper Grade 4 (medium contrast)

Test Combination 2 - Zeiss C/Film Underexposed and Overdeveloped/Paper Grade 5 (high contrast)

Test Combination 3 - Zeiss D/Film Underexposed and Overdeveloped/Paper Grade 4 (medium contrast)

Next, the entire 10-mile test strip was printed for each combination and these three sets of experimental coverage, along with the 1975 control, were delivered for evaluation to four of Minnesota's most experienced forest aerial photo interpreters: Chief Forester John Hubbard, Boise Cascade Corp.; Itasca County Land Commissioner William Marshall; USDA Forest Service Research Forester Alexander Vasilevsky; and Minnesota DNR Regional Staff Forester Bruce ZumBahlen.

Evaluation Results

Without hesitation, all cooperators rejected the control set of photography as being inferior to all three sets of test photography. The three test sets, however, did not appear to differ significantly among themselves. Although some differences of opinion did occur, the final composite selection was (Figure 2):

Filter: Zeiss C (Wratten 12 equivalent)
Film Exposure/Development: Slight Underexposure/Slight Overdevelopment
Paper Grade: Grade 4 (medium contrast)

These results were incorporated into the specifications of two forest aerial photography contracts let by, and flown for, the Minnesota DNR Division of Forestry later in the summer. Preliminary evaluations of the photography indicated a desirable improvement in overall photo tonal quality, but a necessary final assessment by users in the field has not yet been completed.

Discussion

It will be noted in Table 1 that the 1975 Control Photography employed a Zeiss B filter whereas a Zeiss C filter comes closer to fulfilling the contract stipulations for a "..Wratten 12 filter, or equivalent.." (Fig. 1). One can only speculate as to how much tonal degradation resulted when this non-specified filter was used in conjunction with "normal" exposure and processing, but the chances are both collectively decrease tonal contrast. One also wonders how often in the past non-specification filters have been employed without the purchaser's awareness. At the least, it suggests the desirability of requiring a contractor to provide incontrovertible proof of what camera/filter combination will be (is) used.

Despite the large differences in their transmission characteristics, Zeiss C and D filters produced photography with similar tonal quality. By far the greatest influence upon the test photography's final print tonal contrast appears to have been film exposure and processing.

Recommendations

Based upon the results of this study, as well as discussions with a commercial aerial photography firm, and modifications of the U.S. Geological Survey's "Standard Specifications for Aerial Photography for Photogrammetric Mapping" (USGS 1974), a set of contract specifications was prepared. Specific items addressed by the specifications include: filter, aerial photography, film processing, negative inspection, printing, print inspection and flight logs. Copies are available without cost from:

Director
IAFHE Remote Sensing Laboratory
University of Minnesota
College of Forestry
1530 North Cleveland Avenue
St. Paul, MN 55108

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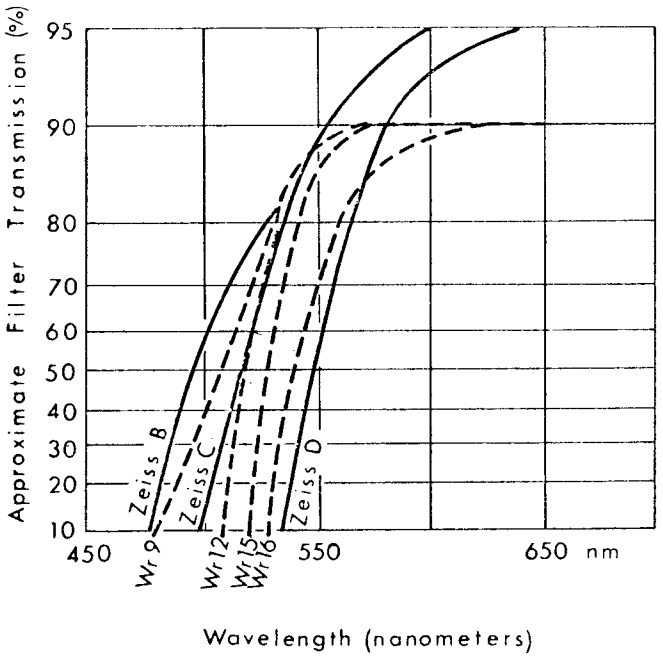
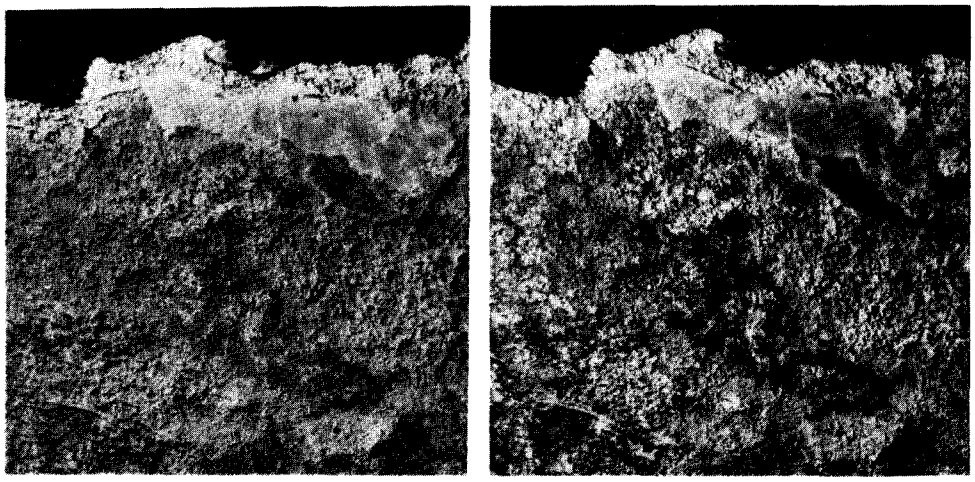


Figure 1. Comparative transmission curves for Zeiss and Wratten Series filters.

Table 1. Comparative characteristics of the 1975 Control Photography and the 1976 Test Photography

Feature	1975 Control Photography	1976 Test Photography
Date/Time	July 17/forenoon July 22/forenoon	July 2/forenoon
Weather	July 17 - partly cloudy July 22 - clear	Clear, light haze
Camera	Zeiss RMK A 15/23	Zeiss RMK A 15/23
Film	EK Aero Infrared 2424	EK Aero Infrared 2424
Filter	Zeiss B	Zeiss C Zeiss D
Exposure	f/8 @ 1/250 - "normal"	Zeiss C Filter Overexposed (f/5.6 @ 1/450) Normally exposed (f/5.6 @ 1/600) Underexposed (f/5.6 @ 1/900) Zeiss D Filter Overexposed (f/8 @ 1/400) Normally exposed (f/8 @ 1/500) Underexposed (f/8 @ 1/800)
Film Processing	Normally developed	Underexposed films were overdeveloped Normally exposed films normally developed Overexposed films underdeveloped
Printing Paper Grade (Contrast)	Grade 5 - high contrast	Grade 2 - low contrast Grade 4 - medium contrast Grade 5 - high contrast*

*Not used in all cases



1975
Control Photography
(Zeiss B/normal film exposure and development/Grade 5 - high contrast paper)

1976
Test Photography
(Zeiss C/film underexposed and overdeveloped/Grade 4 - medium contrast paper)

Figure 2. Comparative portions of the 1:15,840 scale B&W summer infrared 1975 Control Photography and 1976 Test Photography. Note the greater tonal contrast in the Test Photography, despite use of a lower contrast printing paper.