AERIAL PHOTO USE AND INTERPRETATION IN THE FIELDS OF WILDLIFE AND RECREATION*

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WORKERS in the fields of wildlife management and recreation have made fairly extensive use of aerial photographs as maps and for inventorying certain wildlife species. Although they have devoted but little time or effort to developing special photographic interpretation techniques by means of which aerial photographs could be used in wildlife research and development projects most effectively, they have made a beginning; and one notes more and more references in current literature to such uses and techniques.

Broadly speaking, wildlife is a product of soil and water, field and forest; therefore, many of the photographic interpretation techniques described at the VII International Congress of Photogrammetry, as applicable in making inventories of forests, water, soils, minerals, farms and range lands, are also useful in wildlife and recreation inventories.

Indicative of the interest shown in wildlife and recreation are the facts that in the United States alone last year, visitors to the National Parks and Monuments numbered nearly 37,000,000; there were approximately 28,000,000 licensed hunters and fishermen; and more than 50 colleges and universities offered training in wildlife conservation. In preparation for work in the field of wildlife management, students take a large variety of courses, including botany, zoology, agronomy, soils, range management, forestry, statistics, and limnology. A few students may take a course in photogrammetry or get a general introduction to photographic interpretation in a wildlife techniques course. However, few, if any, of the many Federal, State, Provincial or private agencies charged with managing this country's wildlife resources employ photographic interpreters. Correspondence with wildlife biologists in Denmark and England revealed that relatively little use is made of aerial photography in connection with wildlife work in those countries.

Among the state conservation commissions pioneering in the use of aeroplanes in wildlife work were Wyoming, which made aerial surveys of elk in the Jackson Hole area in 1935, and Missouri, which surveyed proposed refuge sites in the timbered Ozark area before aerial photographs were available from the usual Government sources. Since World War II, most of the state conservation departments have made use of aeroplanes. A study by Clyde P. Matteson, Aeronautical Technician of the Colorado Game and Fish Department (1950) showed that of 46 states replying to his questionnaire, 42 used aeroplanes in their wildlife programs. Of these 42 states only 12 considered aerial photography of sufficient importance to list it as a part of their aerial work. Approximately half of the states owned planes, and the other half rented them or hired both planes and pilots. The planes were used primarily for big game and waterfowl census work.

Relatively few uses of aerial photographs, except as maps, have been reported in wildlife literature. Aerial photographs were used in describing study areas by Yeager (1941) and Hochbaum (1944), to cite but two instances; and as a basis for cover mapping by Dalke (1937), Crawford (1946), Marshall (1946), Wilson and Berard (1952), and others. In an earlier article by the author (Leedy, 1948) aimed at acquainting wildlife technicians with aerial photographs

* Prepared for Seventh International Congress. Permission for publication granted by International Society of Photogrammetry.

and indicating ways of obtaining photographs and of utilizing them more widely and efficiently in the field of wildlife management, the following uses were suggested: maps; evaluation and determination of game range; censusing game animals; locating refuge sites; law enforcement; studying areas damaged by fire, floods, insects or disease; determining hunting pressure; locating, mapping, and planning potential dam sites; plotting land-use and wildlife problem areas; determining changes in vegetative cover and land use over a period of years; planning the locations of roads, trails, fire lanes, and other developmental features of newly acquired areas; making special studies of rare or vanishing species in which permanent records of habitat types are desirable; conducting lake surveys, including the mapping of emergent and floating aquatic flora, and possibly the contour mapping of lake bottoms; plotting tax delinquent lands in connection with acquisition of land for game refuge and management areas; and recording pictorially the features of breeding grounds newly discovered in remote areas.

Petrides (1944) pointed out the possibility of applying the principles of naval aircraft recognition to wildlife study by the split-second projection of aerial photographs showing deer, for example, as they would appear to observers in making an aerial census. Spinner (1946) suggested an improved segment method of estimating the numbers of birds in flocks with large flocks of birds in the field.

In a later article Spinner (1949) illustrated the usefulness of aerial photographs in censusing greater snow geese, *Chen hyperborea atlantica*, in the Delaware Bay area where this species winters. The flock was chased out over Delaware Bay to provide a dark background for photographing the white birds. A photograph taken by Master Sergeant Robert Livingston, of the 4146 Base Unit, AMC, USAAF, at an altitude of 500 feet and enlarged to 20 by 24 inches, permitted each goose to be counted. The entire spring flock shown on one print totalled 13,494 individuals. As was pointed out by Allen (1951) this figure was thought to represent the vast majority, if not the entire, Atlantic snow goose population.

Dr. A. S. Hazzard (in litt. December 19, 1951), Director, Institute for Fisheries Research, Michigan, reported:

> " . . . We have used aerial photography in fisheries work to secure lake outlines and stream courses. . . . Also we have used aerial photographs of lakes to follow the distribution of brush shelters. We have used low-level airplane pictures in our stream survey work to a limited extent, both in making the initial studies and for a record of such conditions as existing bank erosion, presence of riffle areas, extent of streamside cover . . . and of the location and extent of beaver ponds."

He stated further:

> "We have also experimented a bit with aerial photography in creel census on a number of lakes near Ann Arbor. Its use was principally to check our method of making boat counts, but it would serve this purpose nicely. Some of the photographs secured were quite striking and could be interpreted without much difficulty in terms of the number of boats and the people in them."

Dobie and Johnson (1951) described a method of making aerial maps of farm ponds. The method makes use of ground markers, a known distance apart and projections from photographic negatives, to produce maps of a chosen scale in spite of variations in plane altitude. They state that if the pond map is made in the fall when the pond is low, it will show the low water area, high water mark, inlets, outlets, aquatic vegetation, upland vegetation, buildings, roads and trails.

Crissey (1949) in his interesting bulletin describing the use of aeroplanes in fish and game work by the Division of Fish and Game in New York reported:

"To date, pictures have been taken for a variety of purposes. Extensive areas have been covered with vertical pictures for the purpose of constructing maps and analyzing the types of cover. In this connection, it is of interest to note that the hardwood-conifer composition of a woodland becomes very evident when the pictures are taken in the winter when the ground is covered with snow. Vertical pictures have also been used in prospecting for sites suitable for waterfowl and muskrat development. Field maps have been constructed from these pictures as a base for intensive habitat surveys. Pictures have been taken before and after development of an area as a means of measuring and illustrating changes that took place. Others have been used in stream pollution cases when they were taken to court.

"A wide variety of oblique pictures have also been taken. The majority of these were intended primarily for the purpose of illustrating written articles and as such have proven to be particularly effective."

William P. Dasmann, Game Range Technician, Bureau of Game Conservation, California Division of Fish and Game, indicated that his Division used aerial photographs in making game inventories, and as maps. He stated:

"In game inventories, herds of animals or flocks of birds are photographed from the air usually with a K-20 camera. The prints are enlarged, and the game species counted on the picture, sometimes with the help of magnifying glasses. Sometimes counts are randomized by blocks on photos where the individuals are numerous, viz., waterfowl.

"We use aerial photos directly as maps, and sometimes take pictures of localized areas for that purpose. These are used to determine both topography, cultural features and vegetation types. But we have no specialized equipment other than simple stereoscopes for that purpose."

Assistant Game Manager Gordon C. Ashcroft, Jr., also of the California Division of Fish and Game, indicated (in litt.) that aerial photographs were useful in determining the relative importance and relation of a part of an area to a much larger game range such as a National Park. For example, in looking at one unit of area from the ground its importance might be considered greater than it actually is.

Mr. A. W. F. Banfield, Chief Mammalogist, Canadian Wildlife Service, stated (in litt.) that his " . . . Service has used aerial photographs widely in the census of caribou, wood bison, and big game of the National Parks of Canada," and that " . . . from the photographs, data on the numbers, sex and age classification of the big game species were obtained." From aerial photographs taken during the late Arctic winter, Banfield (1950) also learned much regarding the migration habits and range of the barren ground caribou, *Rangifera arcticus*.

The Fish and Wildlife Service has used aerial photographs in connection with mapping, censusing waterfowl and other species, in locating boundaries of National Wildlife Refuges for condemnation proceedings, in law enforcement, and in numerous other ways. Aerial photographs, for example, have been taken of salmon along the Pacific Coast as they entered rivers up which they swam for spawning. Much of interest can be learned from these photographs regarding numbers of these fish, migration habits, etc.

Replying to a questionnaire submitted by K. E. Bradshaw of the U. S. Forest Service to Region 4 of the National Park Service, employees of the latter Service stated:

"Extensive use is made of both low and high oblique air photographs of existing and proposed areas, boundaries, existing and proposed road locations, and wildlife habitat. We have been doing this type of work since early in 1945, usually taking our own

photographs. To a lesser extent such pictures have also been used to make counts of wildlife.

"Practically all of the photographs are obliques, taken at low altitudes to show ground and cover details. Such pictures need little interpretation except for enlarging, and labeling on the print the development and planning features. Occasionally we also use the standard high altitude vertical mosaics for correcting our existing maps, for showing extensive recreation layouts, and for mapping vegetative cover. These mosaics we obtain from the usual Governmental and commercial sources. Color photography for oblique air photos has been used by us to a limited extent and has been highly successful. We use these pictures primarily in our public educational and interpretive program."

For public education and orientation of visitors to the Vicksburg National Military Park, Vicksburg, Mississippi, aerial photographs of the Park are on exhibit in the park museum. These afford a stereoscopic view of various features of the Park.

As indicated by Colwell (1950), the manager of a recreational area may find use for an aerial photo mosaic as an attraction to his patrons.

"A neat, suitably annotated mosaic, posted on the bulletin board or in the lounge, is readily interpreted by a hiker who, at the end of the day, wants to show his friends an easier way he found to climb the mountain. It holds a similar attraction for the fisherman who caught a big one in that hole just below the falls, or the golfer who hit into a sand-trap in the seventh hole, or the skier who almost ran smack into a particular tree on that downhill schuss."

Recently the author visited a duck marsh and noted an aerial photo posted in the clubhouse which could be used by hunters in locating their blinds, and in relating at the end of the day the courses taken by the ducks they saw entering the marsh.

Colwell (1950) in his very interesting article also listed the following uses of aerial photographs in the field of forest recreation:

1. Preliminary selection of localities suitable for development into recreational areas.
2. Planning future developments which otherwise would require more detailed ground surveys.
3. Properly locating trails in National Parks and recreation areas—taking into consideration scenic qualities of the routes, proximity to lake and stream fishing, availability of forage for pack animals, directness, and cost of construction and maintenance.
4. Preparing an accurate map of the trail net once it has been laid out.
5. As an aid by recreationists in locating unmapped lakes or other remote fishing spots or hunting areas.
6. As an aid to hikers and to Alpine mountain climbers in picking routes for scaling peaks, or in reaching the most suitable points for photographing scenic areas.

Although there are those who, for reasons best understood by purists, would not favor the use of aerial photographs or stereoscope as aids in mountain climbing (Wagar, 1951), the above illustrations indicate some of the ways in which such photographs may be utilized by individual recreationists, resort owners, and private or public recreational area managers.

Deep sea fishermen who use planes to spot schools of tuna must treasure aerial photographs, which show very clearly the number of fish in the schools and provide them with thrills of a lifetime. Ample proof that tuna show up clearly on aerial photographs can be found in the illustrated article by A. J. McClane (1952) in the March, 1952, issue of *Field and Stream*.

Photo Interpretation Techniques

There is considerably less literature dealing with the interpretation of aerial photographs for wildlife and recreation purposes than with the fact that aerial photos are used in these fields. As stated earlier, very few wildlife agencies have employees skilled in photo interpretation or assigned to this type of work. Photographs used for census work are generally of game concentrations. The photographs, usually taken at low altitudes, are enlarged and the game counted

Fig. 1. Aerial photography is useful in making inventories of wild animals in areas remote or difficult of access by other means. This photograph shows a part of the muskox herd on Nunivak Wildlife Refuge, Alaska. Note the wool being shed by the animals.—*David L. Spencer, Fish and Wildlife Service.*

with the aid of magnifying glasses. Rarely, so far as the author has been able to determine, are the pictures taken in series and viewed under a stereoscope. Although many agencies have taken vertical or oblique pictures of special management areas for use as maps, most photographs used for mapping are obtained by purchasing from Governmental or commercial sources.

In censusing waterfowl, particularly large concentrations of ducks, the U. S. Fish and Wildlife Service has used aerial photographs to verify or note the deviation in visual estimates made from the air or on the ground. Visual estimates, especially those made at high altitudes, are usually below the actual number revealed by aerial photographs. In this connection, Spinner (1949) stated that 52 ornithologists who viewed an enlargement of the aerial photo mentioned earlier, showing 13,494 geese, gave estimates varying from 3,000 to 28,000, with an average of 9,000. He also brought out an interesting point regarding two photographs, one of which was taken of geese as the flock rose from their feeding grounds and the other as the flock settled on the Bay as a compact group. Invariably, Spinner stated, observers overestimated the number in the first photograph and underestimated in the second. Thus it is obvious that the

task of counting thousands of waterfowl on aerial photographs is in itself exacting and tedious.

Kalmbach (1949) constructed a scanning device to facilitate the counting of large numbers of waterfowl on aerial photographs. The device is fully described and illustrated in *The Journal of Wildlife Management*, 13(2): 226–227. Suffice it to say here that it has the over-all appearance of a shallow box approximately 13 inches by 11 inches by $2\frac{1}{4}$ inches in dimensions with a hinged

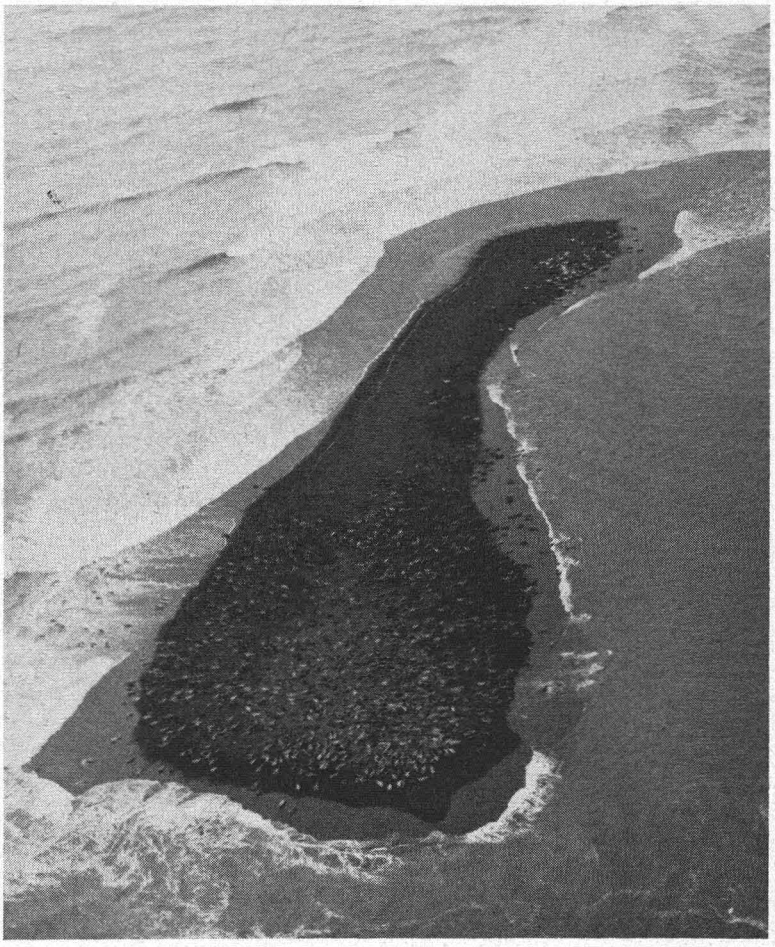

FIG. 2. Aerial photography facilitates the censusing of such animals as these Harbor Seal along the Bering Sea Coast. The seals come to rest on this small island formed at low tide.—*E. P. Haddon, Fish and Wildlife Service.*

lid made of 28-gage brass. A slot in the lid with the same curvature as that of the route of an 8-power binocular microscope mounted at the end of an arm pivoted on a standard to the right of the device permits minute examination of a portion of the photographs at a time. After such a strip has been examined, a lever is pressed which shifts the photo to one side just the width of the scanning slot, thus removing the old and presenting a new and contiguous field for inspection.

Photographs may also be "blocked off" for ease in counting waterfowl by

superimposing on them sheets of acetate or other clear material with grills or blocks of the size desired marked off in fine lines. After a "block" has been examined for ducks it can be marked with a grease pencil so it will not be counted twice.

In estimating waterfowl or other birds in flight, ornithologists customarily count the birds in a small segment of the flock, then estimate the number of times this segment will go into the entire flock to determine the total. In making counts from a plane, however, particularly when one or more large flocks are in the air at the same time and frightened by the plane, this method has proven unsatisfactory. Spinner (1946) felt that if a means of rapidly estimating the num-

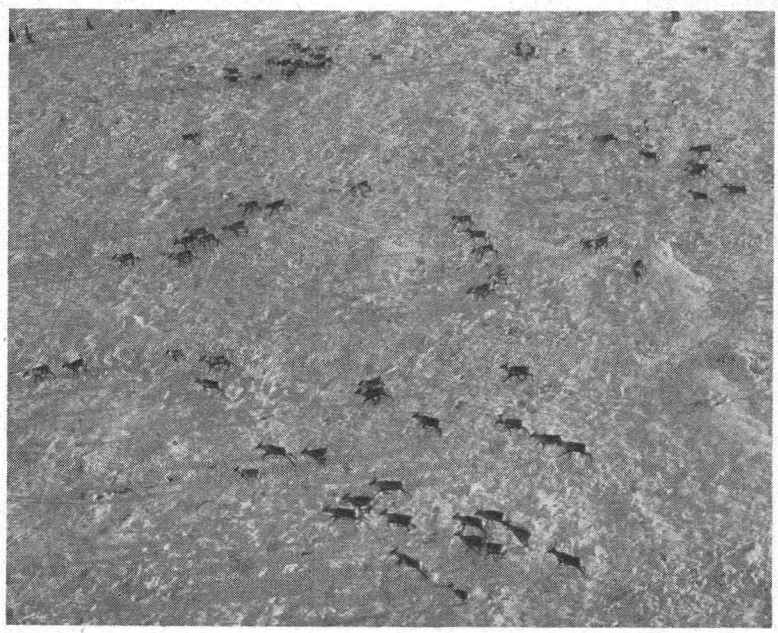

FIG. 3. Large concentrations of animals such as waterfowl on their wintering grounds, spawning salmon, or caribou in migration can be censused by means of aerial photographs. This photo shows Stone's caribou on the Alaska Peninsula.—*Edward F. Chatelain, Fish and Wildlife Service.*

bers in small flocks could be combined with one for obtaining more accurate estimates of large flocks, the resulting observations would have greater value. Enlargements of aerial photographs showing flocks of geese of known size in basic flying formations, i.e., in groups and long strings, were copied on 4 by 5 inch prints. For field use these were attached to stiff 4 by 7 inch cardboards. Then flocks observed in the field were compared with the photographs to determine their approximate size. In some cases two or more photographs were used as accurately counted segments in arriving at the size of larger flocks which otherwise could not have been estimated so well.

For use as base maps in plotting dens, cover and food in Iowa wildlife studies, Trump and Hendrickson (1949) have suggested dimly printed, rather diffused negative images instead of aerial photographs having considerable contrast and sharpness. They found that underexposed but fully developed "negative" prints revealed the landmarks essential for mapping but were dim enough to permit annotation and addition of details in pencil or ink. They used a baloptican to project the image of a regular black-and-white print on a sheet of photo-

stat paper which was then developed, rinsed, fixed, washed and dried. They also found the baloptican to be useful for drawing a map to scale from an aerial photograph. The image was focused on a sheet of paper on the wall of a dark room and the desired features traced over with a pencil.

On "negative" prints, wooded areas and shadows are white, while open fields are darker; but for their purposes, Trump and Hendrickson (1949) found this to be an advantage. During his military photo interpretation experience, the author used as base maps copies of original photographs dimly printed on soft matte paper. These permitted additions of desired details in ink or pencil but were positive prints.

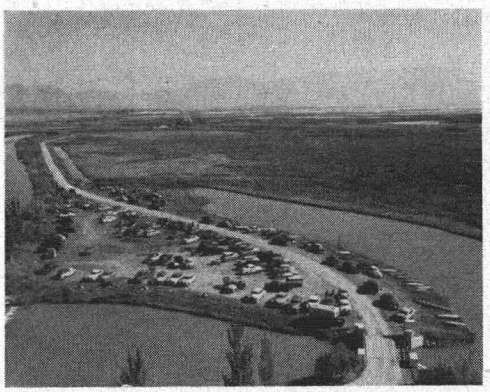

FIG. 4. Aerial photographs may be used as checks on the hunting and fishing pressures sustained by certain areas. This view of the Bear River Migratory Bird Refuge, Utah, shows the parked cars of hunters who have come to the public shooting areas to engage in their favorite sport.—*Rex Gary Schmidt, Fish and Wildlife Service.*

Schultz (1951), in attempting to prepare land-use and cover maps of extensive areas in Tennessee, concluded that a desirable method of mapping should "(1) furnish detail such as is available on aerial photographs, (2) be applicable to field use, and (3) favor the economical reproduction of a final composite map." He found film positives of county aerial photo-indexes used in conjunction with the "Ozalid Process" valuable in making maps. This process is a means of reproducing positive prints of maps, photographs, or other items on papers, cloths, films, and foils of various types. Schultz found that county photo-indexes, available from the Aerial Photographic and Engineering Service, Production and Marketing Administration, showed excellent detail considering the extensive areas covered. Although the indexes contained photograph designations, these did not seriously detract from their use as maps.

DISCUSSION

For getting the most information from aerial photographs used in mapping or in evaluating wildlife habitat, the author wishes to emphasize the value of studying the photographs under a stereoscope. The unnatural, rounded, and tightly hedged appearance of browse species indicative of heavy or overutilization of big game range shows up much more clearly when photographs are examined in this manner. This is true also of such features as topography, drainage patterns and vegetation types. Certain game species themselves can be identified more readily and perhaps classified as to sex and age composition when viewed on stereoscopic pairs of photos. Also, stereoscopic examinations are valuable in counting such species as ducks or deer partially hidden by trees or other vegetation. Beaver pond counts made from aerial photographs are often not as accurate as desirable because the smaller ponds may easily be confused with natural widenings in a stream bed or with spring holes at the feeder heads (Knudson, 1951). Beaver cuttings and other signs usually to be found at beaver ponds would show up much better on good quality photographs viewed stereoscopically than they would on single prints.

Sometimes in censusing ducks when great accuracy is required, each duck counted on a photograph is pricked with a pin to avoid counting it twice or missing it entirely. Usually this degree of accuracy is not necessary, and to save time and get a close approximation of the number of ducks, it is suggested that often photographs can be divided into strata or segments according to duck density on different parts of a picture. Then the strata falling into the various density levels can be sampled and the total number of ducks approximated on the basis of total area represented at each level.

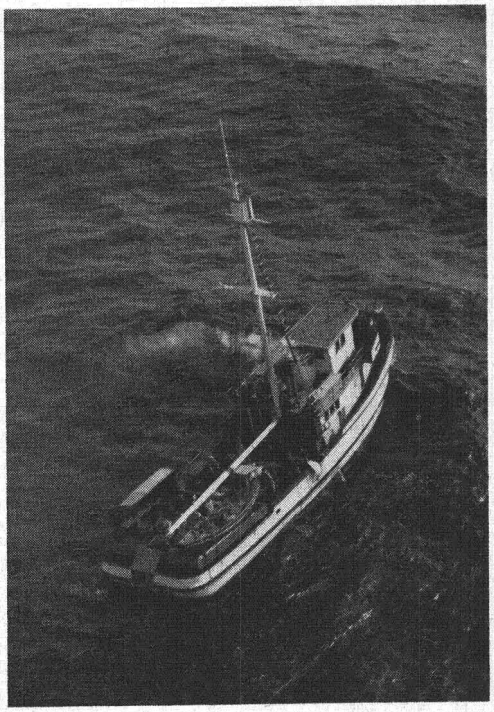

FIG. 5. Photographs of this type may be used by fish and game law enforcement agents in court proceedings as evidence of violation. Note the halibut being hauled over the starboard side of this halibut vessel.—*Official Coast Guard Photograph.*

Much is to be learned regarding the type of plane, camera equipment, film, filters, and conditions under which aerial photos can be taken most effectively for use in the fields of wildlife and recreation. Consideration must be given to cost of operation; season of the year and best time of day for photographing to distinguish between vegetation types or show concentrations of game species; the height at which a plane can be flown above animal concentrations such as waterfowl flocks without disturbing them; and the amount of ground checking necessary to obtain the desired results. Chapman (1947) stressed the importance of the season in aerial photography for obtaining best results in ecological studies. He pointed out that more than 25 years ago Scott and Robbins (1925) had determined that in Burma, February was the month when the distinction between trees was most apparent. In much of the United States, September and October, when the coloring of deciduous leaves is at a peak, would show up species differences very well—especially when color film is used.

In discussing aerial photography of waterfowl, Kalmbach (in litt.) stated:

"In the past the camera equipment used has been a 9×9, K-17 C operating with either a 12- or 24 inch lens. With a 12 inch lens we have found that objects the size of a mallard duck can be satisfactorily recorded on the film at 1,000 foot altitude. However, geese usually are flushed by military planes flying at that altitude and when they are being photographed, the plane should be at 2,000 or more feet altitude. Our objective now is to devise an optimum combination of camera, lens and plane best suited for the recording of waterfowl. The plane should be of such type that it could fly at 1,000 feet or lower without disturbing waterfowl unduly. It should also be of slow enough speed to permit an observer to make visual estimates at the same time that photographs are being taken."

The U. S. Air Force in cooperation with the Fish and Wildlife Service made an experimental flight over the "Grasslands" section of California's San Joaquin Valley in 1948. On this flight, a Sonne S-7 Camera was used to photograph

waterfowl. The low-flying RF-80 Jet plane zoomed past the waterfowl before they were aware of the engine noise, and the waterfowl could be readily counted on the resulting photographs.

It is believed that the shutterless continuous strip camera as described by Katz (1948) would be very well adapted for wildlife work such as strip censusing and evaluation of game range because of the great amount of ground detail shown on the photographs; another suitable type of photography would be the low altitude photography made possible by modifying the shutter of the 6-inch focal length K-17 camera, increasing the top shutter speed from 1/250th second to 1/500th second.

Summary

1. Literature dealing with the use of aerial photographs in the fields of wildlife and recreation is reviewed.

2. Although a majority of agencies dealing with wildlife and forest recreation use aircraft in their programs, probably less than one-third of these use aerial photographs to an appreciable extent.

3. Wildlife workers have used aerial photographs primarily as maps and as an aid in censusing big game, waterfowl, and certain other wildlife.

4. Other uses in the wildlife field include the illustration of published articles, evaluation and determination of game range, planning of wildlife developments, a means of improving visual estimates of wildlife concentrations as seen in the field, education of the public, and ecological studies.

5. Aerial photos are used in the field of recreation for mapping; education of the public; orienting visitors in recreational areas, shooting grounds and national parks; preliminary selection of suitable localities for recreational areas and for the development and planning of these areas; and by recreationists, themselves, in locating hunting and fishing areas, in mountain climbing and hiking and as a source of other information.

6. Other uses of aerial photographs suggested for these fields include locating game management areas, wildlife problem areas and potential dam sites; law enforcement; studying areas damaged by fire, floods, insects or disease; determining hunting and fishing pressure; determining changes in vegetative cover and land use over a period of years; making special studies of rare or vanishing species in which permanent pictorial records of habitat types are desirable; and conducting lake and stream surveys.

7. Most of the agencies concerned with wildlife management and recreation which make use of aerial photographs obtain them from Governmental or commercial sources.

8. Few if any of these agencies employ photo interpreters. Little use is made of a stereoscope in studying the photographs, although the value of such examination is stressed.

9. Special techniques thus far developed in interpreting and using photographs for wildlife purposes are described.

10. Some of the needs and limitations of aerial photography in wildlife and recreation work are indicated.

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PRESENT STATUS OF PHOTO INTERPRETATION IN EARTH SCIENCE*

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ABSTRACT

Photo interpretation now has the status of an essential method of investigation in both basic and applied earth science, and ranks in importance along with the use of standard surveying techniques, the petrographic microscope, and the various geophysical methods. Its primary function is to obtain geologic, topographic, and pedologic information with greater economy, speed, and accuracy than is possible from ground methods alone. This generally can be done with comparatively simple stereoscopic and stereometric equipment, and does not require the elaborate and expensive instrumentation employed in precision cartography. The personal training, experience, and skill of the interpreter are the important factors in obtaining the desired information from photos.

* International Photogrammetry Congress, Commission VII, Phase 2.