REMOTE SENSING APPLICATIONS FOR WILDLIFE HABITAT MANAGEMENT

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INTRODUCTION

By now most of us have heard of remote sensing. We each have a somewhat different perception (view) of what it is and does. Often, the subject conjurs up thoughts of pretty infrared photographs and the magic of gathering data without really being there. Well meaning remote sensing specialists have promised us the world. Many of the early promises have not been fulfilled although many useful applications have been proven.

This paper has been designed to review the state of the art of remote sensing for wildlife habitat management applications. I will not consider telemetry which is a form of remote sensing widely used in wildlife research and management. Nor will I consider remote sensing applications for wildlife population estimates, another equally useful wildlife management application for remote sensing. Instead, I will emphasize the use of imaging remote sensing systems for study, inventory and monitoring of various wildlife habitats.

REMOTE SENSORS FOR HABITAT ANALYSIS

Remote sensing, by definition, is usually described as the acquisition of information about an object or phenomena without having the sensing device in actual physical contact with the subject. The most obvious ahd perhaps most useful example of remote sensing is found in the form of vertical aerial photographs.

The principal remote sensors for wildlife habitat applications include black and white, color and color infrared photography at various scales, microwave systems, Landsat computer compatible tapes and various multispectrual techniques. For purposes of this presentation I will summarize the general approaches with which remote sensing techniques are used to identify, measure and monitor the various renewable natural resources. A more detailed summary for the interested reader can be found in Colwell (1978) and other papers presented in the IV Pecora Symposium at the EROS Data Center. The Pecora IV proceedings cover the subject of applications of remote sensing data to wildlife management.

Wildlife habitat applications, as well as all other natural resource management applications, can be placed in two general categories, inventory and monitoring. Remote sensing techniques provided an excellent means of inventorying the basic habitat resource, including its distribution, extent and quantity on initial analysis or evaluation. Then as changes in habitat quality take place remote sensing offers probably the only cost-effective means of monitoring such changes, at least as they occur over large land areas.

Table 1 is a consideration of some of the various scales of remote sensing imagery and a brief analysis of the applications for each scale and resolution as it might be used by wildlife habitat managers. The combined use of various scales is referred to as multiscale analysis (spatial) or multistage sampling. First, the manager can use the smallest scales for initial inventory and planning, followed by the extraction of more detailed information from larger and larger scales. Multistage sampling is usually carefully designed statistically and involves PPS (probability proportional to sample size) sampling and often some sort of clustering approach (Rohde et al. 1979; Landley 1969).

Two other "multi's" used by remote sensing specialists are multispectral analysis (spectral) and multidate sampling (temporal). The former is used to obtain information concerning landscapes from different portions of the spectrum (multispectral) and the latter to follow habitat changes (monitoring).

TABLE 1. Scales of imagery useful to wildlife habitat managers with suggested uses for each (scale designations adopted from R.C. Heller 1970.

VERY LARGE SCALE:	(obtained from helicpoters, stationary towers, cherry pickers, etc.) 1:100 to 1:500.
	Plant species indentification including grasses, forbs, and trees and seedings of each, erosion estimates, vegetation biomass productivity estimates, soil features induced by rodents, nesting sites, trails and other signs, water depth and clarity, vegetation height and cover characteristics.
LARGE SCALE:	1:600 - 1:2,000
	Species measurements (cover and density), erosion estimates, vegetation biomass productivity estimates, vegetation condition and trend assessment, water depth and clarity, riparian vegetation.
MEDIUM SCALE:	1:5,000
	Detailed vegetation and habitat mapping, vegetation condition and trend assessment, water clarity, relative vegetation cover characteristics.
NORMAL SCALE:	1:12,000 to 1:20,000 (most common scales available for foresters and agriculturalists)
	Vegetation mapping at the plant association or habitat-type level, larger erosion features, distribution and extent of aquatic habitats, some habitat management planning.
SMALL SCALE:	1:30,000 or less
	Wildlife habitat management planning, vegetation, soil and landform mapping on a refuge or management area basis, multiple use planning.
VERY SMALL SCALE:	(taken from orbital altitudes): 1:1,000,000 to 1:2,500,000
	A synoptic view for regional wildlife habitat planning and management, spatial distribution, and extent of various habitats and/or plant communities.

HABITAT CLASSIFICATION

As I started this review, I sought in the literature a good general classification for wildlife habitat. There are few good examples. A first dichotomy might be terrestrial vs. aquatic habitat. However, this is too simple. Perhaps one could summarize by talking of deciduous forest, coniferous forest, tundra, grassland, desert and riparian habitats. This is also too generalized.

I finally decided that the habitat classification question is best evaluated on a case-by-case basis. It should be referenced to an individual wildlife species in a given locality. For example, Peek (1974) described five different types of winter moose habitats for North America: (1) riparian willow/conifer complex along high gradient streams, (2) floodplain, riparian communities with extensive willow stands, (3) aspen and conifer stands in drainages with very limited willow-bottom communities, (4) mountain brush (chokecherry and bitterbrush) communities on foothill ranges, and (5) coniferous forest (Douglas fir and/or spruce-fir stands on slopes adjacent to depleted willow bottoms).

In Arizona, mule deer habitat can be classified with three types: (1) mountain ponderosa pine, (2) chaparral, and (3) desert (Hungerford 1970). In north central Nevada, mule deer habitats are predominantly shrub-grass, pinyon-juniper woodland, mountain brush, apsen or riparian (Tueller and Monroe 1974). Hansen and Reid (1975) described seasonal mule deer ranges in western Colorado as conifer-aspen in the summer and mountain brush, pinyon-juniper woodland or sagebrush-grass as winter ranges. In addition to naturally occurring vegetation, there is the potential for using remote sensing to evaluate wildlife habitat in agricultural or crop settings. This would include field aftermath and fence row weed, shrub and tree vegetation.

There are many other similar examples in the literature. Many species of wildlife may be found exclusively in a single plant community or perhaps confined to two or three plant communities. These vegetation types then constitute the principal habitat for that species.

HABITAT APPLICATIONS

There are numerous examples of the uses of remote sensing for wildlife habitat inventory, analysis, and monitoring. Asherin et al. (1978) used land cover maps emphasizing vegetation, in Montana, for predicting avian use of sections of land in southeastern Montana. Their analysis of habitat suggested that the vertical dimemsion of habitat is possibly more important when areas of greater diversity are considered. In Australia, Hill and Falconer (1978) evaluated Landsat as a means of investigating the relationship between habitat structure and seasonal forage status and the vulnerability of grey kangaroos to hunting pressure. This author (Tueller et al. 1978) has used Landsat digital maps to evaluate emu habitat in West Australia and met some success in separating sites of different potential for emu food and cover requirements.

Various investigators have worked with various scales of photography, including Landsat images, as well as Landsat digital data (Colwell et al. 1978; Gilmer et al. 1978; La Perriere and Morrow 1978; Russell et al 1978). Culpin (1978) has described a method of stream habitat inventory using photo interpretation of large scale color infrared photography. Potential wild turkey habitats as related to specific plant communities have been identified using Landsat II digital data (Katibah and Graves 1978). George at al. (1977) developed a computer-aided digital classification for reindeer range inventory in Alaska.

Large scale imagery in 70 mm format using color and color infrared film is a successful procedure for evaluating marshland vegetation (Seher and Tueller 1973). This work showed potential applications for identifying, inventorying and monitoring both immersed, submersed and floating aquatic vegetation types. Vegetation keys were developed to assist the photo interpreter.

Marmelstein (1978) described remote sensing applications to wildlife management in the U.S. Fish and Wildlife Service. Emphasis was given to baseline ecological analysis for wetlands, energy development lands and artic goose breeding habitat.

IMAGERY TYPES

A variety of image types including film-filter combinations, format sizes and film products are available for wildlife habitat evaluation. Possibly among the most useful would be color and color aerial photography at various scales. The 9" format is the norm although in recent years there has been more interest expressed in 35 mm and 70 mm formats. The 35 mm format has much to commend it because of its relative simplicity and availability. Disadvantages would include the lack of rapid sequence capability and thus stereo pairs at large scales.

For these reasons I am of the opinion that a 70 mm format is optimum for many wildlife habitat applications. With a 70 mm format rapid sequence camera (frame rates to 10 per second) it is easily possible to obtain high quality stereo pairs at scales varying from 1:500 to 1:20,000. Many wildlife habitat applications can be accomplished at such scales.

MICROWAVE

Earth resources synthetic aperature radar (ERSAR) techniques hold future promise for wildlife habitat applications. The reasons for this are inherent in certain of the natural advantages of active microwave sensors, namely: (1) imaging in near all-weather, day and night conditions (2) sensitivity to vegetation and soil moisture conditions; (3) sensitivity to vegetation canopy and structure; (4) controllable illumination direction; (5) spectral information complementary and/or supplementray to Landsat data; and (6) high resolution imaging independent of distance to scene (NASA 1979).

Such data have, im my opinion, considerable application for monitoring changes in wildlife habitats.

LANDSAT

At first glance, many people have written off Landsat as a viable means of evaluating wildlife habitat. This has probably been the result of examining Landsat scenes with their 200 foot plus resolution capabilities. The problem is that we tend to equate this poor resolution and seemingly low information content with our knowledge of ground specifics. This, of course, is a useless exercise. It is not possible nor desirable to use Landsat images for high quality, high resolution medium and large scale aerial photographs.

The value of Landsat images is inherent in their 18 or 9 day repetitive coverage and the synoptic view afforded by the 100 mile-on-a-side images. However, the real value of Landsat is found in the 1:24,000 scale of the Landsat digital data. While the scale is 1:24,000 the resolution is only slightly improved and remains near one acre (.42 hectare) per picture element (pixel). The computer approach offers an excellent means of rapid data evaluation and review. Maps are easily prepared and, as long as the computer compatible tapes are available, the cost is negligible relative to other data sources.

The Landsat digital data are recorded on the on-board multispectral scanner (MSS) in four bands, two in the visible and two in the near infrared portion of the spectrum. Researchers are still working on the problem on interpreting the MSS signatures and relating them to identifiable habitat features and changes in those features.

Further work on the Landsat 4-band signatures will lead to better means of digital analysis on habitat parameters. For example, work is now advancing in the use of red-infrared ratios. Using such ratios there is the potential to determine the relative proportions of green growing vegetation, soil and standing dead vegetation plus litter. Signatures for clear and turbid water and many types of aquatic vegetation have been identified. This plus the fact that numerous computer software packages have been developed for these data suggest that many applications will soon be developed. Also in the future there is a strong probability that we will have spaceborne multispectral scanners with considerably high resolution and much narrower bands, allowing much closer discrimination and monitoring of wildlife habitats.

SUMMARY AND CONCLUSIONS

The inventory, evaluation and monitoring of wildlife habitat has long been recognized as a legitimate and very important requirement of wildlife managers. Remote sensing techniques offer considerable potential for this work. Color and color infrared aerial photography, multispectral cameras, multispectral scanners from aircraft and spaceborne (e.g. Landsat) platforms and microwave sensors, such as ERSAR will be used for this work in the future.

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