Progress Report

NASA Research Grant
NGR 27-002-006

An Evaluation of the Use of ERTS-1 Satellite Imagery for Grizzly Bear Habitat Analysis

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<u>Note</u>

The expense of color photographs prevented us from including them in all copies of this report. If desired, the photos on pages 20, 21, and 25 may be ordered from the Montana Cooperative Wildlife Research Unit at cost ($2.00).

INTRODUCTION

As man encroached on wilderness that formerly comprised much of the western United States, the grizzly bear declined in numbers and disappeared from many areas where it was once abundant. In order to preserve and manage the remaining populations it is imperative that we thoroughly understand the relationship between the grizzly and its environment, and use this knowledge when making land use and wildlife management decisions.

Considerable data on grizzly bear ecology have been gathered during the course of a 13-year study of these bears in the Yellowstone ecosystem[1-7]. This population constitutes one of the few sizeable populations remaining in the United States outside of Alaska. Recent research work at the Montana Cooperative Wildlife Research Unit has placed increasing emphasis on habitat evaluation and integration of habitat data with accumulated knowledge of the grizzly's food habits, home range, movements, and population dynamics. The result will be a better understanding of grizzly bear habitat usage and requirements. It will also permit more accurate estimates to be made of population density and distribution, and allow wildlife managers to predict the effects of land use changes (logging, construction of roads, etc.) on existing bear populations. Grizzly bear habitat can be evaluated to determine if grizzlies can be reintroduced and survive in habitat from which they have been eliminated.

The development of remote sensing techniques of land use and habitat evaluation using aerial photography, multispectral scanning, sidelooking radar, active or passive microwave imaging, and other methods, has been rapid in the last few years. These techniques have great potential for reducing both the effort and cost of surveying the inaccessible and extensive wilderness areas that comprise favorable grizzly bear habitat. This report evaluates the use of one of these techniques, multispectral imaging from earth-orbiting satellites.

Viewing equipment for analyzing ERTS-1 multispectral images was recently acquired by the University of Montana Geology Department as part of an Earth Resources Program contract with the National Aeronautics and Space Administration (Applicability of ERTS-1 to Montana Geology, NAS5-21826; R.M. Weidman, Principal Investigator). This provided us with an opportunity to compare ERTS-1 imagery with habitat data gathered for the U.S. Forest Service and Montana State Fish and Game Department during the summer of 1972 (11). Our comparison of multispectral images with habitat data have enabled us to come to some conclusions about the usefulness of this technique and to identify some promising areas for further investigation.

Since the use of satellite imagery is a new technique, we have included details of the Earth Resources Technology Satellite System and discussed some of the capabilities and potentialities of this method of studying environmental problems.

THE EARTH RESOURCES TECHNOLOGY SATELLITE (ERTS-1)

ERTS-1 was launched on July 25, 1972, and has transmitted multispectral images of approximately 2.5 million square miles of the earth's surface daily since July 25, 1972. Images are obtained with two sensor systems, a set of 3 return-beam vidicon television cameras and a multispectral scanner, in the .5-.6, .6-.7, and .7-.8

μm bands. The multispectral scanner (MSS) provides an additional band in the .8-1.1 μm region. Images from these two systems are recorded on two wideband video tape recorders when the satellite is not within transmission range of a receiving station.

The images are transmitted to three U.S. receiving stations (in Maryland, California, and Alaska) and to a Canadian station in Saskatchewan during each daytime pass of the satellite. During nighttime passes, images recorded over other parts of the world are transmitted to the U.S. stations. A total of about 1350 images a day are received in digital form from the satellite and converted to photographic images at the NASA Data Processing Facility in Greenbelt, Md. Copies of these images are distributed to several government agencies and to about 350 investigators who are evaluating the use of such imagery in various resource management programs.

The satellite is in a nearly polar orbit at an altitude of 500 miles and makes about 14 passes a day, in a southwesterly direction, from 80°N to 80°S latitude. Passes occur at approximately the same local time at each location to insure uniform illumination. The fields of view of the cameras encompass a strip 110 miles wide along the satellite's path, and overlapping images are taken along selected portions of each strip. The orbit characteristics are such that a strip observed one day is contiguous with the strip observed the previous day. As each strip advances by about 20° in longitude (112 miles at the equator or 70 miles in Montana) from a pass on one day to the same pass the next day, the entire world could be covered by observations once every 18 days.

Objects larger than 300 ft. may be identified. The images are sufficiently free of distortion so that they can readily serve as maps on scales up to 1:250,000. This and the ability of ERTS-1 to view very large areas repeatedly makes the satellite an effective and economic tool to map various environmental characteristics and changes [12].

IMAGERY COVERAGE OF MONTANA AND STUDY AREA

The coverage of ERTS-1 MSS imagery for Montana is shown in figure 1. The satellite moves from north to south along the paths shown as dotted lines. Images are taken at approximately 100 mile intervals along each path. Adjacent paths are covered on successive days, moving from east to west. The same orbit path is repeated at 18-day intervals.

Since each image is roughly square and covers an area measuring 115 miles on each side, there is about 10% north-south overlap on successive frames taken in each orbit, and about 40% overlap on frames taken on successive days from adjacent orbits. It is thus possible to obtain side-lap stereo viewing of most areas with images taken in adjacent orbits.

The location of the study area is shown in Fig. 1, along with the coverage of the images that were used in our evaluation. These images were selected by checking the NASA indexes (ERTS U.S. Standard Catalog, NAS1.48:972) and by examing the file of photographs maintained by the Geology Department. Coverage began after launch of the satellite in July, 1972 and continues up to the present. The time of greatest interest to us was from July to November 1972. This covered

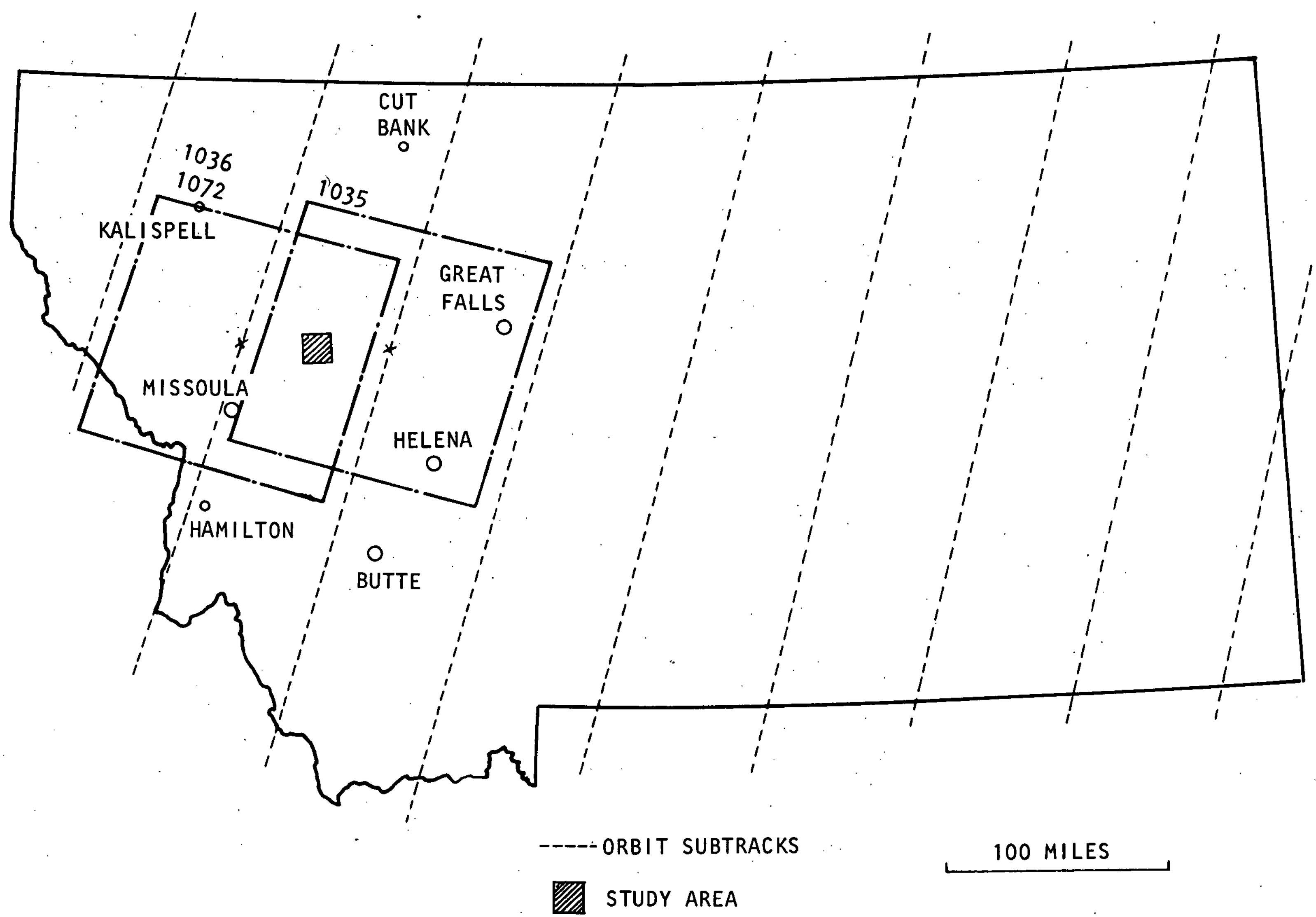


Fig. 1: ERTS-1 coverage of Montana and study area

the period when personnel were in the field obtaining ground truth data. Satellite imagery obtained during this period is listed in table I. Although coverage of the study area occurred every 18 days, many images were unusable because of cloud cover. One set of images in August and one in October were cloud-free, and were selected for evaluation. Frame 1036-17571 (Aug. 28) was used for most of the vegetation analysis. This frame and frame 1072-17571 (Oct. 3) were used together to examine time-lapse effects in the appearance of vegetation and snow cover. Frame 1035-17513 (Aug. 27) and frame 1036-17571 (Aug. 28) were used together for side-lap stereo viewing.

STUDY AREA

The 52 square mile study area is in the center of the newly-formed 240,500 acre Lincoln-Scapegoat Wilderness which is 75 miles west of Great Falls, Montana. It lies within the Lolo National Forest and is bordered by the Bob Marshall Wilderness area on the northwest. Elevations in the study area range from 5600 to 9200 ft., with over half of the area above 8000 feet. The relative isolation and light use of the area, combined with specific vegetation and topographic characteristics, make it a favorable habitat for grizzlies. Between July 29 and September 15, 1972, the area was type-mapped for food plants utilized by grizzlies. A population survey of grizzlies, black bear, and other mammals and birds was made over a somewhat larger area at the same time [11].

TABLE I

ERTS-1 IMAGERY OF STUDY AREA

July-Nov. 1972

Date	Frame	Cloud Cover	Subsatellite Point		Sun Angle Elev.	Sun Angle Az.
8-10	1018-17571	10%	47.12°N	113.88°W	51.7°	137.3°
8-27*	1035-17513	0	47.28	112.43	47.1	142.7
8-28*	1036-17571	0	47.30	113.80	46.0	143.0
9-15	1054-17571	60	47.33	113.77	41.2	148.6
10-2	1071-17513	10	47.51	112.23	35.3	153.3
10-3*	1072-17571	10	47.43	113.72	35.0	153.5
10-20	1089-17515	0	47.38	112.35	29.3	156.8
10-21	1090-17574	70	47.33	113.80	29.0	156.9
11-7	1107-17521	30	47.26	112.45	23.8	158.7
11-8	1108-17575	40	47.26	113.85	23.5	158.8
11-25	1125-17522	40	47.32	112.46	19.3	159.2

* Frames selected for evaluation

GRIZZLY HABITAT CRITERIA

A study of the food habits and habitat requirements of grizzlies in the Yellowstone ecosystem [5] indicates that the following criteria are important for the maintenance of a grizzly population:

1. <u>Space</u>

   The home ranges of grizzly bears may encompass areas up to 1500 square miles. Large wilderness areas or de facto wilderness areas of national parks and national forests provide the required area.

2. <u>Isolation</u>

   Grizzlies conflict with man and his livestock, and have been eliminated from developed areas. Areas where bears remain and potential habitat for re-introduction of grizzlies is isolated and should receive only light recreational and livestock use. Roads and extensive trails degrade grizzly habitat.

3. <u>Food</u>

   An abundance of natural foods must be available from April to November, and must be sufficiently varied so that occasional annual deficiencies of one or more sources do not jeopardize the population. Basic foods are carrion, ungulates, rodents, berries, pine nuts, green vegetation, bulbs and tubers, and in some situations, fish.

4. <u>Vegetation types</u>

   A wide range of vegetational types characterize prime grizzly bear habitat. A mixture of timber and alpine meadows provide the bears with places to forage, socialize, and breed. Alder thickets, lodgepole downfalls, and other dense vegetation are preferred bedding sites. Large tracts of undisturbed timber provide protection and seclusion.

While other factors may influence a population in a particular situation, those cited above are the ones which were given primary consideration in our investigation.

HABITAT ASPECTS THAT CAN BE INVESTIGATED WITH ERTS-1 IMAGERY

Information about many of the important features of grizzly habitat can be obtained from ERTS-1 imagery. The high altitude from which the images are taken allows accurate mapping directly from photographs. The repetitive coverage obtained every 18 days is useful in investigating seasonal changes in vegetation and snow cover. The imagery is ideally suited for evaluating general topographic character and identifying broad classes of vegetation in existing or potential grizzly habitat.

The large scale of the images also results in some disadvantages. The resolution limit is about 300 ft., which restricts the kinds of information which can be obtained. For example, isolated trees, most roads, and small patches of vegetation or other features less than about 2 acres in extent cannot be seen on the imagery. However, vegetation classes can be distinguished (forest vs. meadow), but identification of particular species within a class (pine vs. fir) is generally not possible at present.

We identified several ways in which ERTS-1 imagery can be either a useful supplement to other techniques or offers significant advantages or cost savings over other habitat analysis methods. These include determination of general vegetation character, simple land use classification, and identification of a major food species (whitebark pine). Monitoring seasonal vegetation changes and observing the extent and altitude of snow cover at intervals throughout the year also proved feasible. These are discussed in more detail in RESULTS.

IMAGE ANALYSIS METHODS

Most image analysis was done with a color-additive viewer using positive transparency enlargements (9x9", scale 1:1,000,000) of the multispectral scanner scenes. Portions of these transparencies encompassing the study area, 3x4" in size, were cut out and mounted in 70mm glass and metal slide holders. The areas covered are illustrated in Fig. 2.

The prepared slides for each of the four MSS bands were then placed in a Spectral Data Corporation Model 64 Multispectral Viewer. Red, green, blue, or white light of variable intensity was projected through each of the four transparencies to form a color composite image on a 9x9" ground glass viewing screen. The viewer optics provide a x3.37 enlargement of the slide, giving an image scale of 1:297,000 on the viewing screen. Fig. 3 gives a general impression of the size and scale of the display, which was designated as Scene 1. After adjustments to place all four images in register, various combinations of band, colors, and light intensities can be set up to give maximum enhancement to features of interest in the composite image.

After obtaining the desired scene display by appropriate adjustments, the image was permanently recorded by photographing the viewing screen with a 35mm camera and Type B High Speed Ektachrome film. The resulting 2x2" slides could later be examined, projected, or used to make prints as required.

A 9x9" transparent overlay was prepared for the viewer screen to aid in identifying major topographic features and landmarks. A convenient and low cost method of making such overlays consisted of

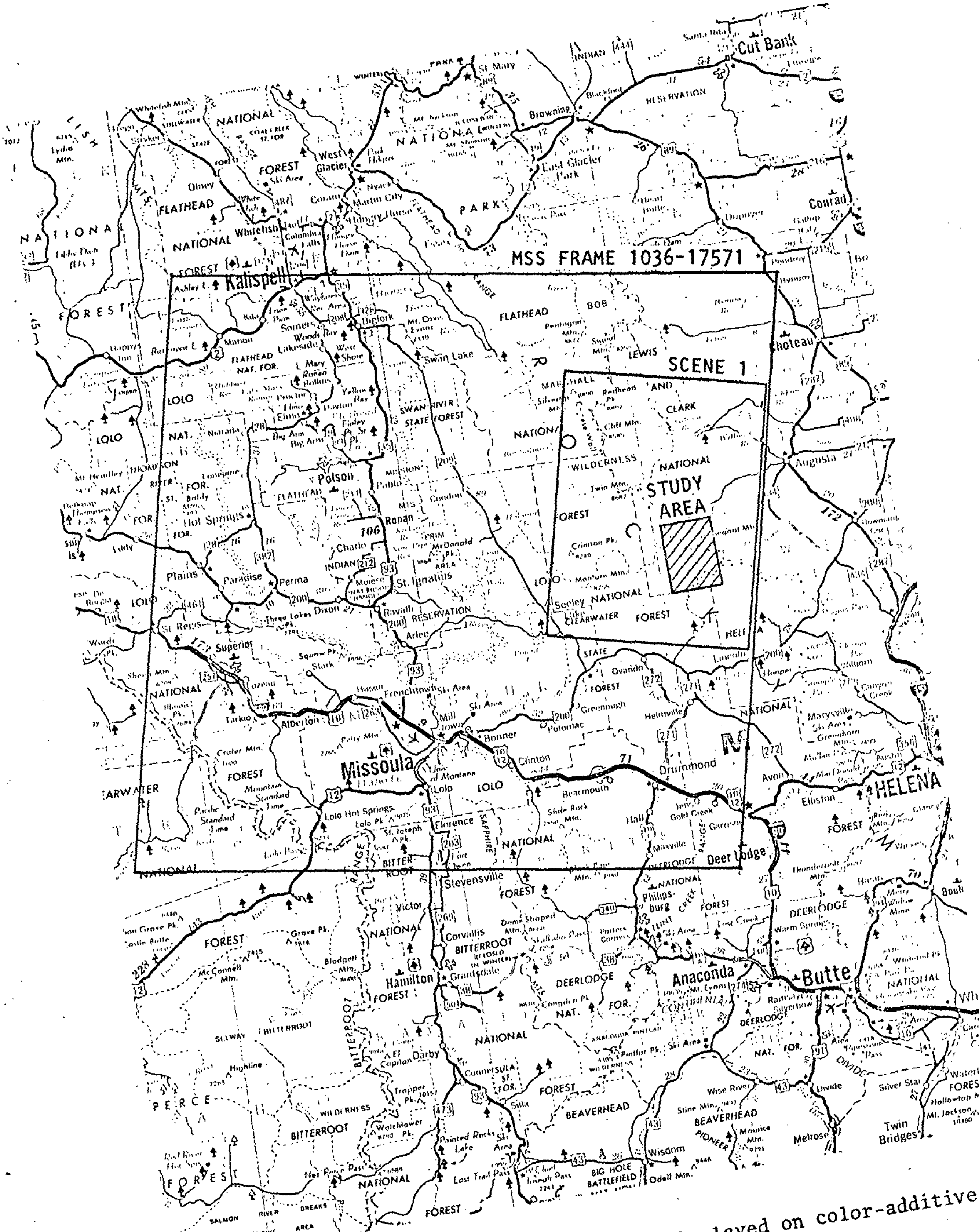


Fig. 2: Boundaries of MSS frame, area displayed on color-additive viewer (scene 1), and study area

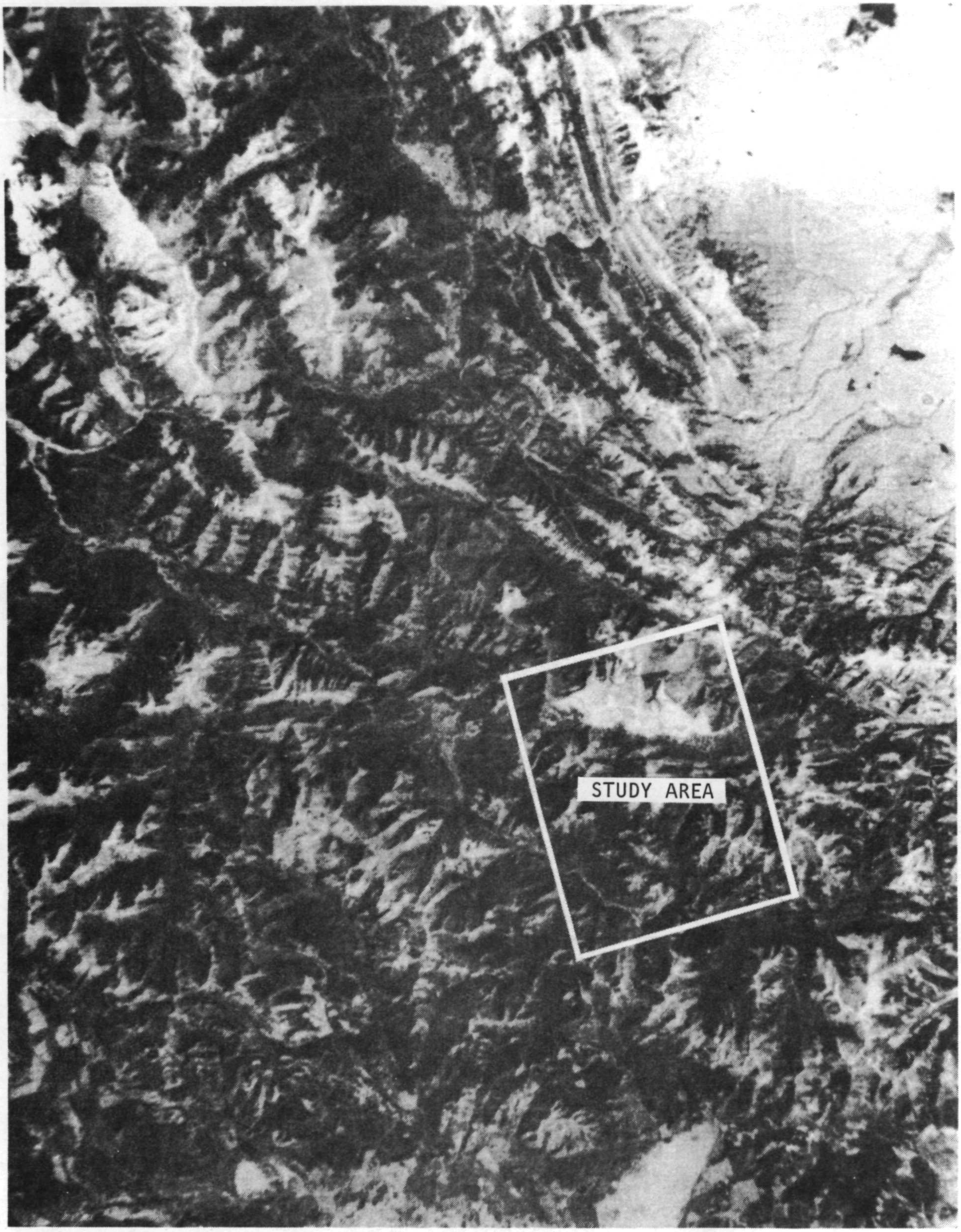


Fig. 3: Area displayed on color-additive viewer (approx. actual size)

copying a portion of a 1:250,000 scale USGS topographic map on a Xerox 7000 electrostatic copying machine at the #2 reduction setting (84.5%) and then making a 1:1 thermographic overhead projection transparency from this reduced-size copy. The resulting overlay matched the image scale on the viewing screen within 1% and allowed forest boundaries, drainages, mountains, and other features to be easily identified.

A composite aerial photograph map of the study area was also prepared from Forest Service 1:15,840 black and white panchromatic photographs to aid in identifying small features not shown on the topographic map.

A Bauch & Lomb model ZT-4 Zoom Transfer Scope was used to draw vegetation maps from the 35mm slides of color composite images and to superimpose topographic maps on the images for identification of major features and determination of snow cover elevation.

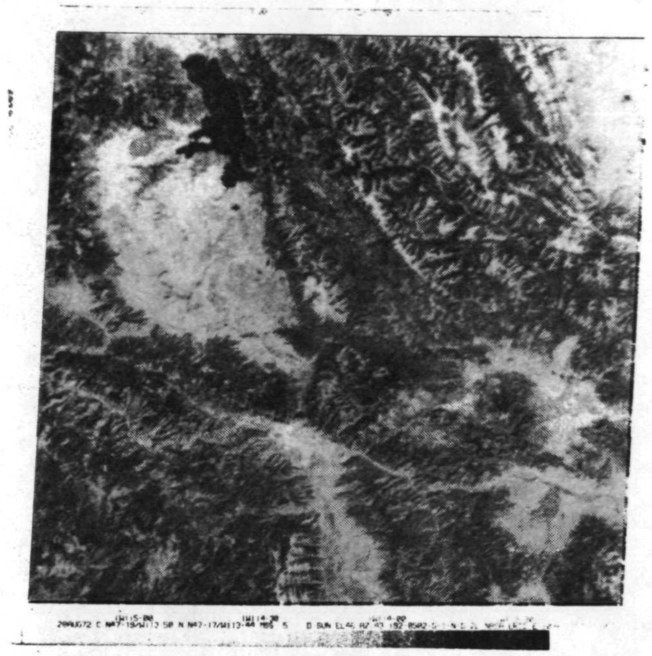
RESULTS

Image color effects

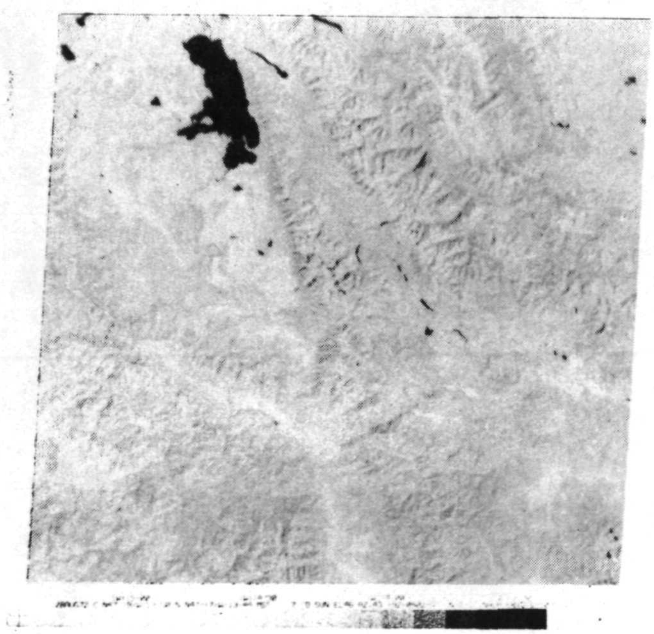
Conclusions similar to those of other investigators [8-10] were reached after evaluating the comparative utility of the four MSS images, both individually and in combinations. Typical images are shown in Fig. 4.

The two infrared bands (band 6, 0.7 to 0.8 μm; band 7, 0.8 to 1.1 μm) were very similar in appearance, with rivers and lakes showing black and growing plants in light tones. They reduced the dark tones of forested areas normally apparent in visible light so that the

Band 4 (green) .5-.6 μm



Band 5 (red) .6-.7 μm



Band 6 (near infrared) .7-.8 μm

Band 7 (infrared) .8-1.1 μm

Fig. 4: Multispectral scanner images of western Montana (frame 1036-17571)

topography of the scene was very clear. Band 5 images (0.6 to 0.7 μm, red) most closely approached the appearance of normal aerial photographs; forests and growing vegetation appeared in dark tones and dry vegetation in light tones. Band 4 images (0.5 to 0.6 μm, green) were the least useful for vegetative mapping and had a slightly hazy appearance due to atmospheric scattering, but were the best for identifying snow cover.

A combination of bands 5 and 7 gave the finest detail for vegetative mapping. Adding band 4 to these two gave greater subtlety of color but resulted in a slight reduction in detail, both because of the haze effect and the additional difficulty of adjusting three images for perfect registration instead of two.

Simulated false-color infrared images were obtained by illuminating band 4 with blue light, band 5 with green, and band 7 with red. Band 6 was usually not used because of its similarity to band 7. In these images growing vegetation appears in various shades of red. A simulated normal-color image could be obtained by projecting band 4 in blue, band 5 in red, and band 7 in green. The resulting image is similar to what an observer would see from the air, with growing vegetation in exaggerated shades of green.

Scene Illumination Effects

The transparencies supplied by the EROS data center are photometrically accurate, having densities which correspond to absolute scene brightness. As a result, scenes obtained during winter months at high latitudes are often very dark. Two effects are responsible for this darkening: one is the lower average illumination level due to oblique lighting; the other is the presence of many more shadows in areas of uneven topography.

Sun angles above the horizon for imagery of the study area were summarized in Table I. They vary from 52° on August 10 to 19° on November 25.

We found that vegetation mapping was more difficult in mountainous areas with November imagery than with August imagery. North- and northwest-facing slopes received much less light at low sun angles than south-facing ones, and resulted in tone variations that were larger than those used to discriminate between vegetation types in bright evenly-illuminated areas. Discrimination within large sloping areas illuminated at very low angles was poor because of the general dark tone, and no details could be distinguished in full shadow.

Determination of general vegetation character

High alpine meadows appear in light red or pink in the simulated false-color infrared images and can be easily identified and distinguished from the timbered areas which are a darker red or grayish-red. Large areas can be quickly examined on the images and those portions with combinations of forest and meadows, favorable grizzly bear habitat, can be noted for further examination.

Classification of Habitat Quality by Type and intensity of land use

Areas that have been identified as possible bear habitat by the initial examination of vegetation character can be further classified by eliminating those portions that are heavily used by man and grading the remaining area by a measure of land use intensity.

An overlay can be prepared for the satellite image which shows all settlements, agricultural land, grazing land, logging or mining activity, roads, and trails in the area. Areas within a certain radius of settlements and residences, all agricultural land, and a strip adjacent to roads and trails with width proportional to traffic volume are eliminated. Grizzlies tend to avoid such areas, and those who do not are usually eliminated in the eventual bear-man conflicts which result. The remaining area is considered to be potentially suitable habitat for further evaluation. A simple example of one possible type of overlay is shown in Fig. 5. Urban areas, agricultural land,and grazing land are usually easily identifiable on the satellite imagery by their characteristic colors and can be mapped directly. Roads and trails are generally not visible; their locations must be obtained from maps. The width of the excluded strips adjacent to them can be determined from traffic counts, visitor statistics, and other sources.

Before this method can be used it will be necessary to establish an approximate scale factor for the excluded high-use areas; on trails, for example, the width of the excluded strip would be a certain number of feet per visitor man-day. Such scales would be, initially at least, rather arbitrary. An analysis of Yellowstone Park visitor use would probably provide the best starting point since better records of both bear and human distribution exist there than any other area. The resulting scales would need to be modified in some respects for habitat evaluation outside of national parks. This classification method could not be expected to be accurate in any absolute sense, but would permit use intensity in various areas to be

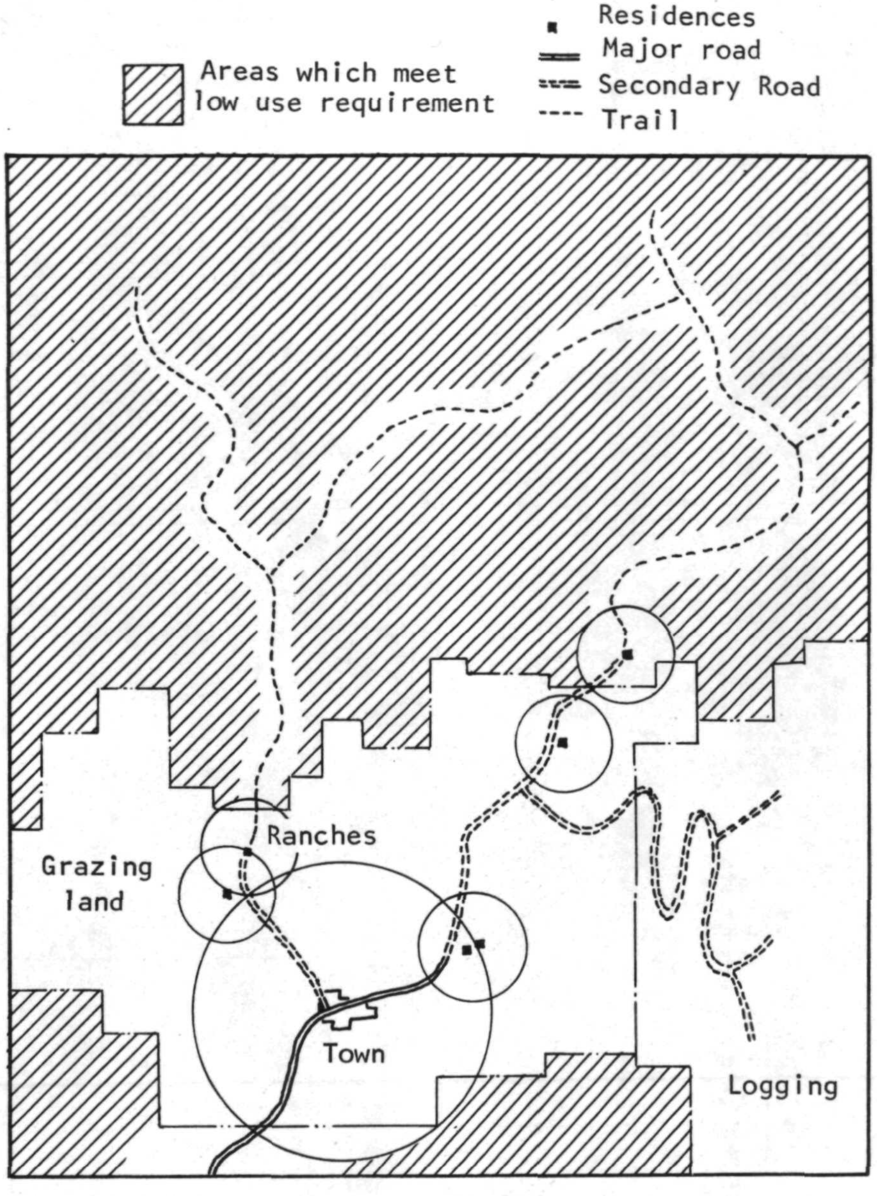


Fig. 5: Example of a use-intensity overlay

compared with one another and rankings of habitat quality to be made.

Identification of Whitebark Pine

Examination of the color composite image of the study area with the color-additive viewer did not reveal any distinctive variations in color or tone that would permit differentiation of the various tree species from one another. However, we found that a combination of tree cover imagery and altitude information permitted reasonably accurate identification of whitebark and and limber pine, important food species for grizzly bears.

The ground survey showed that whitebark pine (*Pinus albicaulis*) and limber pine (*Pinus flexilis*) occurred predominantly on higher ridges in the study area, usually above 7000 ft. elevation. The approximate distribution of these pines is shown in Fig. 3 of ref. (11). Both species were considered as whitebark pine for classification purposes.

A projection mask was prepared from a topographic map which showed all areas above 7000 ft. in black. This image was combined (using white light) with the false-color infrared (Fig. 6) or normal-color images in the color-additive viewer. The resulting false-color image is shown in Fig. 7. In this image timbered areas above 7000 ft. appear dark red, and can be easily identified and mapped. A simulated normal-color image of the study area is shown in Fig. 8.

Timbered areas mapped from the false-color or normal-color images are shown in Fig. 9 in relation to the distribution of whitebark pine observed on the ground. The area covered by whitebark pine is 11.8 square miles, and the high elevation timbered areas identified

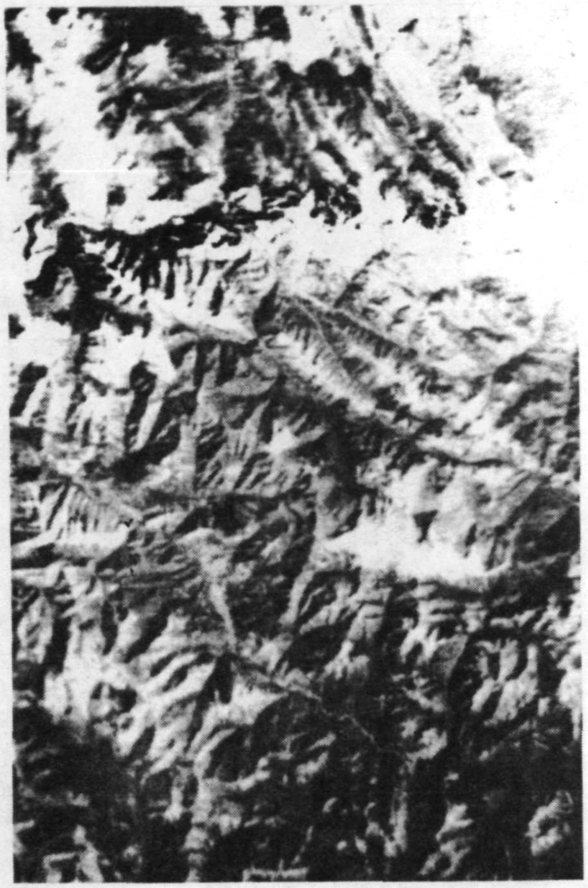


Fig. 6: Simulated false-color infrared image of scene 1 as displayed on color-additive viewer. Growing vegetation appears in shades of red.

Fig. 7: Scene 1 with high-altitude overlay superimposed in white light. Only the areas above 7000 ft. remain visible.

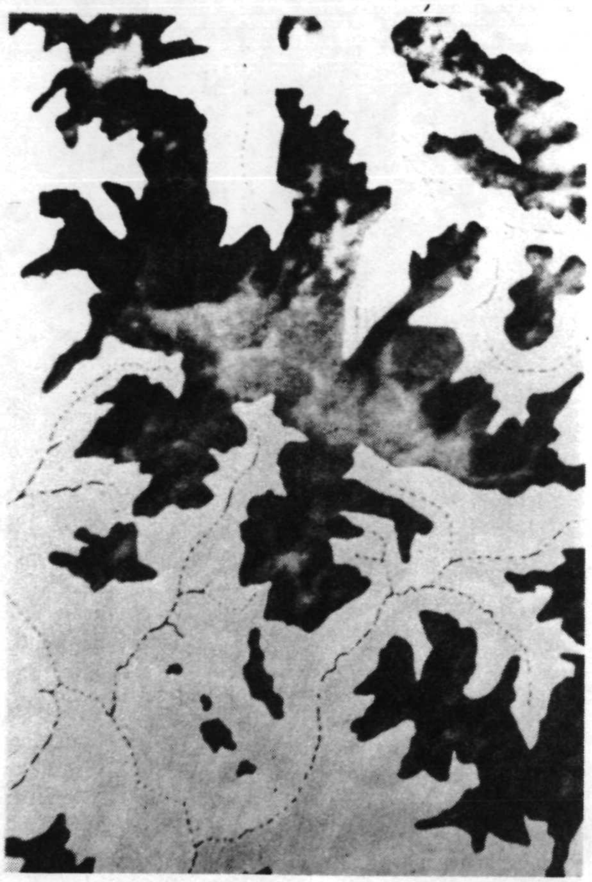


Fig. 8: Simulated normal-color image of study area with high altitude overlay superimposed. Growing vegetation appears in shades of green.

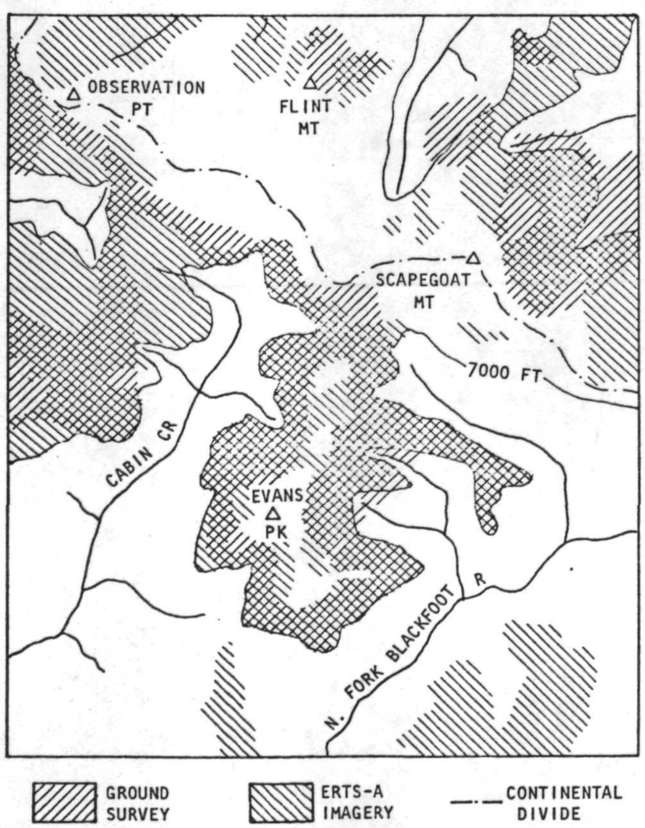


Fig. 9: Distribution of white-bark pine observed on the ground ground compared with high-altitude timbered areas mapped from satellite imagery.

from satellite imagery cover 17.1 square miles (excluding the two southernmost areas, which were not checked in the ground survey). The crosshatched common area is 9.8 square miles. If the ground survey were entirely accurate, the results indicate that 83% of the whitebark pine was correctly identified from the satellite imagery, with an additional area amounting to 45% of the whitebark pine area shown as whitebark pine which was actually other species. This is a reasonably good result, especially considering the simplicity of the method and the limited accuracy of the ground survey.

Other factors beside altitude which influence where whitebark pine occurs include aspect, exposure, soil type, and available moisture. On north-facing slopes they were often found at lower elevations than on south-facing slopes. More accurate estimates of distribution could be made using satellite imagery by incorporating such factors into the discrimination process.

Identification of Shrubs, Grasses, and Herbs

Other important plant food items in the study area utilized by the grizzly include huckleberry and grouseberry (*Vaccinium spp.*), tubers of *Claytonia spp.* and *Lomatium spp.*, and several other herbs and grasses. These occur as low shrubs growing as understory among larger trees or small plants in open areas.

It was not possible to identify any of these species from the satellite imagery alone. Open alpine meadows could be easily distinguished from timber stands, but particular species of vegetation in the meadows could not be separated. Mapping the area and extent of the meadows may provide sufficient data to allow an accurate estimate of the amount of tuberous and other foods available, since the general composition of alpine meadow vegetation varies relatively little. It can be reasonably assumed, for example, that the amount and distribution of *Claytonia spp.* and *Lomatium spp.* determined by sampling in one location would be representative of other alpine areas within the ecosystem.

The understory species (*Vaccinium spp.*) were, of course, not visible at all. Understory typing would probably be limited to identifying likely areas for sampling by ground observers.

Some discrimination between visible vegetation types should be possible on the basis of association with indentifiable species (whitebark pine), altitude, soil type, topography (exposure), or a combination of these factors.

Since green plants are easily distinguished from dry or dead ones by their high reflectance in the infrared bands and the resulting appearance in false-color or normal-color images, a series of scenes at 18-day intervals can be used to determine the time of appearance of new growth in the spring, and drying and dying of vegetation in the late summer and fall. To the extent that this is species-specific, it provides an additional type discrimination factor. Other investigators have found that this is a promising technique for distinguishing coniferous trees from hardwoods, and for identifying some species of hardwoods and agricultural crops [13].

Mapping snow cover

Information about snow conditions is helpful in studies of the grizzly, since it determines the bear's hibernation behavior and influences the availability of food in the spring and fall.

Snow appeared most distinctively in bands 4 or 5, where it had highest contrast with surrounding snow-free terrain. Although clouds and snow had about the same brightness, they could generally be distinguished without difficulty because of characteristic differences in shapes and because of the shadows that accompanied clouds. The boundaries of snowcovered areas are easily distinguished on bare or lightly-vegetated terrain. They become more difficult to see in heavy timber. These observations agree with the findings of other investigators [9, 14, 15].

A time-lapse technique proved to be very useful in determining changes in snow cover over a period of time. Two band 4 images of the same area, one taken in August and one in October, were superimposed on the viewer. The August image was illuminated with red light, the October image with green. In areas where no changes in tone had occurred during the time between the images were taken, the resulting composite was a neutral greenish-gray. Areas that were lighter in the October image appeared red, and areas that were darker appeared green.

The resulting effect is illustrated in Fig. 10. Areas covered by snow in October which were not covered in August are bright red and can be easily distinguished. Examination of this image with a topographic map overlay shows that the snow level on October 3 was at 8000 ft. (7500 ft. on north-facing slopes) in the 1600 square mile area shown.

Additional data for vegetation type mapping can be obtained from snow cover information, since it is closely related to moisture

Fig. 10: Composite image of scene 1 with superimposed altitude overlay. Recent snow appears bright red.

conditions. Differential rates of melting and the resulting changes in snow field boundaries can provide data about exposure and average temperature that will help discriminate between some types of vegetation that indistinguishable on the basis of appearance alone. The appearance and flowering of certain plant species is closely related to snow field boundaries, so the location of these boundaries can indicate the type of vegetation and the general phenology in these areas.

DISCUSSION

The results of this brief investigation show that ERTS-1 multispectral scanner imagery can be of considerable value in habitat analysis. Useful information about several aspects of the grizzly's environment can be obtained with minimal cost and effort from a few hours spent examing the imagery. The authors have not had prior photointerpretation experience, and so we may have overlooked information (of which other investigators are already aware) that could be obtained from the imagery. We plan to continue evaluating this technique in ongoing programs where habitat data are needed.

We feel that satellite imagery is most valuable at present as a supplement to, not a replacement for, field observations by personnel on the ground. Limitations in image resolution and in the kinds of information that can be obtained from multispectral scanning allow much room for error if used alone. The imagery can be used, however, to perform a great deal of initial screening and to select those areas where field effort can be most productively concentrated. In surveying wilderness areas to locate suitable habitat for reintroduction of grizzlies, for example, large portions could be eliminated from consideration on the basis of the imagery alone with high confidence. Field work can then be focused on the remaining locations which appear to meet minimum requirements. Examination of satellite imagery at the beginning of a study should thus allow an effective sampling strategy to be developed which will minimize the field effort and overall program cost.

Using the techniques described, we could rapidly survey the three largest ecosystems in the western United States (Yellowstone, Selway-Bitterroot, and Bob Marshall) to determine the location and extent of favorable grizzly habitat, to assist in making more accurate estimates of the present grizzly population in these areas, and to locate the most promising sites for reintroduction. Such information is badly needed and could be obtained with comparatively modest funding. Together with the extensive data on grizzly food habits, movements, ranges, and general bear ecology that has already been gathered, such a survey could provide several western states with a basis for evaluating their hunting regulations and harvest, and provide both state and federal agencies with better data than is now available to consider when making management and land use decisions.

Satellite remote sensing methods are a valuable addition to the tools of the wildlife researcher and manager in their present state of development. The usefulness of the data from ERTS-1 will probably expand in the near future, as a large number of researchers are presently developing various analysis methods to increase the types and quality of data that can be obtained from the images. This effort should result in additional techniques that would be useful in habitat analysis. For future programs, NASA is planning to develop improved multispectral scanners with 60 ft. resolution capability and other radiometric and high-resolution radar imaging devices. Remote sensing will become increasingly valuable in wildlife research and management as this improved equipment becomes available on future satellites.

ACKNOWLEDGEMENTS

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