# New System Techniques For Ecosystem Management And an Application To the Yellowstone Ecosystem

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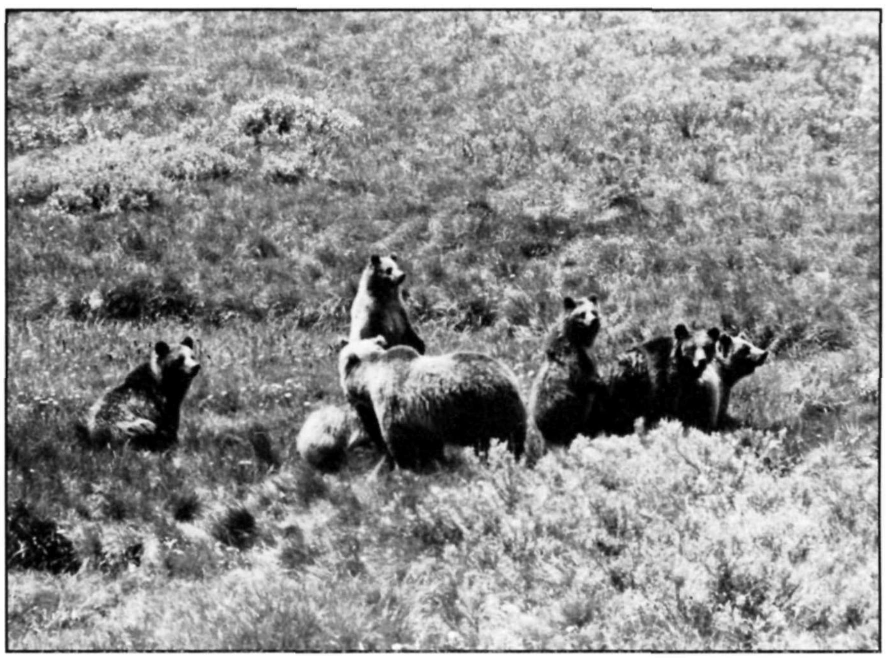


*Photo/Craighead Wildlife-Wildlands Institute*

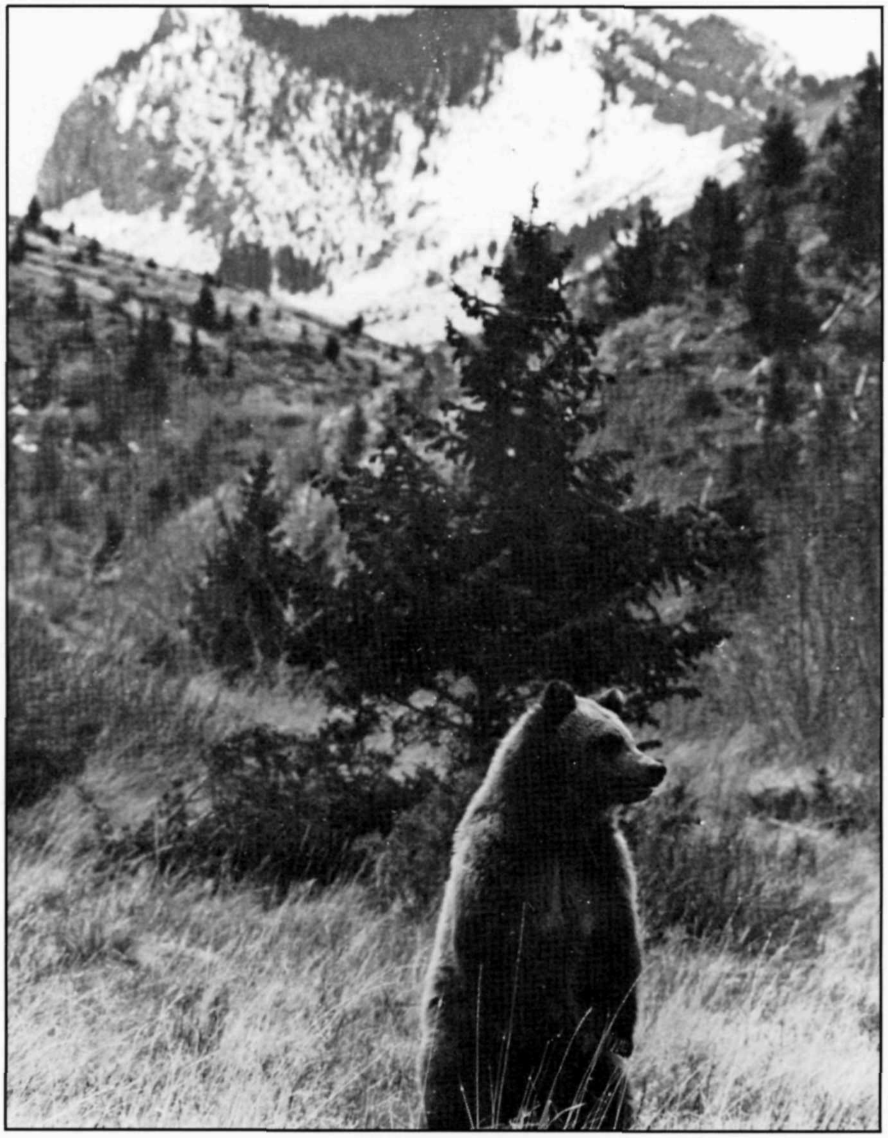
We have been hearing a great deal recently about the need for ecosystem management, but little about how to accomplish such a task. Part of the problem is the broad use of the term "ecosystem" in discussion of natural systems with very different structure and scope. The term has been used to define biotic systems as small as microhabitats and as large as Yellowstone National Park and adjacent national forests.

"Ecosystem" was first employed as a term by British plant ecologist A.G. Tansley (1935) to conceptualize the interplay of vegetation, animal species and the abiotic resources that support them. Subsequent advances in theoretical ecology added concepts of biotic and abiotic cycling, water budgets, nutrient flow, producer-consumer relationships, temporal dynamics and energy flow. It became clear that no ecosystem is truly closed in space or time. That is, while an ecosystem's spatial aspects are real, they have no precise delimitations, and an ecosystem's dynamics vary cyclically and through time.

It is, then, the responsibility of the person using the term to define its parameters. In this article, ecosystem refers to a large, biogeographic area, the animal species indigenous to the area and vegetation that has been ecologically classified (Daubenmire and Daubenmire 1968, Mueggler and Handl 1974, Corliss et al. 1973, Pfister et al. 1977). In this context, we can speak of the Yellowstone, Northern Continental Divide and Selway-Bitterroot ecosystems without delineating specific boundaries.

The Yellowstone biogeographic area is perhaps the best known large ecosystem in North America, largely because of its biological uniqueness, its long history of protection, its relative isolation and the numerous scientific studies that have been conducted there. It was also one of the first large land areas publicly recognized as a biological entity. As early as 1882, General Phil Sheridan suggested that the Yellowstone preserve, with its more than three million acres, was not large enough to provide adequate protection for its wildlife. His proposal to double the size of the park by including land used by migrating ungulates was unsuccessful.

The ecosystem concept emerged again in 1918, when an addition of 1,265 square miles east and south of the



Photo/Douglas O'Looney

Yellowstone boundary was suggested to accommodate wildlife. This later became part of Teton National Park and Teton National Forest. In later years, the ecosystem was roughly defined by the summer and wintering areas of at least six distinct elk herds and their migratory corridors.

Then, just over a decade ago, an ecosystem boundary was defined specifically in terms of critical habitat for grizzly bears (Craighead 1980). Most recently, the Greater Yellowstone Coalition proposed a biopolitical ecosystem boundary, which might be described as the current federal land management boundaries. Unfortunately, despite these various attempts to define the limits of the ecosystem, none have included a detailed, quantitative assessment of the area's vegetation, with accompanying biotic boundaries. Such an assessment is extremely important because it can be used to relate specific animal populations to a quantitative food base.

The methodology for an assessment is available, as are sophisticated techniques for determining animal habitat use and preference on an ecosystem scale (Craighead 1982). This article discusses the development of these techniques and how they can be applied in management of ecosystem resources, particularly the resources of the Yellowstone ecosystem.

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Efforts to map the spatial distribution of vegetation date back to the 16th century, when maps were beginning to be widely used. These maps were generally crude and reflected the limited knowledge of explorers and naturalists. It was not until the development of aerial photography earlier in this century that the vegetative characteristics of relatively large areas could be recorded "remotely" and studied.

Scanning instruments capable of measuring a wide spectrum of the radiation reflected by vegetation and other surface features were developed in the early 1960s for aerial reconnaissance. In 1969, a prototype spectral scanning system was put into orbit around the earth aboard the Apollo 9 spacecraft. The first Earth Resources Technology Satellite, ERTS-A, later named Landsat-1, was launched in 1972. Thus, after centuries of mapping with many different criteria and classification schemes, it was now possible to use precise data — in this case, spectral reflectance values — and interpretive digital computers to classify and map the earth's surface (Colwell 1971, Varney et al. 1974, Hoffer et al. 1975).

The vegetation and land cover of several wilderness areas has been mapped and classified with the aid of aerial photographs (Racine 1974, Dirschl et al. 1974, Cowardin et al. 1979) and/or satellite imagery (Winterberger 1984, Adams and Connery 1983, Meyer and Spencer 1983, Acevedo et al. 1982, Talbot et al. 1984). On the ground, distribution and relative abundance of plant species and communities has been determined by intensive vegetation surveys (Racine 1974, Cadbury et

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*After working for nearly a decade on various wildlife projects in Alaska,* **Derek J. Craighead** *returned to Montana to work at the Wildlife-Wildlands Institute. He is now president of the institute and is in charge of its satellite-tracking projects in Alaska.*

al. 1971, Dirschl et al. 1974). The combination of these two approaches — that is, classifying and mapping a large area of wilderness with satellite imagery and, simultaneously, correlating a detailed quantitative description of the vegetation, was the next critical step (Craighead et al. 1982). Meaningful ecological comparisons between ecosystems in different geographic areas were then possible (Craighead et al. 1986).

The Landsat satellites gather a continuous series of digital images of the earth's surface from a polar orbit at an altitude of about 560 miles. Scanning systems that record radiant energy over a wide spectrum of wave lengths collect and digitize the imagery data for later transmission — "down linking" to ground receivers. The basic spectral unit digitized by the scanning system is the picture element, or pixel. A pixel represents the brightness level of a rectangular area on the earth's surface; its size varies according to the scanning system. The pixel recorded by the Landsat Multispectral Scanning System (MSS) is 1.12 acres. The newer Landsat Thematic Mapper can define an area about one-fifth that size.

Vegetation complexes are first identified in the field. In the laboratory, a digital image-analyzer measures the range of a sample of pixel values for each complex and builds a unique spectral signature. The signature is then extrapolated to the rest of the digital map, thus transforming the digitized spectral data to color-coded maps, pixel by pixel. When merged with topographic models of the area, a digital-topographic-vegetation map and data base are generated. Thus, the mapping system can be applied to one-fifth of an acre or an entire ecosystem.

The digital map portrays the study area in terms of spectral values that represent vegetation complexes. The areas of similar spectral reflectance have similar vegetation. The botanical composition within the complex, both qualitative and quantitative, then requires extensive on-the-ground sampling and analysis. This is termed "ground truthing."

In any satellite system to map vegetation, a direct relationship must be established between the spectral data and the vegetation it represents. We used vegetation sample plots and transects to describe each vegetation complex botanically, in terms of percent cover and frequencies of individual species' occurrence. These were translated into habitat-type groupings, such as forest habitat types, ecological land units or plant series. The units were then further described in terms of plant communities and plant species.

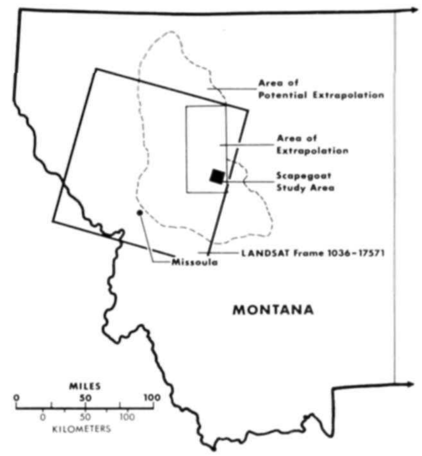



**Figure 1**
**The Montana study areas**

*Photo/B.W. O'Gara*

In Montana, where we used satellite imagery to classify, map and describe 1,774 square miles of the Scapegoat and Bob Marshall Wilderness areas (Figure 1), and in Alaska, where we similarly mapped a 13,038 square mile area (Figure 2), we developed ground-truthing techniques for application on an ecosystem scale (Craighead et al. 1982, 1988). In Montana, a vegetation-type map of the study areas was produced on the ground for subsequent comparison with the satellite digital map. Aerial photographs, aerial reconnaissance and site visits were used to identify training sites — large homogeneous areas of vegetation, each of which provides the spectral signatures which delineate the vegetation complexes. The color-coded digital maps were taken into the field, and the boundaries of vegetation complexes were compared with actual habitat boundaries. Botanical data were compiled from numerous sample plots in each vegetation complex, and percent cover was estimated to the five percent level for three strata: tree, shrub and

dwarf tree, and ground cover. Species occurring at less than five percent were considered trace species. Ground cover, as well as bare ground, were considered in all plot estimates to total 100 percent.

The same plot sizes were used in Alaska, but percent cover was estimated to the one percent level. In addition to the three strata evaluated in Montana, the Alaska study measured coverage by a sublayer of sphagnum, moss and lichen species.

The mapping system is best adapted to classify large vegetation units within entire ecosystems by their spectral signatures, but it is not limited to this. For example, researchers could readily use the system to map and botanically quantify a one- to twenty-square-mile area of special interest — a watershed, series of mountain slopes, etc. First, the latitude and longitude of the area is determined. It is then located on the MSS digital tape by a user-interactive computer and video-displayed. The areas or vegetation sites may lie in one or more vegetation complexes.

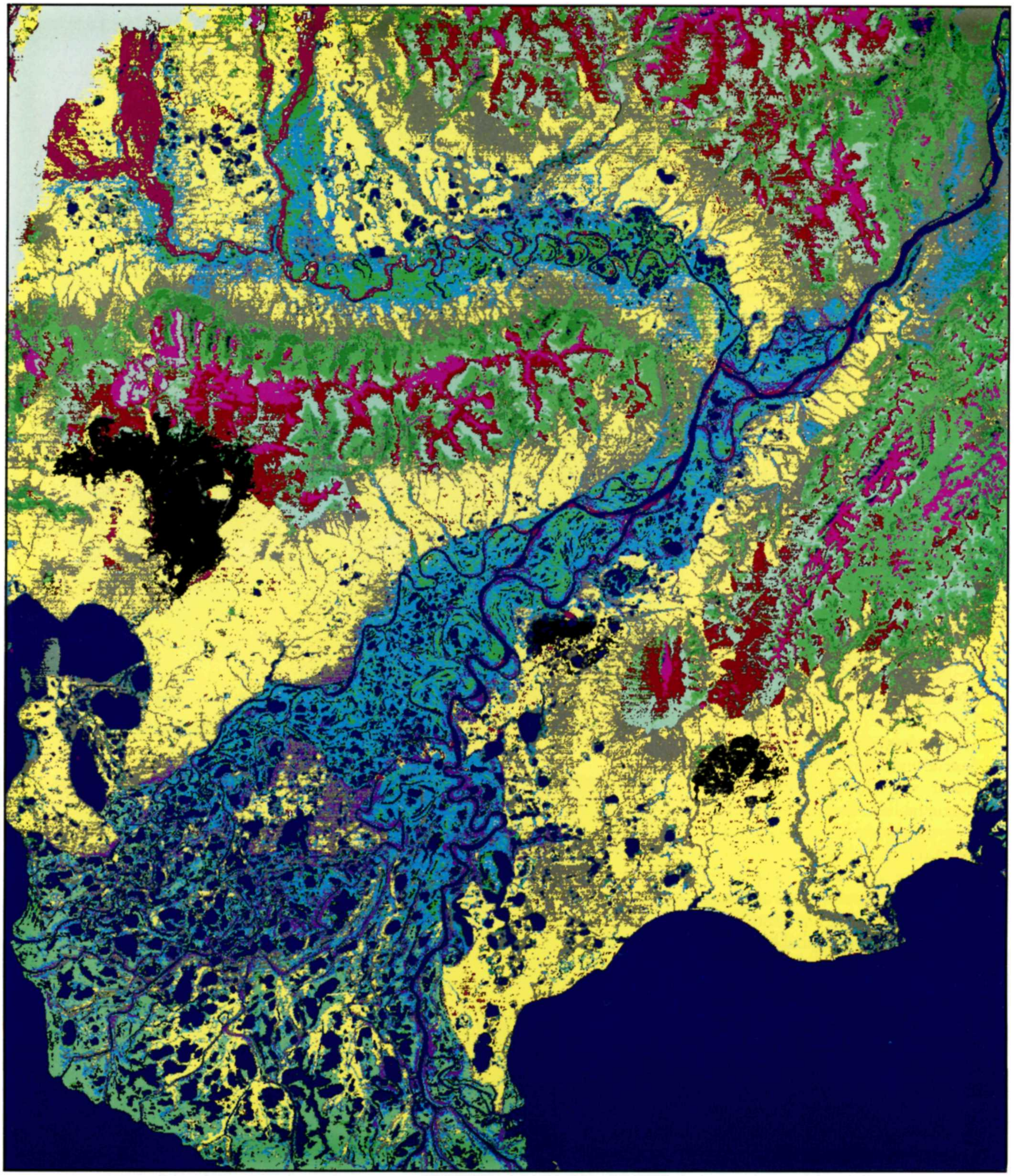
Any number of these vegetation sites or animal use locations, defined in the field or identified from aerial photographs, are then delineated by drawing their boundaries, manually or by computer, into polygons. These can be as discrete as a single, large plant community or a combination of several communities. Similarly, land form units, such as the ecological land unit, animal homes ranges or sites of high animal use as small as one acre, can be computer-delineated on the map. Once the polygons are designated, color codes are assigned, and a color-coded (thematic) map with subunits specifically delineated within vegetation complexes can be computer-constructed, printed and enlarged for field use.

Thematic maps can be used to interpret similar small land areas located throughout the ecosystem, even though the data cannot be computer-extrapolated to other areas. However, both the small polygon-defined sites and the large spectrally defined vegetation complexes can be used in total-area computer computations and in statistical analyses of interspersion, juxtaposition and habitat diversity.

Photo/Craighead Wildlife-Wildlands Institute

To illustrate the application more specifically, assume that we are mapping a ten-square-mile area of heavily used grizzly bear habitat. Vegetation complexes (which can be extrapolated to the larger ecosystem) and one- to ten-acre dispersed areas of riparian marshland and specific avalanche slopes (signature polygons which cannot be extrapolated) must be identified. The vegetation comprising the spectrally defined complexes is mapped by applying botanical data gathered in the field. Polygons are drawn around all the specific sites; they are color-coded and incorporated into the digital base map displaying the vegetation complexes. Readouts of area statistics can then be obtained from the digital map data base, for both the large and small units.

Different ecosystems, if they are accurately mapped and described by one or more of existing satellite imagery systems, can be compared to show similarities and differences. This can be accomplished at a number of levels. Starting with the larger classification units, bioclimatic zones can be compared: the vegetation of one biogeographic area's alpine zone with another's, the subalpine with subalpine and temperate with temperate. The vegetation composition of progressively smaller vegetation units, such as forest series, vegetation complexes, forest habitat types and plant communities can also be quantitatively compared and analyzed. It is also feasible to computer-analyze such parameters as edge effect, vegetation composition of animal home ranges, ecological diversity, percent abundance of a plant species or the abundance of preferred food plants in the home ranges of bears, moose, elk and other species.



*Digital vegetation map of the primary Alaska grizzly bear study area. Each color represents one of 21 vegetation complexes. Each complex has been sampled on the ground and the plant species composition described. The major physiographic features from top to bottom are: Baird Mountains, Squirrel River, Kiana Hills and the Kobuk River delta. Seven grizzly bear home ranges were identified in the Baird Mountains and Squirrel River area. The Kobuk delta is prime moose, muskrat and waterfowl habitat. Figure 2 provides additional location information.*

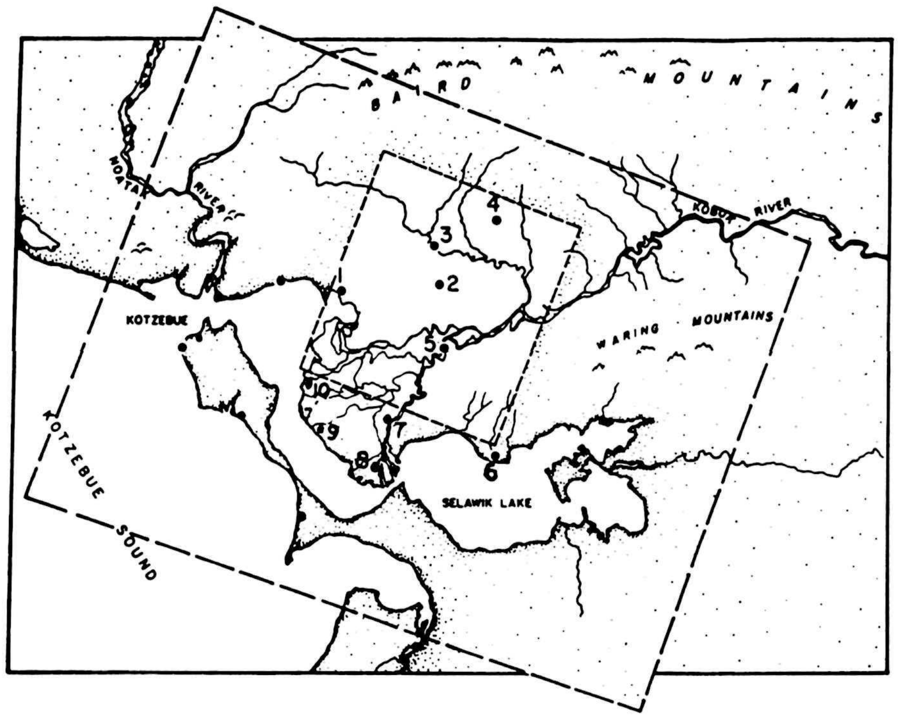



**Figure 2. The Northwestern Alaska study area, also presented in the vegetation map on facing page; that map concentrates on the area outlined in the center of the map above. The main geographic characteristics are 1) Hotham Inlet, 2) Kiana Hills, 3) Squirrel River, 4) Baird Mountains, 5) upper Kobuk delta, 6) Selawik Lake, 7, 8, 9, 10) Kobuk River channels and lower delta.**

For our work in Alaska, we used a worldwide data-gathering system, the NOAA/Tiros Satellite System, to locate specific animals equipped with radio collars.* We captured and fitted both caribou and grizzly bears with radio collars that transmitted signals which allowed their location via satellite. The collars fitted to the animals contained two radio transmitters: an ultra-high-frequency Telonics PTT and a conventional very-high-frequency transmitter. This project permitted us to determine habitat preference and use by both animals. We were able to integrate data from Landsat-II and Tiros-N for information applicable to management of a large wilderness ecosystem.

The NOAA satellites move in circular, sun-synchronous polar orbits at altitudes of 516 to 540 miles in 101- to 103-minute periods. During each orbit, the satellites pass over both poles, but cross the equator at a new position because their paths are displaced 25 degrees to the west as a result of the earth's rotation. The mean number of passes during a 24-hour period in which a satellite is visible above the horizon, regardless of longitude, is 7 at 0 degrees latitude (the equator) and 28 at 90 degrees latitude (the poles).

Data from instrumented caribou and grizzly bear were received from the satellite at Gilmore Creek, near Fairbanks, transferred to Suitland, Maryland, for message separation and then transmitted to Toulouse, France, for processing and distribution. Processed data were sent to NOAA at Suitland, where they were stored on a large mainframe computer. We then retrieved the data via modem.

The time and length of time that a satellite is visible above the horizon and, therefore, capable of receiving a PTT radio signal can be predicted for any given location. The radio collars on caribou were programmed to transmit a 0.06-second signal for a six-hour duty cycle, or transmitting period, during three consecutive days each week. This sequence was designed and programmed to provide at least one location fix during each duty cycle and to allow a minimum transmitter-operation life of six months. The radio collars on grizzly bears were programmed to transmit a 0.06-second signal every minute of a 24-hour duty cycle. This sequence reduced the operational life but maximized the number of location fixes.

Two prototype radio collars were tested on caribou and seven on grizzly bears. Each 0.06-second transmission during a duty cycle included the collar's unique identification number and sensor output values. To determine or "fix" a UHF location, one satellite had to receive at least five signals from the radio collars in a seven-minute period.

A radio collar's location could be determined from single or multiple satellite passes. Transmissions received during a single pass produced two symmetrical solutions; a software program used these to select the most probable locations relative to the most recent location. Data from two passes produced a single, unambiguous position (Oyharcabal 1983). The data were condensed and processed with a program that converted the coded figures into distances, azimuths and times between each radio location and then sum-

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**The NOAA/Tiros Satellite System is a cooperative effort of the United States, the United Kingdom and France. This joint venture by the National Aeronautics and Space Administration (NASA), the National Oceanic and Atmospheric Administration (NOAA), the British Meteorological Service and the French Centre National d'Etudes Spatiales (CNES) constitutes a worldwide data-gathering system composed of:*

*1) Small data collection stations, or Platform Terminal Transmitters (PTTs), which record aspects of the earth's environment and transmit the data by radio signals; 2) a radio transceiver, housed in a Tiros satellite, which receives the PTT signal and retransmits it to an earth receiving station; and 3) a data-processing center administered by CNES under the name Service Argos.*

*PTTs have been used at both fixed and moving locations such as sea ice, ocean buoys, ships and high-altitude balloons to record air and sea temperatures, humidity, wind speed and direction and atmospheric pressure. Because the satellite's digital systems can determine consecutive locations of a PTT's radio signals, it is possible to calculate speed and direction of ocean currents, ice flows and moving animals. Locations of PTTs are determined by solving algorithms using the measured Doppler shift of the transmitter's carrier frequency.*

marized time and distance traveled.

The locations of the two instrumented caribou were satellite-fixed 108 and 89 times over 146- and 113-day periods, respectively (Craighead and Craighead 1987). More than 400 locations per bear were recorded for each of the seven grizzlies fitted with the more refined radio collars (Craighead and Craighead, in preparation). Locations for caribou were accurate within 0.5 miles and within 0.16 miles for grizzlies.

The ability to follow instrumented animals with great precision through an ecosystem where vegetation is classified and mapped provides considerable interpretive possibilities. The satellite location system is most advantageous in studies of animals inhabiting large ecosystems or remote regions where transportation, logistics and environmental or political conditions make field work difficult and expensive. Such animals include, in addition to bears and caribou, wildebeests, snow leopards, Siberian tigers, elephants, whales, seals and large migratory birds. The system is especially effective where many location fixes are needed over a long period when the studied species is sensitive to disturbance. Satellites can provide worldwide coverage, so there are virtually no restrictions on field sites with this methodology.

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Both the vegetation-mapping system and the animal-location system consist of digitized data that can be computer-displayed and computer-analyzed. This provides tremendous potential for collating and analyzing data and arranging them in categories of information. We can then begin asking questions.

Quantifying animal use of habitat sheds light both on the habitat and the animals that use it. For example, we can expect to begin answering questions such as, What types of vegetation do bears prefer for feeding, resting, bedding, denning? Do bears preferentially use certain types of vegetation in their home ranges and avoid others? How does nocturnal activity compare with diurnal activity? What habitat is seasonally most important for bears?

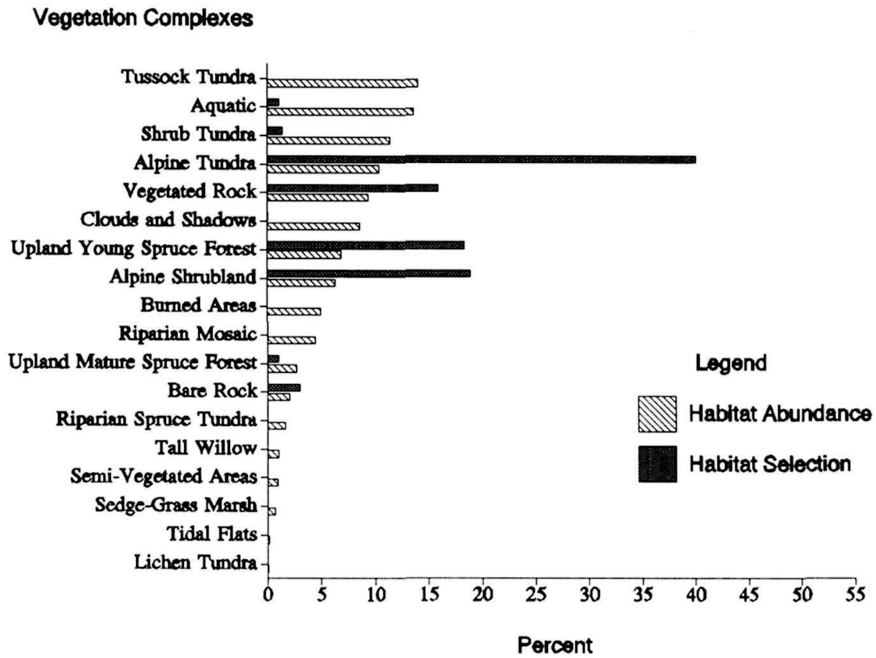


**Figure 3. Relation of percent habitat abundance to percent habitat selection by a grizzly bear in northwestern Alaska. Each vegetation complex is botanically described to the plant community and species level.**

How are the preferred vegetation types distributed and used throughout a large ecosystem? Is there a direct relationship between the distribution of specific vegetation types and bear distribution? Can the carrying capacity of an ecosystem for grizzly bears be accurately calculated from habitat selection data?

Most importantly, if these kind of questions can be answered, can such information help determine population recovery goals?

To answer these and similar questions, we first had to determine whether a computer program could combine animal locations made by the NOAA/Tiros satellite with the vegetation data base from the Landsat satellite and whether, with a combination of the two data sets, the vegetation type occupied by grizzly bears, for example, could be precisely determined. We hypothesized that "occupancy" defined use. Repetitive locations provided a basis for evaluating habitat use or preference. Having demonstrated the accuracy and effectiveness of the two systems individually, we proceeded to determine the feasibility of computer-integrating them (Craighead and Craighead 1987, Craighead et al. 1982, 1986, 1988).

We tested the accuracy of the integrated system applied to grizzly bears in the summer of 1988. First, the same type of radio collars used on the bears were manually placed in various vegetation complexes in the Alaskan study area. In other words, we mimicked the role of the bear in moving from site to site. The field description of the vegetation at each radio site and subsequent satellite fix were then compared with the same ground area where vegetation had been mapped earlier via Landsat.

On the basis of our results, we felt confident to analyze habitat preference from the radio locations of grizzly bears. Using four computer programs to integrate bear location data from the Tiros-N satellite with Landsat multispectral vegetation data, we are now analyzing habitat preference from more than 5,000 bear locations and using the information to quantify habitat use by grizzlies (Figure 3).

Obviously, the combination vegetation-mapping/animal radio loca-

tion system could provide valuable information for managers of wilderness resources. Use of the system as a management tool would require the following:

• Develop or complete hierarchical vegetation classification systems for extensive geographic areas; these should include vegetation classes ranging from the series to the plant community

• Standardize vegetation field-sampling procedures to establish comparable descriptive data bases

• Standardize, within the limits of current computer capability, a color code classification for the vegetation categories high in the hierarchical vegetation classification; for example shades of green for forest complexes, violet for shrublands, yellow for grasslands, etc.

• Develop specific botanical and ecological criteria for delineating ecosystems or biogeographical areas, to improve the accuracy of extrapolation

• Standardize terminology wherever possible

• Continue refinement of the satellite animal-location system

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Grizzly bear management based on population data has been largely ineffective and often very controversial. The system we have outlined here could give wildlife managers the kind of information they need to manage grizzlies on an ecosystem level through better, holistic understanding of the bears' specific habitat and spatial requirements.

The grizzly bear was listed as a threatened species in July 1975. The U.S. Fish and Wildlife Service approved a recovery plan for the species in January 1982. The first revision of that plan is now being circulated for agency and public review. It is directed toward seven populations in seven distinct ecosystems — Yellowstone, Northern Continental Divide, Cabinet-Yaak, Selkirk, North Cascades, Selway-Bitterroot and San Juan Mountains. Only two of these populations — the Yellowstone and Northern Continental Divide — are considered viable, and they are the only two that have been the subject of long-term research.

The recovery plan's objective is to delist each population when it fulfills certain biological and ecological criteria. The overall plan suffers some major deficiencies, as does the specific plan for the Yellowstone ecosystem, many of which could be rectified with application of a vegetation data base provided by satellite ecosystem classification and mapping. We will address a few of the major deficiencies as they relate to bear recovery and ecosystem habitat management.

General recovery criteria for grizzly bears include "a minimum number of females with cubs seen annually, distribution of family groups throughout the recovery zone, and a limit on human-caused mortality." The first two objectives are directly related to habitat quality. Yet the recovery plan for the Yellowstone ecosystem does not provide adequate resource planning or habitat protection for the future, nor does it recommend a system to provide understanding of the ecosystem-wide habitat necessary to support a recovered grizzly bear population.

It also lacks a scientifically defensible target for population recovery. The current target of a minimum number of females with cubs *seen* annually over a six-year running average is based on untested techniques because it assumes a speculative ratio of 60 percent observed to unobserved bears. The habitat, or vegetation complexes, occupied by family groups has not been sufficiently quantified to allow extrapolation to and designation of unoccupied bear management units. This could be a major flaw in evaluating the population for delisting.

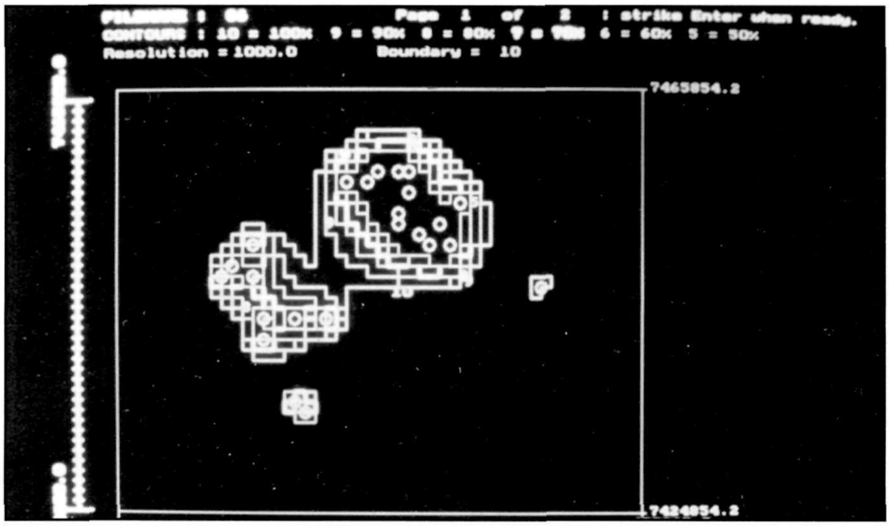
The recovery plan also does not adequately address genetic viability and gene flow. Gene flow, the transmission of genetic characteristics in populations, is especially critical for a small, isolated population. Travel corridors are essential for maintaining the genetic viability of the Yellowstone grizzly population; if these are not

*Photo/Craighead Wildlife-Wildlands Institute*

available, a recovered population might come to depend on periodic bear transplants. The recovery plan recognizes the Yellowstone area as an ecological island but fails to delineate botanically the undeveloped habitat that links it to other major ecosystems or to designate the hazards to bears using such corridors. Also unaddressed are how to protect the corridors, how to encourage bear movement between the three ecosystems and whether maintenance of travel corridors is even feasible, now or in the future. Indeed, there have so far been no verified reports of corridor use by bears.

The current method of designating critical habitat for grizzly bears is to assign habitat to one of five management "situations," loosely defined in terms of the importance of the habitat to bears and frequency of bear use. This is essentially an agency response meant to dilute what appeared to be the original congressional intent of delineating entire ecosystems. Space, as well as the vegetation resources, are essential to the grizzly bear.

Management "situation" boundaries are actually artificial enclaves within a




*Contour maps are a convenient means of displaying the estimated home ranges of animals. This map is based on 29 locations of bear No. 96 in a study area in northwestern Alaska. The innermost contours represent the area with the largest density of observations. A quantitative description of the bear's home range can be obtained by laying the home range map on a vegetation cover map.*

habitat continuum; they do not consistently correspond to recorded bear densities, to preferred habitat or to spatial needs. The recovery plan proposes no technique for detecting slow, long-term habitat deterioration that could affect bear recovery, future carrying capacity or redesignation of management situation boundaries.

Another management technique now in vogue is the cumulative-effects analysis model, used to assess habitat conditions. This system lacks a systematized ecological data base applicable throughout an ecosystem. Both the cumulative-effects model and the designation of management situation boundaries need to be oriented to an ecosystem vegetation map and submitted to peer review by non-agency researchers.

The vegetation mapping system described earlier could improve the recovery plan by providing:

- A quantitative basis for multi-aspect resource planning and habitat protection for the entire ecosystem; this would provide the holistic view necessary for formulating policy
- A basic ecological understanding of grizzly bear habitat throughout an ecosystem and a definitive comparison of occupied versus unoccupied habitat, or management unit versus management unit
- A systematic, objective method of determining population recovery size through habitat analysis without the need for an intensive capture, mark and release program
- Vegetation data analyses applicable to bear densities, home ranges, food habits, activity centers and habitat linkages between ecosystems and, eventually, ecosystem versus ecosystem
- A more definitive analysis of edge effect as it relates to habitat components and to human use sites
- Standardized, quantitative data for delineating management boundaries or for discarding such boundaries for a more holistic approach to defining critical habitat and preferred habitat throughout the system
- A quantitative, standardized methodology for botanically describing and mapping ecosystems so that long-term and catastrophic habitat changes can be evaluated

Enough is known about the food preferences and habitat requirements of grizzly bears to interpret this information with an entire ecosystem in mind. The systems we have described allow calculation of area and percent area of preferred grizzly bear habitat in a home range, activity center or entire ecosystem. The systems also provide quantitative data on food plant abundance, the size and distribution of bear home ranges and activity centers and, ultimately, ecosystem carrying capacity.

In the future, it will be possible to compare these parameters and others between ecosystems — the Yellowstone ecosystem with the Northern Continental Divide, for example, and both with the Selway-Bitterroot. More meaningful comparisons will also be possible between bear habitat in Montana and Alaska. By using models to integrate cumulative effects with a definitive vegetation data base and precise animal locations, it is possible to predict what wilderness uses will be compatible with a viable grizzly population and what population levels should be possible in any given biogeographic area, or portion of that area.

Such information allows goals to be set, the progress of recovery programs to be judged and questions confronting policy makers to be addressed. For example, where should grizzly bears be perpetuated? How much and what kind of terrain is required? Where and under what conditions do human-caused bear deaths occur, and can they be ameliorated? Can a wilderness habitat support a viable population, or are adjoining multiple-use lands essential? What is the optimum bear density for a specific biogeographic area? How do bear density and distribution, in relation to habitat, compare between ecosystems? How can such knowledge refine management objectives and reduce duplication in bear research projects?

The satellite vegetation mapping and animal-location systems have proved themselves applicable to a wide range of ecosystem terrain and vegetation. At this point, however, the social, political and bureaucratic climate does not favor their application. For example, political and agency boundaries rarely reflect ecological boundaries.

For vision to become reality, state and federal agencies that manage the resources of administratively divided ecosystems need to agree on a common mission, integrate their policy and begin cooperating to accomplish specific management objectives — such as preserving the grizzly bear in perpetuity and working toward a better understanding of ecosystem-wide habitat.

*Photo/Douglas O'Looney*

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