

CRATERS OF THE MOON NATIONAL MONUMENT
MONITORING PROPOSAL

Draft August 1993

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SCOPE OF THE PROPOSAL

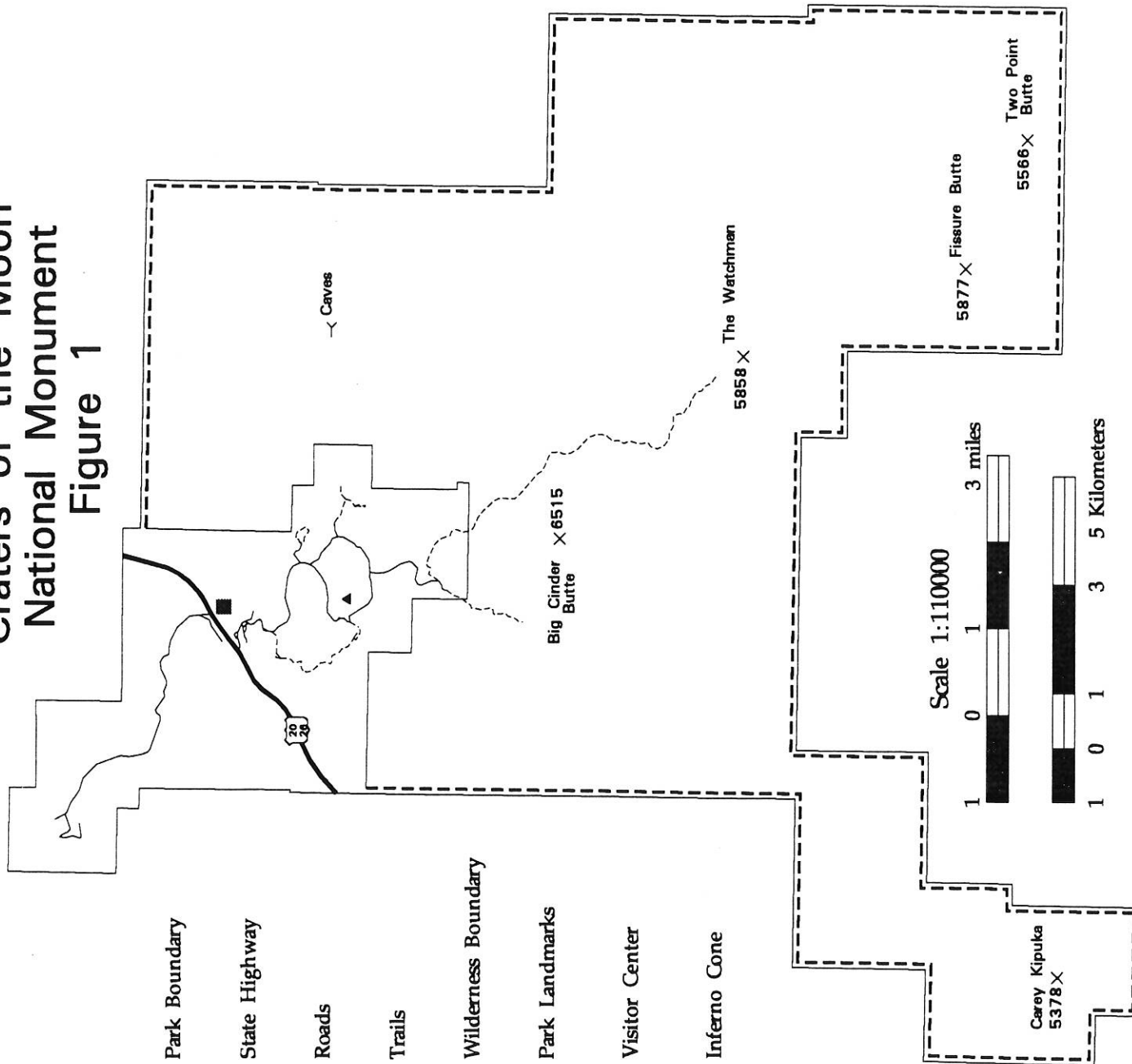
Craters of the Moon National Monument (CRMO) is situated on the northern edge of the Snake River Basin (SRB) in southern Idaho (Fig. 1). The SRB is a broad high elevation semi-arid plateau bounded by the Snake River to the south and east and by extensions of the Rocky Mountains to the north. The continuity of landforms, geologic structure, and plant communities have defined it as a distinct "Ecoregion" (Omerik 1986).

CRMO is situated amid a matrix of federal lands managed by the Bureau of Land Management (BLM) and the Department of Energy as the Idaho National Engineering Lab (INEL). Approximately 350,000 ha of BLM lands surrounding the monument have been either recommended as wilderness or are wilderness study areas (Fig. 2). Approximately 206,000 ha of these lands to the east and south of the monument have also been proposed to be placed under NPS management as the "Craters of the Moon National Park and Preserve" (Fig. 3) (Wright et al. 1993). In recognition of these potential land management changes, this proposal takes an ecosystem approach. It seeks to integrate on-going and potential monitoring efforts of all land regional management agencies into a comprehensive plan. Under this approach, intensive monitoring is proposed for sites located within

Craters of the Moon National Monument

Figure 1

- Park Boundary
- State Highway
- Roads
- - - Trails
- - - Wilderness Boundary
- × Park Landmarks
- Visitor Center
- ▲ Inferno Cone



Scale 1:110000

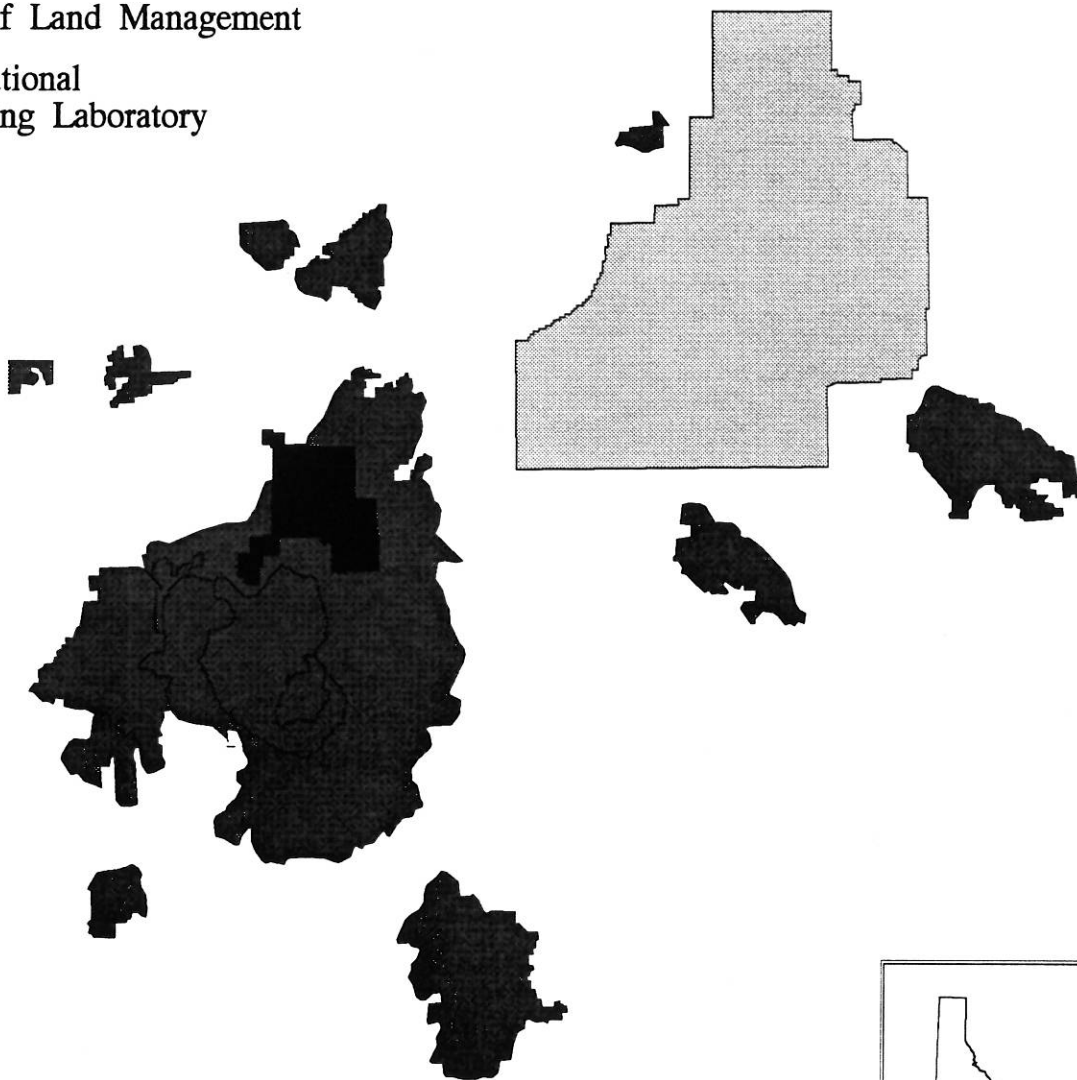
1 0 1 3 miles

1 0 1 3 5 Kilometers

Craters of the Moon and Surrounding Bureau of Land Management areas

*Map
needs
work
Land
Mgt?*

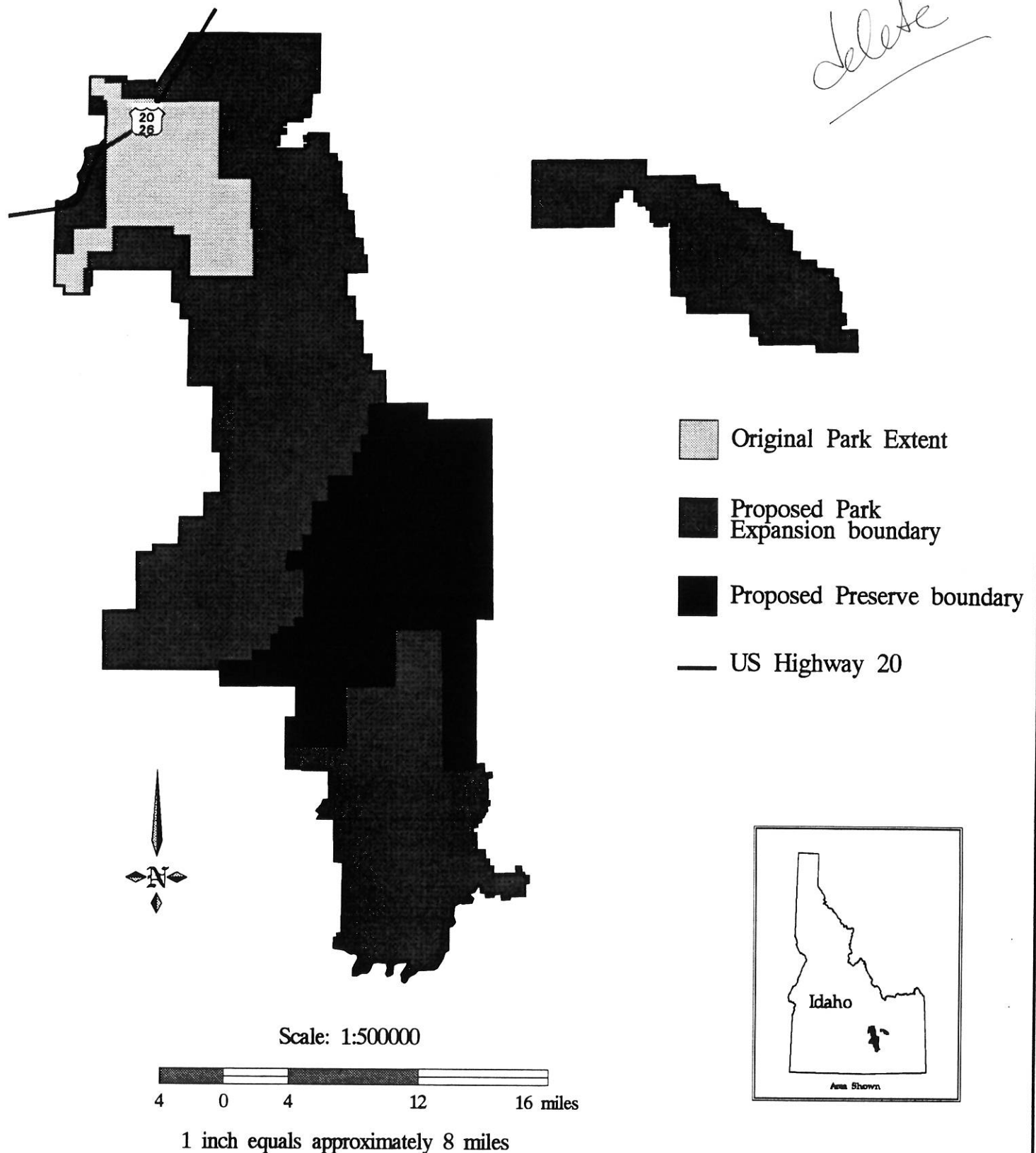
-  Craters of the Moon
-  Bureau of Land Management
-  Idaho National Engineering Laboratory



Scale 1 : 1000000
8 0 8 16 miles
1 inch equals approximately 16 miles



Proposed Expansion of Craters of the Moon National Park and Preserve



the existing monument and extensive monitoring efforts will take place on sites located throughout the SRB ecoregion.

WHY CRMO QUALIFIES AS A PROTOTYPE MONITORING PARK

Historically, research, inventory, and monitoring (RI&M) at CRMO, as in most parks, was subject specific, being primarily driven by the need to deal with specific environmental or management 'problems'. However, over the past decade, CRMO has broadened the focus of its RI&M programs to include a great diversity of ecosystem components. The current program is driven as much by the need to fill in gaps in the basic ecological knowledge of the area as it is to deal with specific management problems. This program has been primarily conducted through NPS support provided to the University of Idaho Cooperative Park Studies Unit (UICPSU). *Absorbed in NBS - Discussed Relationship w/ NBS*

The existing RI&M program has been guided by an overall plan which has been refined over the past decade. The plan is embodied in the conceptual model shown in Figure 4. One of the initial assumptions of this model was that because parks like CRMO generally had little experience with large-scale monitoring programs, programs and the support for them should be developed incrementally. As a consequence, the plan advocated that programs should start with the most basic level of information and only expanded as experience was gained (Quinn and van Riper 1990, Wright 1993). One of the first steps at CRMO was the completion of a computerized resource database which located and summarized the

RMP

results of all park and regional resource studies (Sparhawk and Wright 1990). This project was undertaken in part to help identify pertinent resource data that would be useful for incorporating in monitoring programs and thus to help avoid redundant data collection efforts.

This database and the subsequent synthesis of its findings by Blakesley and Wright (1988) were instrumental in assessing the level of scientific knowledge at CRMO and thus helping to identify information gaps which could be filled by additional research and monitoring both within and outside the monument. This process is necessarily a "positive feedback cycle" in which even as knowledge of the resources of CRMO increases, more questions emerge which give rise to the need for additional research and monitoring.

One measure of the completeness of the natural resource inventory at CRMO is a listing of the number of studies that have been conducted on various resources both in and on lands adjacent to the monument. Tabulated in Table 1., the list shows both the diversity and ^{2.}intensity of studies which have been carried out in the SRB. Synthesizing the cumulative results of these studies provides an assessment of the level of resource understanding for the ecosystems of CRMO as illustrated by the chart in Table 2. The high degree of resource knowledge already accumulated at CRMO and on surrounding lands, combined with the high levels of park, regional, and external agency support are positive indications that CRMO can confidently initiate a successful broad-based monitoring program.

A CONCEPTUAL MODEL OF INFORMATION USE AND MANAGEMENT IN A PARK

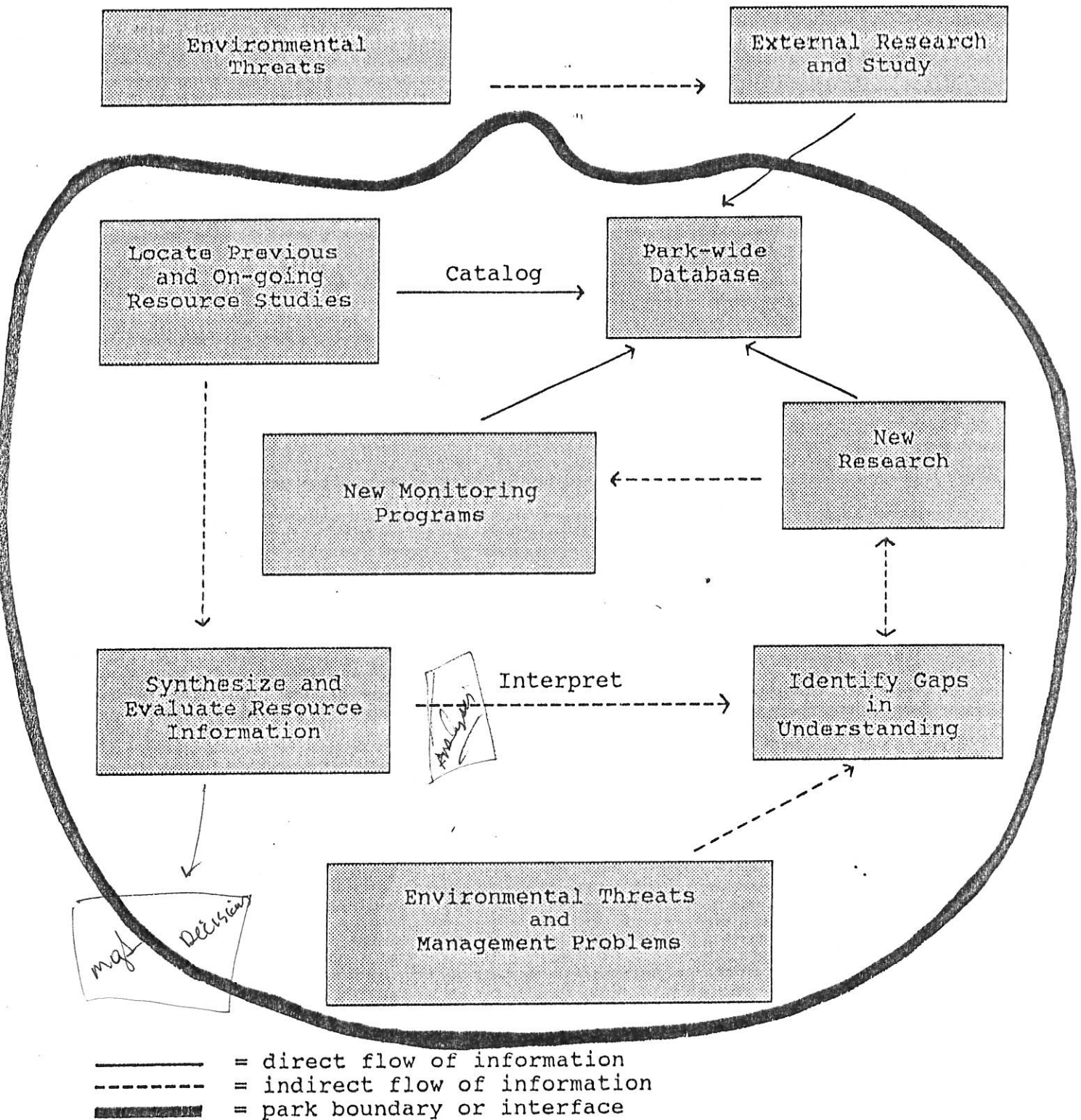


Fig 4 (To be Revised)

Table 1. Summary of the major types of resource studies at CRMO and on adjacent lands (from Sparhawk and Wright 1990).

<u>Resource Studied</u>	<u>Number of Studies</u>
1. FAUNA	
terrestrial invertebrates	13
reptiles and amphibians	6
birds	39
mammals	49
2. FLORA	
general description, habitat quality,	78
limber pine ecology and growth	9
plant succession	8
shrub ecology and habitat	13
grasses	6
lichens	7
3. GEOLOGY	
geologic characteristics and description	194
geologic processes	96
minerals	39
landscape features and landforms	29
soils	8
4. HYDROLOGIC FEATURES	
hydrology description and characteristics	18
water quality	9
5. ATMOSPHERIC AND METEOROLOGICAL	
general descriptive	37
air quality	30
climate, weather	8

Table 2. A qualitative assessment of the knowledge of various resource categories at CRMO (based on Blakesley and Wright 1988).

<u>Subject of Study</u>	<u>Degree of Completeness</u>										
	10	20	30	40	50	60	70	80	90	100	
GEOLOGY											
General Description	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX										
Geologic History	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX										
Substrate Composition	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX										
Cave Resources	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX										
FLORA											
Description	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX										
Species List	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX										
SUCCESSION											
Volcanic areas	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX										
Other Areas	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX										
Community ecology	XXXXXXXXXXXXXXXXXXXXXXXXXXXX										
Fire history	XXXXXXXXXXXXXXXXXXXX										
Fire effects	XXXXXXXXXXXX										
FAUNA											
Invertebrates	XXXXX										
Reptiles	XX										
Birds	XXXXXXXXXXXXXXXXXXXXXXXXXXXX										
Mammals	XXXXXXXXXXXX										
AIR QUALITY											
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX											
WATER QUALITY											
XXXXXXXXXXXXXXXXXXXX											
SOILS											
XXXXX											
CLIMATE											
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX											
ARCHEOLOGY											
XXXXXXXXXXXXXXXXXXXX											

EXISTING MONITORING PROGRAMS

Several long-term monitoring programs, summarized in Table 3., have been initiated at CRMO over the past decade. Many of these programs have been initiated in cooperation with other land and resource management agencies in Idaho. The experience gained in running these programs as well as the support provided by the park in terms of FTE's, project funding, logistical support, and technical direction and funding through the UICPSU all provide good indicators that CRMO can successfully manage an expanded monitoring program.

The Monument currently has a separate resource management division that reports directly to the Superintendent. The division is headed by a GS-401-9/2 resource management specialist. Other members of the division include a GS-404-7/4 biological technician, and a GS-025-4/1 seasonal ranger. GIS

OBJECTIVES OF THE MONITORING PROPOSED PROGRAM

The importance of clearly defining the objectives of a monitoring program have been stressed by many authors (Goldsmith 1991, Silsbee and Peterson 1991). Sound objectives help define all aspects of a program including the choice of the attributes to be monitored. The most commonly stated objective for NPS programs is to use monitoring information to help managers make better informed management decisions (Quinn and van Riper 1990). The objectives of this program are, in part, based on this premise. A related objective is document the effects of activities or threats outside

Table 3. Existing Monitoring Programs at CRMO

1. Visibility

Components Monitored: atmospheric visibility using
teleradiometer and 35 mm camera

Length of Program: Since 1982; daily sampling in summer

Comments: INEL has helped fund a variety of monitoring programs
that are located at the Monument. Cooperative ventures
include monitoring for radionuclides and particulates.

year round

2. Atmospheric Particulates

Components Monitored: total suspected particulates using a hi-
volume gravimetric sampler

Length of Program: Since 1974; daily sampling

Comments: Program run in cooperation with Idaho Air Quality
Bureau

switched to IMPROVE PREVENT system

INEL

3. Mule Deer

Components Monitored: Mule deer numbers, sex, and age class
(fawn, yearling, adult)

Length of Program: Since 1982; once a year ⁴one week⁵ in August

Comments: Results are used by Idaho Game and Fish Dept. to help
assess regional harvest levels.

4. Climate

Components Monitored: Standard Class I weather station
parameters

Length of Program: Since 1942, daily measurements

Comments: The only long-term climatic data available on this
portion of the SRB

5. Passerine Birds

Components Monitored: Presence/absence of all passerine species
defined sampling locations in each of 17
vegetation types.

Length of Program: Since 1985; yearly ¹2 weeks in spring

Table 3. Continued

6 Grassland Fire Recovery

*Transects
in Little
Pine*

Components Monitored: Frequency (presence) of grasses and forbs and basal area of shrubs along established 100 m transects in recent burn.

Length of Program: Since 1984, every 3 years.

7. Browse and vegetation composition

Components Monitored: Frequency of grasses and forbs, basal area and stem lengths of shrubs along established transects in known mule deer use areas.

*Replaced
by frequency
monitoring*

Length of Program: Since 1984, every 2 years

8. Vegetation Change

Components Monitored: Plant density and fragmentation as observed from established photopoints.

Length of Program: Since 1986; every 5 years

9 Limber Pine Succession

Components Monitored: Numbers and spatial patterns of limber pine in established 10 x 10 m stem plots.

Length of Program: Since 1985, every 10 years

10 Acid Deposition

Components Monitored: Ph according to protocols of NADP program

Length of Program: Since 1980

Comments: Operating in a joint effort with the BLM Idaho State Office

Table 3. Continued

11. Radionuclides

Components Monitored: Environmental radiation exposures,
particulate beta activity, antimony

Length of Program: Since 1982

Comments: Operating jointly with INEL, ISU

12. Radionuclides in vegetation

Components Monitored: Thyroids from road-killed mule deer

Length of Program: Since 1989

Comments: Program and analyses conducted by INEL.

13. Seismicity

Components Monitored: Seismic activity along the Great Rift

Length of Program: Periodically since 1990

Comments: Sampling equipment loaned from INEL

WQ - designed

photopoints for wilderness monitoring

the park. The primary concerns of CRMO in this regard are air quality degradation from activities at INEL and industrial sites in Pocatello, Idaho, and visitor-use disturbances. Again, the objectives and the monitoring elements chosen reflect this concern. Finally, some authors have suggested that monitoring programs are important simply to document changes just for the sake of familiarity with the resources, to gain insights into how the ecosystem works, or to provide a reference point to which less pristine areas can be compared (Croze 1982, Wiersma 1984, Silsbee and Peterson 1993). The objectives of the proposed program also reflect these goals.

The broad objectives of this program are then to:

1. Detect the ecological effects of long-term environmental change including the effects of changes in climate, air quality, and land use on the resources and ecological processes associated with arid land environments.
2. Detect the changes associated with visitor use and management activities or decisions on the resources and ecological processes within and adjacent to the monument.
3. Assess the changes in abundance, density, and composition of rare, threatened, endangered species and those chosen as key indicators for certain species groups.

DEVELOPMENT OF THE INDIVIDUAL ELEMENTS OF THE PROGRAM

Guided by these objectives, the individual elements of the monitoring program are designed to address the three primary attributes of arid-land ecosystems; composition, structure, and process (Howe and Westley 1988). Most park monitoring programs have typically addressed only ecosystem composition, focusing for example on the identification, number, and biomass of a particular

species group while ignoring the complexity of habitats or topographic features that embody the structure - or the ecological processes that make the ecosystem work. As a result, the traditional monitoring approaches may not detect losses of ecosystem structure or the disruption of fundamental ecological processes (Noss 1990). The proposed program attempts to seek a balance between elements designed to monitor composition, structure, and process.

The individual elements of the monitoring program are also designed to look equally at different aspects of space and time. For example, some ecological factors can only be understood by looking at broad land-scapes, while other factors require intensive micro-site studies. The selection of the specific monitoring attributes, some representing individual organisms at a specific site, others representing communities or organisms at a landscape level are designed to deal with that situation. Equivalently changes in some ecological phenomena can only be witnessed over long time intervals while others may change relatively quickly (Magnuson 1990). The program also recognizes that in ecosystems there are broadly three kinds of intrinsic changes: stochastic, successional and cyclical (Hellowell 1991). The program has tried to anticipate how the various resources in the ecoregion are effected by these types of changes and the individual elements have been chosen accordingly. Because the program addresses fundamental ecosystem properties, it should be valuable to other parks in arid land environments.

The monitoring program offered in this proposal is realistic

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in its goals and expectations. The program is based on the fundamental precepts that no monitoring program can monitor everything and that monitoring is cheaper, easier, and ultimately more successful when the techniques are simple to use and they focus on specific components of the ecosystem. Past experience with existing monitoring programs have shown that simplicity will often mean ease of collection of data, ease of analysis of those data, ease of interpretation of results and, above all, ease of handing over responsibility to someone in a more subordinate position. The latter is important in national parks because as a long-term exercise, monitoring frequently involves many different people, each possibly only for a few years (Usher 1991).

The proposed program has 26 individual elements. The relation of these elements to the ecosystem characteristics that will be to monitored as well as to different spatial and temporal levels are illustrated in Tables 4 and 5. In addition to its suitability for addressing the above factors, the choice of each element was also based on how well it met specific characteristics which should be considered in all monitoring programs (Clarke 1986). These characteristics were:

1. Sensitivity: the indicators are sufficiently sensitive to provide an early warning of change;
2. Spatial distribution: The findings from an indicator can be extrapolated over a relatively broad geographic area;
3. Unbiased: The indicators are capable of providing an assessment of change over a wide ranges;
4. They are easy and cost-effective to measure, analyze, and interpret;
5. They are relevant to ecologically significant phenomena.

6. Management Relevance

Table 5. Techniques proposed for monitoring changes in ecosystem process and structure over various time scales at a gradient of site sizes.

INTENSIVE (MICRO-SITE) ← -----> EXTENSIVE REGIONAL

<u>PROCESS</u>	
16) erosion	17) eruptive cycles
18) fire	19) plant succession
20) disturbance	
21) parasitism	
22) nutrient cycling <i>WQA</i>	
23) air quality	
<u>STRUCTURE</u>	
	24) habitat fragmentation
	25) changes in geologic landforms
26) mule deer population structure	



Annual -----> Decade -----> Multiple Decades
Time Scale for Change Detection

The methods, i.e., the type of measure and units of analysis employed for each element of the program are described in Table 6. This proposal refrains from an elaborate description of methods, relying instead on proven techniques, many of which are specific to arid lands in the SRB, and which have extensive support in the scientific literature.

DATA MANAGEMENT

The UICPSU has in the past managed most of the research and monitoring data that have been produced at CRMO. It is proposed that this relationship continue. The UICPSU has the staffing, technical expertise, and computer hardware necessary to provide this assistance. The unit has, over the past five years, developed and managed the largest basic resource database in the NPS (Wright 1993).

Specific elements of the data management program are described below:

1). In order to provide control and assure quality data collection, a series of handbooks (e.g., standard operating procedures) (SOP's) will be written for each of the ^{new} monitoring programs prior to their initiation. ^{& existing resumed.} Patterned after those that have been written for existing CRMO monitoring programs (e.g., Griffith 1984), these (SOPs) will provide explicit guidance on how, when and where to collect data, appropriate analytical techniques, and proper archival procedures. They will be written by specialists for the given technique and reviewed by UI statistical consultants. In

Table 6. Methods (measures and analysis), reference, and interval of measurement for proposed monitoring activities. (Numbers of activities correspond to those in Tables 4 & 5, numbers of references correspond to those in lit cited).

MONITORING ACTIVITIES	METHODS (REFERENCE #)	TIME INTERVAL	one year
1) plant community patterns	1:12000 aerial photos, comparative GIS analysis, fractal analysis (5)	5 years	
2) plant community distribution ¹	comparative analysis using GIS scanned images and photo interpretation from defined photo-points (Appendix) (50)	5 years	
3) raptor numbers	population abundance indices from counts along established road transects using <u>Ferruginus hawk</u> as indicator sp. (3, 6)	May 2 weeks each year	2 weeks
only 4 records just 1990 4) lava patterns	infrared aerial photos, side-looking radar (28,35,45) comparative GIS analysis	10 years	
5) lagomorphs	index of relative abundance; from evening spot-light road transects using black-tailed jackrabbit as indicator (12)	1 week each year	1 week
6) soil development	changes in depth at specific sites on newer lava flows using soil-depth pins (25)	5 year	
7) upland game bird trends	population trend indices at on known breeding leks using sage grouse as indicator (21)	May 5 days each year	1 week
8) T&E species	population censuses using harp-type bat traps (Appendix) situated in selected cave openings to obtain data on density, population trend, & composition using Townsends l.e. bat as indicator (13, 42)	1 week each year	1 week
9) reptile species trends	population censuses obtained from representative pitfall traps and drift fences (Appendix) (16, 4); sagebrush lizard as indicator	2 year	

Table 6. Continued

MONITORING ACTIVITIES	MEASUREMENTS (REFERENCE #)	TIME INTERVAL
10) indicator species		weekly
a) beetles	pitfall traps	June/July
b) lichens	established plots in transects on rock out-crops & limber pine stands; abundance, composition, and pollution measures using scanning electron microscopy & X-ray energy dispersal analysis (32)	1 year
c) mule deer ¹	observations along an established road transect (15, 7)	⁴ / ₁ week/yr August
11) caves	comparative analysis of visitor use impacts and hazards using videographic methods; measures of radon 222 (8); abundance of lava tube beetles (33)	2 years
12) climate ¹	standard Class I measures (7)	daily
13) passerine birds ¹	Indices of abundance & trend gained through station index techniques at 2 sampling stations in each of 17 vegetation types (7,18,27)	June 2 weeks/yr
14) plant species ¹ composition	100 1-meter plots along established transects measuring frequency of grass species & shrub basal area (7, 38)	2-3 years
15) exotic plant species ¹	plant community composition on Carey Kipuka using techniques as in # 14 (41, 7) <i>highway survey corridor</i>	2 years
16) erosion	network of established erosion-pins at sensitive sites (25)	2 years
17) eruptive cycles	comparative analysis of periodic LANDSAT images (24) and continuation of seismic monitoring program	10 years

Table 6. Continued

MONITORING ACTIVITIES	MEASUREMENTS (REFERENCE #)	TIME INTERVAL
18) fire	frequency & extent of burns using aerial photos and GIS analysis <i>Veg. Response - Transects</i>	3 years
19) plant succession ¹	comparative analysis of existing photo points (50); stem mapping plots of limber pine on cinder cones (48); changes in cinder cone/herbaceous plants (9, 10)	5 years
20) disturbance	erosion-pin transects & laser survey profiles of Inferno Cone; photo-point analysis of visitor disturbance of spatter cones (7)	2-3 years
21) parasitism	abundance of dwarf mistletoe alone established quadrats in limber pine stands (43)	5 years
22) <i>Water Quality</i> ~~nutrient cycling~~ ¹	changes in nutrient and chemical composition of Little Cottonwood Creek (11) + <i>Techniques under dev.</i>	June 1 year
23) air quality ¹ <i>IMPROVE PREVENT</i>	atmospheric particulates using ~~high-volume gravimetric sampler~~ , visibility use teleradiometer, acid deposition according to NADP standards, radionuclides using particulate beta activity & antimony levels (7)	<i>Based on 1993 Study</i> daily
24) habitat	GAP analysis of vegetation continuity; LANDSAT images for SNB (36)	5 years
25) geological landforms	LANDSAT and radiometry and side-looking radar (28, 35, 45)	10 years
26) mule deer ¹ sex and age structure	observations along established road transect (7, 15)	August 1 week/yr

¹ Extensions of existing monitoring programs

some cases, the procedures may require pilot studies or an analysis of existing data in order to develop the best sampling intensity, plot sizes, and other details. We anticipate scientists and analysts at INEL will be able to provide useful input into this process.

2). Redundant back-up procedures will be employed for storing data and data security using both existing UICPSU and park computer hardware. UICPSU facilities include optical disks, cd-roms, 8 mm tape drives, and three 5 giga-byte harddrives. We will also tie CRMO into the existing UI computer networks to facilitate data transfer.

3). As indicated in the methods (Table 6) GIS technology will be widely employed in the project. In the past, CRMO has relied on the UICPSU GIS lab which has served as the regional technical center for its GIS support. This fully equipped lab has three Sun Sparc-10 workstations, 20 gigabytes of mass storage, input/output devices, and is supported by ARC-INFO, GRASS, ERDAS, IDRESI, and ATLAS GIS software. CRMO also has its own GIS workstation with mass storage and ARC-INFO and ARC-CAD software.

The baseline GIS for CRMO is virtually complete. Map themes, all at the 1:24,000 scale, include:

- a) park boundary, roads, trails, facilities
- b) existing vegetation
- c) geology, landforms
- d) lava flow distribution and ages
- e) elevation, aspect, slope (DEM)
- f) hydrology
- g) cave location and type
- h) archeological sites
- i) proposed park expansion boundary

DATA ANALYSIS

There are three characteristics of monitoring data that are of general interest: trend, cycles and noise (West 1986). The analytical procedures associated with each monitoring element will be established to identify and characterize these features of the data. One technique we will use will be time-series analysis, a procedure which allows an analyst to describe how a variable changes through time and to predict how the variable will change in the future. In determining the sampling frequency for some elements we will explore the use of Bayesian statistics (Jameson 1985). This technique can provide the analyst with an estimation of the number of samples that must be made and how often samples must be taken to maintain a predefined level of variance in these data.

We will structure all monitoring and analysis routines to conform with national and regional schemes where present such as the national breeding bird atlas (Laughlin et al. 1982) and programs to monitor specific indicator species conducted by the Fish and Wildlife Service (Tate 1986).

→ REGIONAL COORDINATION AND REPORTING

can't use this name Technical Assistance
A regional advisory board will be established to guide the overall monitoring program. Participants will include:

- a) resource management specialist, CRMO
- b) Unit Leader, UICPSU
- c) principal biological scientist, INEL
- d) district resource biologist, BLM
- e) district biologist, Idaho Fish and Game Dept.
- f) BLM Research Unit - OSU

The responsibility of the ~~advisory board~~ will be to assure sampling and analytical protocols are established and met and that the program is fully integrated into existing regional programs and that it meets the needs of all management agencies in the region.

A yearly report will be published summarizing the findings and trends indicated by each of the monitoring elements. Day to day program administration will be handled by a resource manager at CRMO (new position) and a full-time research associate employed through the UICPSU (new position). Their responsibilities will be to handle all sub-contracts, i.e., establishing specific monitoring protocols and writing of the handbooks, hiring and supervising staff needed to test and carry out the individual programs, assuring that data archival and analysis protocols are met, and production of the annual report.

- 01 Blakesley, J. A. and R. G. Wright. 1988. A review of scientific research at Craters of the Moon National Monument. University of Idaho Forest, Wildlife and Range Experiment Station Bulletin 50. 41 p.
- 02 Bunting, S. and R. G. Wright. 1988. Fire management plan for Craters of the Moon National Monument. Unpubl. Final Rep. University of Idaho CPSU. 75 p.
- 03 Call, M. W. 1978. Nesting habitats and surveying techniques for common western raptors. Tech. Note TN-316. BLM Denver, Co. 115 p.
- 04 Cambell, H. and S. Christman. 1982. Field techniques for herpetofaunal community analysis. Fish and Wildlife Service Wildlife Research Rep. 13.
- 05 Clarke, R. 1986. The handbook of ecological monitoring. Oxford Science Publ. London. 298 p.
- 06 Craig, T. H. 1978. A car survey of raptors in southeastern Idaho. Raptor Research 12:40-45.
- 07 Craters of the Moon National Monument. On-going monitoring programs directed by the Natural Resources Division.
- 08 Craters of the Moon National Monument. 1993. Cave Management Program. NPS. Publ.
- 09 Day, T. A. 1985. Plant association and soil factors in primary succession on cinder cones in Idaho. M. S. Thesis. University of Idaho, Moscow. 62 p.
- 10 Day, T. A. and R. G. Wright. 1989. Positive plant association with *Eriogonum ovalifolium* in primary succession. Vegetatio 80:37-45.
- 11 Falter, M. J. and R. G. Wright. 1992. Aquatic resource assessment Craters of the Moon National Monument. Unpubl. Progress Rep. to the NPS.
- 12 Flinders, J. and R. M. Hansen. 1973. Abundance and dispersion of leporids within a shortgrass ecosystem. J. Mammalogy 54:287-291.
- 13 Gender, D. L. 1986. Wintering bats of the upper Snake River Plain: Occurrence in lava tube caves. Great Basin Naturalist 46:241-244.
- 14 Goldsmith, F. B. 1991. Monitoring for conservation and ecology. Chapman and Hall, London. 275 p.
- 15 Griffith, B. 1984. Standard operating procedures: Mule deer population monitoring and permanent vegetation transect

monitoring at Craters of the Moon. Coop. Park Studies Unit, University of Idaho Report B84-1. 41p.

- 16 Guyer, C. and A. D. Linder. 1985. Growth and population structure of the short-horned lizard and the sagebrush lizard in southeastern Idaho. Northwest Science 55:44-49.
- 17 Hellawell, J. M. 1991. Development of a rationale for monitoring. p. 1-14. IN: F. B. Goldsmith (ed). Monitoring for conservation and ecology. Chapman and Hall, London. 275 p.
- 18 Hoffman, R. A. 1988. Craters of the Moon National Monument Baseline inventory and monitoring. University of Idaho CPSU Report B-88-4.
- 19 Howe, H. F. and L. C. Westley. 1988. Ecological relationships of plants and animals. Oxford University Press, N. Y. 273 p.
- 20 Jameson, D. A. 1985. Sampling intensity for monitoring of environmental systems. Applied mathematics and computation. Elsevier Sci. Publ. N. Y.
- 21 Jenni, D. A. and J. E. Hartzler. 1978. Attendance at a sage grouse lek: implications for spring census. J. Wildlife Management 42:46-52.
- 22 Kochert, M. N. 1986. Raptors. p. 313-349. IN: A. Cooperrider, R. Boyd, and H. Stuart (eds). Inventory and monitoring of wildlife habitat. U.S. GPO. Washington, D. C. 858 p.
- 23 Laughlin, S. B., D. P. Kibbe, and P. Eagles. 1982. Atlasing the distribution of the breeding birds of North America. American Birds. 36:6-19.
- 24 Lefebvre, R. H. 1975. Mapping Craters of the Moon volcanic field with LANDSAT imagery. 10th Intern. Sym. on Remote Sensing of the Environment. Proc. 2:951-957.
- 25 Leopold, L. B., W. Emmett, and R. Myrick. 1966. Channel and hillslope processes in a semiarid area. U. S. G. S. Prof. Paper 352-6.
- 26 Magnuson, J. J. 1990. Long-term ecological research and the invisible present. BioScience 40:495-501.
- 27 Mannan, R. W. and E. C. Meslow. 1981. Census techniques for nongame birds. p. 181-196. IN: F. L. Miller and A. Gunn (eds) Symp. on census and inventory methods for population and habitats. University of Idaho College of FWR.
- 28 Martel, L. and R. Greeley. 1984. Radar observations of fissure-fed basaltic lava flows, Craters of the Moon. Geol. Soc. of Amer. Abstracts 16:585.

- 29 Nash, T. H. and L L. Sigal. 1981. Ecological approaches to the use of lichenized fungi as indicators of air pollution. IN: D. Wicklow and G. C. Carroll (eds). The fungal community. Marce Dekker, N. Y.
- 30 Noss, R. F. 1990. Indicators for monitoring biodiversity: A hierarchical approach. Conservation Biology 4:355-364.
- 31 Omernik, J. M. 1986. Ecoregions of the United States. Map. U. S. Environmental Protection Agency, Corvallis, Or.
- 32 Pearson, L. C. 1988. Summary of the 1988 Craters of the Moon lichen study. Unpubl. Report. Ricks College, Rexburg, Id.
- 33 Peck, S. B. 1974. Biology of the Idaho lva tube beetle. Glacicavicola, National Speleological Soc. Bull. 36:19-24.
- 34 Quinn, J. F. and C. van Riper III. 1990. Design considerations for national park inventory databases. p. 5-15. IN: C. Van Riper III, T. J. Stohlgren, S. D. Viers, and S. C. Hillyer (eds). Examples of resource inventory and monitoring in national parks of California. NPS Trans. and Proc. Series 8.
- 35 Rothery, D. A. and R. H. Lefebvre. 1985. The causes of age dependent changes in the spectral response of lavas, Craters of the Moon. Intern. J. Remote Sensing 6:1483-1489.
- 36 Scott, J. M., F. Davis, B. Csuti, R. Noss, and R. G. Wright. 1993. Gap Analysis: A geographic approach to protection of biological diversity. Wildlife Monogr, 123.
- 37 Silsbee, D. G. and D. L. Peterson. 1991. Designing and implementing comprehensive long-term inventory and monitoring programs for National Park System lands. Natural Resources Report NPS/NRUW/NRR-91/04.
- 38 Smith, S. D., S. C. Bunting, and M. Hironaka. 1986. Sensitivity of frequency plots for detecting vegetational change. Northwest Science 60:279-286.
- 39 Sparhawk, S. and R. G. Wright. 1990. The Craters of the Moon resource database: Its structure and contents. Final Report University of Idaho CPSU. B-90-2.
- 40 Tate, T. 1986. The blue list for 1986. American Birds. 40:227-235.
- 41 Tisdale, E. W., M. Hironaka, and M. A. Fosberg. 1965. An area of pristine vegetation in Craters of the Moon National Monument. Ecology 46:349-352.
- 42 Tuttle, M. 1974. An improved traps for bats. J. Mammalogy 55:475-477.

- 43 Urban, K. A. 1968. An ecological appraisal of the dwarf mistletoe problem at Craters of the Moon National Monument, Idaho. M. S. Thesis, University of Idaho, Moscow. 13 p.
- 44 Usher, M. B. 1991. Scientific requirements of a monitoring programme. p. 15-30. IN: F. B. Goldsmith (ed). Monitoring for conservation and ecology. Chapman and Hall, London. 275 p.
- 45 Viglienzzone, L. and R. Greeley. 1981. Remote sensing of fissure-fed basalt flows and their source areas: Craters of the Moon volcanic field. NASA Tech. Memo. 84211:443-445.
- 46 West, W. H. 1986. Statistical analysis. p. 741-756. IN: A. Cooperrider, R. Boyd, and H. Stuart (eds). Inventory and monitoring of wildlife habitat. U.S. GPO. Washington, D. C. 858 p.
- 47 Wright, R. G. 1993. The Pacific Northwest Region resource database project: A synthesis. NPS Natural Resource Report NPS/NRUI/NRR-93/11.
- 48 Wright, R. G. and S. Bunting. 1988. Monitoring protocols for stem plots of limber pine. Unpubl. Rep. University of Idaho CPSU. 22 p.
- 49 Wright, R. G., J. G. MacCracken, and J. Hall. 1993. An ecological valuation of proposed new conservation areas in Idaho. In Press. Conservation Biology.
- 50 Wright, R. G. and S. C. Bunting. In Press. The landscapes of Craters of the Moon National Monument: An evaluation of environmental change. University of Idaho Press.

BUDGET

Funds Requested

Category	year 1	year 2	year 3	year 4	year 5
Salary & Benefits					
GS-11 Resource Manager <i>Biologist</i>	<i>48,500</i> ~~33,630~~	33,630	33,630	33,630	33,630 <i>WSS Park</i>
GS-9 Research Associate	28,000	28,000	28,000	28,000	28,000 <i>University</i>
Benefits (25%)	15,400	15,400	15,400	15,400	15,400
Project Funds (See Attached)	29,275	19,400	16,400	13,200	7,300
Travel	5,500	3,500	3,500	3,500	3,500
Miscellaneous Report Production Supplies	4,000	2,000	2,000	2,000	2,000
Total	115,805	101,930	98,930	95,730	89,830
Grand Total:	\$502,225				

Project (#) Element	Tasks	Funds Year 1	Funds Year 2	Funds Year 3	Funds Year 4	Funds Yr 5
Plant community patterns (1)	Sampling Protocol aerial photos GPS rec. Tech.	700 6,500 6,800 700	700			
Plant Community Distr. (2)	Sampling Protocol Tech. <i>photo Scanner</i>	0	1,000 <i>1,800</i>			
Raptor Numbers (3)	Sampling Protocol Tech.	1,000 1,200	1,200	1,200	1,200	1,200
Lava patterns (4)	Sampling Protocol IR photo GIS lab	1,000	3,500	1,200		
Logomorphs (5)	Sampling Protocol Tech.	750 <i>1200-800</i>	800	800	800	800
Soil Development (6)	Sampling Protocol Tech.*	0 0				
Upland Game Birds (7)	Sampling Protocol Tech.	700 800	800	800	800	800
T&E Species (8)	Sampling Protocol Tech.*	500 <i>-0-</i>				
Reptiles (9)	Sampling Protocol Equip. Tech.	1,100 1,300	800		800	
Indicator species (10) (beetles)	Sampling Protocol Tech.*	0 0				

Project (#) Element	Tasks	Funds Year 1	Funds Year 2	Funds Year 3	Funds Year 4	Funds Yr 5
Indicator species (10) (lichens)	Sampling Protocol lab anal Tech	1,100	750 1,000	750 1,000	750 1,000	750 1,000
Indicator species (10) Mule deer	Sampling Protocol Tech.*	0 0				
Cave condition (11)	Sampling Protocol radon analysis video- equip. Tech.*	0 1,100	900		900	
Climate (12)	Sampling Protocol Tech.*	0 0				
Passerine Birds (13)	Sampling Protocol Tech.*	0 0				
Plant Sp. Composition (14)	Sampling Protocol Tech.	0		1,200		
Exotic Pl. Species (15)	Sampling Protocol Tech.	0	1,200			
Erosion (16)	Sampling Protocol Tech.*	325				
Eruptive Cycles (17)	Sampling Protocol LANDSAT images GIS anal	0		2,500	2,100	
Fire (18)	Sampling Protocol Aerial photos Tech.*	0	2,500		2,500	

Project (#) Element	Tasks	Funds Year 1	Funds Year 2	Funds Year 3	Funds Year 4	Funds Yr 5
Plant Succession (19)	Sampling Protocol Tech.*	0 0				
Disturbance (20)	Sampling Protocol Tech.	1,200	900		900	
Parasitism (21)	Sampling Protocol Tech.*	500 0				
Nutrient Cycling (22)	Sampling Protocol lab anal Tech.	0	700 850	700 850	700 850	700 850
Air Quality (23)	Sampling Protocol Tech.*	0 0				
Habitat analysis (24)	Sampling Protocol GIS anal	0 1,200		1,200		1,200
Geological landforms (25)	Sampling Protocol LANDSAT Anal. Radiomet	0		2,000 2,200		
Mule deer population dynamics (26)	Sampling Protocol Tech.*	0 0				

* Accounted for in salary programmed

Craters of the Moon National Monument Photo Point Monitoring Locations

