ABSTRACTS OF PARK RESEARCH FUNDED BY THE MIDWEST REGIONAL OFFICE, NATIONAL PARK SERVICE: 1973-1982

RESEARCH/RESOURCES MANAGEMENT REPORT MWR-1

U.S. DEPARTMENT OF THE INTERIOR
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Research/Resources Management Report MWR-1

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INTRODUCTION

This report presents abstracts of completed research funded by the Research and Science Division, Midwest Regional Office, National Park Service, from fiscal year 1973, the year preceeding the reorganization of the Region, through late fiscal year 1982. During this 10-year period, 97 contracts and purchase orders totaling 1,199,823 dollars were let, and 111 research papers, theses, and maps were received as final reports. Table 1 shows the number of contracts and purchase orders let and the total dollar amount of completed research funded per park for the period.

The National Park Service's Midwest Region covers 10 states in the Great Plains and Great Lakes area (Nebraska, Kansas, Missouri, Iowa, Minnesota, Wisconsin, Michigan, Illinois, Indiana, and Ohio). The physical and biological diversity of the Region is reflected in the variety of the research conducted in the parks. Research topics range from a survey of prairie vegetation in several small parks to the ecology of boreal forests at Voyageurs; from threatened plants in a number of parks to endangered wolves at Isle Royale; from hydrology of springs at Ozark to air pollution at Indiana Dunes; and from recreational boating use patterns on the Lower Saint Croix to hiking trail and campground use at Isle Royale.

The reader should note that many of the abstracts that follow were written by the authors and, although as factual as possible, may not emphasize certain results or conclusions that the researcher(s) would have.

Table 1: Number of Contracts or Purchase Orders Let and the Total Dollar Amount of Completed Research Funded per Park: 1973-1982

PARK	CX or PX[1]	DOLLARS
Agate Fossil Beds	1	3,000
Apostle Islands	10	97,411
Herbert Hoover	1	6,000
Indiana Dunes	7	92,688
Isle Royale	20	256,281
Ozark	12	90,318
Pipestone	2	24,634
Pictured Rocks	10	59,251
Saint Croix	4	65,800
Sleeping Bear Dunes	11	79,002
Voyageurs	9	191,461
Wilson's Creek	1	3,000
Multi-park	9	150,971
TOTAL	97	1,119,823

[1]includes MT (transfer of funds)

ABSTRACTS

Agate Fossil Beds National Monument

REPORT ON THE GEOLOGY AND PALEONTOLOGY OF AGATE FOSSIL BEDS NATIONAL MONUMENT, SIOUX COUNTY, NEBRASKA (PX-6000-7-0540)

-- Robert H. Hunt, Jr., University of Nebraska, Lincoln

A geological and paleontological survey of the Agate Fossil Beds National Monument was accomplished during the summer of 1977 with field check of results during the summer of 1978. A geological map of the monument and surrounding region was prepared at a scale of 1:15,840 [1 inch=1320 feet], illustrating the relationship of the major geological formations exposed within and in the vicinity of the monument. The principal fossil quarries of the Agate hills (Carnegie Hill, University Hill, Beardog Hill) were evaluated in terms of fossil resources, nature of the sedimentary deposits and future development potential in the light of responsible scientific practice. The fossil potential of the remainder of the monument was surveyed and the results discussed. No significant sites were discovered outside the immediate area of the main Agate hills.

A BOTANICAL SURVEY OF OAK ISLAND, APOSTLE ISLANDS NATIONAL LAKESHORE

(CX-6000-6-R049)

-- John F. Hildebrandt, Michigan Technological University, Houghton, Michigan

The forest structure of Oak Island, Apostle Islands National Lakeshore, was measured in the summer of 1977. In addition, Oak Island plant communities were analyzed for community/site stability. Thirteen community types were classified by dominant tree species; three by life forms other than trees. Sugar maple (Acer saccharum) and paper birch (Betula papyrifera) had equivalent importances in respect to the overall vegetation; sugar maple dominated the island's center, while paper birch dominated the steeper sloping margins. Red oak (Quercus rubra) dominated the dryer southwest quarter of the island. Community/site stability values ranged from 0--fragile (sandspit community) to 5 and 6--most stable (hardwood forest communities).

Apostle Islands National Lakeshore

AN INVENTORY OF SELECTED NATURAL AND CULTURAL RESOURCES ON EIGHT ISLANDS OF THE APOSTLE ISLANDS NATIONAL LAKESHORE, WISCONSIN (PX-6000-6-0959)

-- Sigurd Olson Institute of Environmental Studies, Northland College, Ashland, Wisconsin

Selected natural and cultural resources were identified, measured, and mapped as part of a 10-week program by a work force of twenty-five Northland College students and five leaders, with supervision by the Sigurd Olson Institute of Environmental Studies. Between June 23 and August 22, 1977, eight islands were studied: Basswood, Cat, Hermit, Manitou, Michigan, Outer, Rocky, and South Twin Islands. Field work consisted of: (1) a vegetation inventory on systematically placed plots; (2) a soils inventory and mapping at the same locations; (3) a survey and mapping of shoreline geology and type; (4) a reconnaissance survey of birds, mammal, amphibian, and reptile populations; and (5) a reconnaissance of each island for landing sites, camping sites, hiking trails, and locations of interest such as scenic areas, historical sites, unique biological areas, and ecologically fragile areas. Summaries of these data should serve as useful baseline information for future land-use planning and field research.

Apostle Islands National Lakeshore

BASIC ECOLOGICAL STUDY AND RECREATIONAL INVENTORY OF SAND ISLAND, APOSTLE ISLANDS NATIONAL LAKESHORE (CX-6000-7-R059)

-- R. K. Anderson, C. J. Milfred, et al., University of Wisconsin, Stevens Point

An ecological study and recreational resources inventory of Sand and Eagle Islands in the Apostle Islands National Lakeshore was conducted during the summer of 1980. The objectives of the study were to prepare a soil map and develop soil interpretations for recreational use, examine existing trails to determine their suitability for use by visitors and select and map suitable routes for proposed trails, and inventory and analyze plant and animal communities. The study objective for Eagle Island was to determine the productivity of blue heron (Ardea herodias), herring gull (Larus argentatus), and double-crested cormorant (Phalacrocorax auritus). Soil properties were related to suitability for recreational use and maps showing areas not suitable for use were prepared. Human access to Eagle Island was not recommenended during the heron nesting and brood rearing period. Possible reasons for the absence of deer on Sand Island were discussed.

Apostle Islands National Lakeshore

BASIC ECOLOGICAL STUDY OF OUTER ISLAND, APOSTLE ISLANDS NATIONAL LAKESHORE (CX-6000-7-R059)

-- R. K. Anderson, C. J. Milfred, et al., University of Wisconsin, Stevens Point

An ecological study of Outer Island, Apostle Islands National Lakeshore, was conducted during the summer of 1978. The objectives of the study were to prepare a soil map and evaluate the soil characteristics and landforms of the island, collect and analyze water samples, and inventory and analyze plant and animal communities. Management alternatives were proposed for reducing the current beaver population on the island. However, the data showed that beaver need to be studied in greater detail to facilitate a more accurate assessment of current and future population dynamics. Soil properties were related to suitability for recreational use and a map showing areas most suitable for use was prepared. An environmental analysis of existing trails and proposed trails and primitive campsites was conducted with sensitive areas delineated. Trails or campsites were not recommended for any part of the Outer Island sandspit lying south of the lagoon except in the immediate beach zone.

Apostle Islands National Lakeshore

BIRD POPULATIONS OF THREE FOREST STANDS, OAK ISLAND, APOSTLE ISLANDS NATIONAL LAKESHORE (CX-6000-6-R049)

-- Jo Birchly Manbeck, Michigan Technological University, Houghton, Michigan

Bird populations in three vegetation types on Oak Island, Apostle Islands National Lakeshore, were surveyed between June 1 and July 22, 1977. Three territorial mapping plots were established, each entirely contained within a homogeneous habitat type. A total of 17 bird species were found in all three habitats combined: 13 species were present in an oak hardwood stand, represented by 808 breeding pairs per 100 hectares; 14 species were in a mature maple stand, represented by 466 breeding pairs per 100 hectares; and seven species were in an aspen-birch association, represented by 211 breeding pairs per 100 hectares. The red-eyed vireo, ovenbird, black-throated green warbler, American robin, and hairy woodpecker were present in each habitat type and were the most abundant species. A statistical comparison of plots was made using the percentage difference method. Avian population levels and species richness were suggested as means of monitoring environmental changes and determining aesthetically valuable areas for visitor use.

Apostle Islands National Lakeshore

COMPUTER-AIDED CLASSIFICATION OF FOREST COVER TYPES FROM SMALL SCALE AERIAL PHOTOGRAPHY (PX-6000-8-0688)

-- John C. Bliss, Thomas M. Bonnicksen, and Thomas H. Mace, University of Wisconsin, Madison

The National Park Service must map forest cover types over extensive areas in order to fulfill its goal of maintaining or reconstructing presettlement vegetation within national parks and monuments. Furthermore, such cover type maps must be updated on a regular basis to document vegetation changes. Computer-aided classification of small-scale aerial photography is a promising technique for generating forest cover type maps efficiently and inexpensively. In this study, seven cover types at Apostle Islands National Lakeshore were classified with an overall accuracy of 62 percent from a reproduction of a 1:120,000 color infrared transparency of a conifer-hardwood forest. The results were encouraging, given the degraded quality of the photograph and the fact that features were not centered, as well as the lack of information on lens vignetting characteristics to make corrections. Suggestions were made for resolving these problems in future research and applications. In addition, it was hypothesized that the overall accuracy was artificially low because the computer-aided classification more accurately portrayed the intermixing of cover types than the hand-drawn maps to which it was compared.

Apostle Islands National Lakeshore

FOREST AND DISTURBANCE HISTORY OF THE APOSTLE ISLANDS (PX-6000-9-0875)

-- Albert M. Swain, University of Wisconsin, Madison

This paleoecological work examined during 1979-1980 the recent and past fire history of Stockton Island and the composition and changes occurring in the presettlement forests on Stockton Island, Bear Island, and the Bayfield peninsula. Tree cores from living trees and pie-shaped wedges or cross sections from fire-scarred stumps and snags were obtained from the Stockton Island tombolo. Two bogs on Stockton Island were cored for pollen and charcoal analysis. Cores of sediment were also obtained from a bog on Bear Island and from Long Lake on the Bayfield peninsula. Tree-ring analysis of fire-scarred living trees and charred stumps showed that fires were relatively frequent on the tombolo (at least nine fires during the past 250 years) while the frequency north of the tombolo ranged from zero to about three fires during the same interval. Several general trends were evident in the pollen and charcoal profiles. White pine has declined during the past 6,000 years while birch has increased. Between 3,000 years ago and the present, oak (Quercus) pollen has decreased while hemlock and spruce have increased. The Long Lake area has been subjected to a greater frequency of forest fires compared to the Apostle Islands, which were protected from large regional fires by extensive water breaks. The effects of logging were evident on all of the pollen diagrams from the islands and the mainland.

Apostle Islands National Lakeshore

INVENTORY OF SELECT STOCKTON ISLAND RESOURCES FOR RECREATIONAL PLANNING (CX-6000-7-R059)

-- R. K. Anderson, C. J. Milfred, et al., University of Wisconsin, Stevens Point

This 1979 study was conducted on Stockton Island at Apostle Islands National Lakeshore. The soils of the island were mapped and interpreted relative to their capacities for recreational use on proposed and existing trails and campgrounds. Along Presque Isle campground the amount of bank erosion due to hikers and campers was determined. Other studies included collection of water quality samples from the larger streams and from the lagoon outlet to Julian Bay and Lake Superior; population and habitat data on beaver, loons, and sandhill cranes; plant species composition of the original forest types; fire and logging history; and existing plant species composition.

Apostle Islands National Lakeshore

SHORELINE EROSION IN THE APOSTLE ISLANDS NATIONAL LAKESHORE: IDENTIFY AREAS OF ACTIVE EROSION AND DEVELOP METHODS TO QUANTIFY RATES (PX-6000-9-0690)

-- C. J. Milfred, et al., University of Wisconsin, Stevens Point

The purpose of this 2-year study (1979-80) was to establish baselines that could be located and remeasured at intervals of time to provide data on average rates of shoreline recession on Michigan and Raspberry Islands, Apostle Islands National Lakeshore.

The extent of eroding shorelines was surveyed from a boat and by walking along the shore. Areas of active erosion where recent slumping had occurred were readily identified. Sites for baselines were selected based on the survey of shoreline conditions. At each site a 50 meter baseline was established approximately 10 to 20 meters back from the eroding bluff edge. Stratigraphy exposed in the eroding bluffs were examined, a generalized profile of the bluff-face was prepared, and stratigraphic samples were analyzed. Base maps were prepared by copying on 1:24,000 USGS quadrangle maps the location of baselines, stratigraphic descriptions, and sampling site locations.

Erosion was found to be an active process along much of the Michigan Island shoreline. Remeasurement of these sites was recommended to provide park managers with information to evaluate shoreline erosion problems and help to identify areas that may need additional study. Erosion was not as extensive on Raspberry Island. However, an area of active erosion was closely associated with the lighthouse and should be closely monitored.

Apostle Islands National Lakeshore

SOILS AND SURFICIAL GEOLOGY OF FOUR APOSTLE ISLANDS (CX-6000-5-0221)

-- S. J. Cary, P. F. McDowell, and L. J. Graumlich, University of Wisconsin, Madison

The soils and surficial geology of Rocky, Oak, York, and Raspberry Islands, part of Apostle Islands National Lakeshore, were surveyed in 1976 and 1977. A rich diversity of environmental factors affecting soil development has given rise to complex soilscapes. Most common on Rocky, York, and Raspberry Islands are fertile soils of deciduous forests (Eutroboralfs of the Alfisol order) formed in deposits of fine-grained glacial and glacio-lacustrine material. Prevalent on Oak Island are sandy Podzol soils (Haplorthods of the Spodosol order) formed in coarse beach deposits more than one meter thick. Since moderate slopes of 5 to 20 percent provided the best opportunity for thick sand and gravel accumulations in the ancient beach zones, the pedologic uniqueness of Oak Island can be explained by the sloping surface it presented to subsiding post-glacial lake levels.

Apostle Islands National Lakeshore

STATUS OF BREEDING GULLS AND TERNS ON THE WISCONSIN SHORE OF LAKE SUPERIOR IN 1979 (PX-6000-9-0689)

-- Sumner W. Matteson, Madison, Wisconsin

In 1979, the Wisconsin shore of Lake Superior was surveyed from May 22 to June 6 and from July 2 to July 13 to determine changes in the status of gull and tern populations identified in a similar survey in 1974. A total of approximately 1,060 pairs of herring gulls nested along the Wisconsin shore of Lake Superior in 1979--about a 5 percent increase in population since 1974. Breeding pairs were concentrated in 16 colonies (compared to 13 in 1974), with all but 73 pairs nesting in the Apostle Islands. Two ring-billed gull colonies were located along the Wisconsin shore: on the southwest shore of Gull Island and at the southern tip of Long Island. The colony at Gull numbered 98 pairs compared to 10-25 pairs in 1974; the colony at Long Island numbered 80-100 pairs. Common tern numbers along the Wisconsin shore have remained relatively stable: 50 pairs compared to 56 pairs in 1974. Nesting pairs of three other species (piping plover, double-crested cormorant, and great blue heron), all highly vulnerable to human disturbance, were also discovered. Recommendations for the management and protection of the gulls and terns were made.

Apostle Islands National Lakeshore

THE VEGETATION ECOLOGY OF RASPBERRY, ROCKY, AND YORK ISLANDS, APOSTLE ISLANDS NATIONAL LAKESHORE, WISCONSIN (CX-6000-5-0221)

-- Richard W. Dobie, Michigan Technological University, Houghton, Michigan

The present ecological condition of Raspberry, Rocky, and York Islands, Apostle Islands National Lakeshore, was surveyed in the spring of 1976. The objectives of this study were to (1) describe the present plant communities of the islands, (2) compare the species composition of the plant communities on both an inter- and intra-island basis, (3) determine correlations between the plant communities, geology and soils, and the influence of animals, (4) provide a checklist of plants found on each island, and (5) develop vegetation maps of each island. This information was sought in order to assist park personnel in planning and controlling public use of the island ecosystem. Each island was surveyed by means of a grid of sample plots designed to encompass all plant communities present. Community types and their boundaries were established by means of aerial photography and the dominant tree species found in each plot. Of the communities delineated on each island, most were found to be able to withstand the impact of increased usage, provided the visitation rate does not climb greatly. However, some communities--especially on Raspberry and Rocky Islands--were considered to be too fragile to allow unlimited free access.

Apostle Islands National Lakeshore

VERTEBRATE POPULATIONS OF RASPBERRY, ROCKY, YORK, AND OAK ISLANDS, APOSTLE ISLANDS NATIONAL LAKESHORE, WISCONSIN (CX-6000-5-0221)

-- Kenneth R. Patzoldt, Michigan Technological University, Houghton, Michigan

Surveys of the existing vertebrates of Raspberry, Rocky, York, and Oak Islands at Apostle Islands National Lakeshore, Wisconsin, were conducted during the summers of 1976 and 1977. Data were gathered by walking transects, spot mapping, snap-trapping, live-trapping, and mist netting. Distributions, relative abundance, home ranges, and habitat utilization were determined for most species. An annotated species list was developed for the existing fauna. Eight species of amphibians, two species of reptiles, 123 species of birds, and 19 species of mammals were found. Differences in species composition were noted between islands. On no island were all species present; Oak, the largest island studied, had the greatest species diversity. Distance from the mainland did not correlate well with species richness. The redback vole (Clethrionomys gapperi) was the most abundant mammal on the islands studied. Favorable habitat conditions, lack of competing species, and few predator species probably accounted for their high numbers. Comparisons of various population parameters were made.

Herbert Hoover National Historic Site

REESTABLISHMENT AND MANAGEMENT OF NATIVE PRAIRIE AREAS (PX-6000-5-0714)

-- Roger Q. Landers, Iowa State University, Ames, Iowa

The purpose of this study was to compare various methods of prairie forb introduction into established grasslands. There is evidence that the establishment of new individuals from seed in a grassland depends on local disturbance such as wormcasts, molehills, footprints, fires, etc., and that these disturbances provide a suitable site for seed germination and establishment. During this study (1976-1977), a herbicide, N-(phosphonomethyl) glyane (trade name: Roundup), and fire were used to create disturbances where seeds and transplants were added to well-established grassland at four sites located within 15 miles of Ames, Iowa, and at Herbert Hoover National Historic Site. Results showed transplanting sturdy plants or seedlings can be very successful over a broad range of seasons and weather conditions. The main problem involved the high input of labor to grow or locate the plants and to transplant them into the desired location. Until techniques are worked out to successfully insert forbs by seed into established grasslands, it can be done by transplants and abundant labor.

AIR POLLUTION RESEARCH AND MONITORING, INDIANA DUNES NATIONAL LAKESHORE (CX-6000-6-R097)

-- F. A. Wood, et al., University of Minnesota, St. Paul

During the summer of 1976, this study provided the first documented evidence of air pollution injury to vegetation in the Indiana Dunes National Lakeshore area. Although this geographic region has been under air pollution stress for some time, observation of the vegetation in the study area indicated that ambient pollutant concentrations (ozone and sulfur dioxide) are sufficiently high to injure the vegetation and that the effects of air pollution may still be in progress. Additional air quality and meteorological data would be beneficial in determining the relationship between ambient air pollutant concentrations and vegetational effects. This information is vital to park management and the implementation of emission standards through the state regulatory agency.

AN EVALUATION OF PHYSICAL AND BIOLOGICAL CONTROLS ON COASTAL EROSION IN THE INDIANA DUNES NATIONAL LAKESHORE (PX-6000-5-0650)

-- Stephen E. Davis, William L. Wood, and Susan M. Markley, Purdue University, West Lafayette, Indiana

The objectives of this investigation (1975-1976) were to (1) assess the long- and short-term coastal erosion of Indiana Dunes National Lakeshore, (2) determine the lakeshore's coastal vegetative distribution and its influence on beach and dune stabilization, (3) evaluate the effectiveness of beach nourishment as an alternative for controlling beach erosion and maintaining dune protection, and (4) recommend the best alternatives for beach erosion control and dune protection.

Beach and dune stability were described in relation to the general characteristics and properties as they relate to their formation and stability. Beach and dune recession and erosion rates along the study area were presented.

The status of the beach nourishment project at the National Lakeshore and some general considerations for the use of beach nourishment in future projects were discussed. Consequences of non-maintenance of the beach nourishment project were also discussed with particular attention given to Mt. Baldy.

The characteristics, distribution, and environmental response of vegetation within the study area was analyzed. Particular attention was given to successional processes.

Recommendations for coastal protection of the National Lakeshore were presented which center on natural erosion control. Alternatives for beach nourishment and coastal dune degradation were presented.

BASIC ECOSYSTEM STUDIES OF THE INDIANA DUNES NATIONAL LAKESHORE (CX-6000-7-R049)

-- School of Public and Environmental Affairs, Indiana University Northwest, Gary, Indiana

The Indiana Dunes National Lakeshore, lying at the head of Lake Michigan, is a challenging resource for the region and the nation. This park has potential for significant natural resource preservation and interpretation of an excellent geologic record of the origin and evolution of the Great Lakes area and its significant flora and fauna associations. Concurrently, the lakeshore, established in 1976, promises to become the site of extensive recreational activities, a "Gateway-Midwest," for millions of metropolitan residents, and thus a highly visited but traditional national park in an urban area.

The Indiana University School of Public and Environmental Affairs conducted research to establish an ecosystems data base for the lakeshore areas from 1972 to 1975. The goal of this early effort was to provide information for a more complete inventory of lakeshore natural resources and to aid in

identifying the fragile areas in need of careful husbandry. An extensive report of findings, furnished in 1975, covered soils and geology, land use classifications, settlement history, general climatologic conditions, aquatic biological communities, terrestrial biological communities, and noise levels and analysis.

Study efforts between 1978 and 1981 were directed towards expanding these data bases and analyses to the areas authorized for inclusion into the lakeshore under the 1976 expansion act. A second purpose was to present all map data in an atlas format on "photo-map" bases having a scale of 1-inch to 400 feet. Studies of soils and geology, land use classification and settlement history, and aquatic and terrestrial biologic communities were extensions of the earlier study. Climatological data gathering and analyses and inclusion of air quality mapping was expanded from the 1972-1975 studies; however, noise studies were not included.

Six sections comprise the final integrated inventory: 1) settlement historical geography and land use; 2) biological studies in the Indiana Dunes including specific plant communities and animals of the lakeshore; 3) soils and geology; 4) climatology and air quality; 5) noise conditions within the 1966 lakeshore boundaries; and 6) an analysis of environmental concerns.

Indiana Dunes National Lakeshore

DATA ANALYSIS AND RECOMMENDATIONS REGARDING NATURAL RESOURCES MANAGEMENT AT INDIANA DUNES (PX-6000-5-0651)

-- Mark Reshkin, Valparaiso, Indiana

The several land classes of this urban lakeshore encompass heterogeneous natural areas. Some of the land classification units contain a variety of ecosystems displaying a wide range of natural resource values and an equally wide range of tolerances to development for recreational purposes. Legislation creating the lakeshore produced a series of mutually interwoven goals and purposes which might be summarized as directing the National Park Service to maximize the urban recreational potential of the Indiana Dunes while concurrently conserving and interpreting the very significant natural resources of the area.

Thus, the Natural Resource Management Plan and ensuing management program must identify and determine the equilibrium condition(s) to be achieved and/or maintained for each land class within the lakeshore. This must be done to maintain a consistency among the master plan, the interpretive prospectus, and the resource management plan and program for each of the segmented units of the Indiana Dunes. This consistency must be based on the philosophy of

maintaining the naturalness of the area while developing recreational and interpretive programs and facilities for large numbers of urban, day-use visitors.

This study (1975) was an initial effort to determine areas of (1) scientific significance, (2) fragility with respect to the maintenance of environmental quality, and (3) merit with respect to further research, both applied and basic. External threats to the lakeshore's natural resources were identified and the stationing of a resident scientist at Indiana dunes was recommended.

Indiana Dunes National Lakeshore

EFFECTS OF AIR POLLUTANTS ON TERRESTRIAL VEGETATION IN INDIANA DUNES NATIONAL LAKESHORE 1976-1977 (CX-6000-7-R033)

-- S. V. Krupa, University of Minnesota, St. Paul

Vegetation in the Indiana Dunes National Lakeshore is and has been undoubtedly subjected to a mixture of air pollutants. This study documented initial efforts to assess the impact of these pollutants on vegetation. During the summers of 1976 and 1977, ozone or oxidant-like vegetational injury was observed on 13 of 36 field plots, and sulfur dioxide injury was observed on 4 of 36 field plots. Three of the four field sites containing oxidant-injured vegetation in 1977 also contained oxidant-injured vegetation in 1976. The one field site showing SO_2 injury in 1977 contained the most severely SO_2-injured vegetation in 1976. Two years of field observation suggested that a one to four square mile area located four to five miles due south of the Burns Harbor industrial complex may have a potentially severe sulfur dioxide pollution problem. Additionally, a smaller area, located two to three miles south of Michigan City, may have a somewhat less severe sulfur dioxide problem. Ozone injury on vegetation was widespread principally in two bands extending southward from the Lake Michigan shoreline.

Indiana Dunes National Lakeshore

THE BAILLY AREA OF PORTER COUNTY, INDIANA: FINAL REPORT OF A GEOHISTORICAL STUDY UNDERTAKEN ON BEHALF OF THE INDIANA DUNES NATIONAL LAKESHORE (PX-6000-7-0887)

-- Sarah Gibbard Cook and Robert S. Jackson, Robert Jackson and Associates, Evanston, Illinois

The temporal scope of this study in 1977 was from about the time of the first recorded European-American travel and settlement in what is now Porter County, Indiana, to about the time of the establishment of the Lakeshore. The geographical scope was limted to all lands owned by Joseph Bailly, actively influenced by him, or associated with his name. The center of interest was Baillytown, where Bailly once owned land and platted a town (never built). The chapter on transporation defined the chronological link between the topography and human activity in the area. Geographical distinctions were made between different aspects of the topography, such as the Calumet Beach Ridge and the Upper Little Calumet Basin, the Great Marsh, and the Sandhills and Interdunal Wetlands. The kinds of human activities which affected each area were examined.

Isle Royale National Park

BENTHIC MACROINVERTEBRATES AND CHEMISTRY OF THREE STREAMS ON ISLE ROYALE NATIONAL PARK, MICHIGAN (PX-6000-9-0484)

-- Richard Drew Bowden, Michigan Technological University, Houghton, Michigan

The benthic macroinvertebrate community and chemistry of three low order streams on Isle Royale National Park, Michigan, were examined from May through October 1979. The pH and alkalinity values showed inverse relationships with discharge. Stream pH ranged from 6.0 to 8.0 and alkalinity from 9.2 to 89.7 mg/l as $CaCO_3$. Both pH and alkalinity were distinctly lower at the headwater areas than at downstream sites. Cation analysis revealed inverse relationships with discharge for calcium, magnesium, and potassium. Sodium showed little relationship to discharge. All cations except potassium showed high streamwater concentrations, with ranges as follows: Calcium 6.90 - 25.60 mg/l; magnesium 1.65 - 7.70; sodium 0.50 - 3.40; and potassium 0.20 - 1.40. Concentrations were higher at downstream sites than upstream sites. Diverse composition of macroinvertebrate fauna were found in all streams, with taxa generally comparable to similar Lake Superior basin streams. The majority of the invertebrates collected were in the class Insecta. Diptera was the dominant order at upstream sites, whereas Ephemeroptera, Coleoptera, Plecoptera and Trichoptera were more prominent downstream.

Isle Royale National Park

COMPARISON OF PRESETTLEMENT AND MODERN UPLAND BOREAL FORESTS ON ISLE ROYALE NATIONAL PARK (CX-6000-4-0137)

-- Robert A. Janke, Dennis McKaig, and Randall Raymond, Michigan Technological University, Houghton, Michigan

The presettlement upland boreal forest type of Isle Royale National Park, as reconstructed from the original land survey notes of 1847-48, was compared with the existing forest as sampled in 1974. A drastic reduction in balsam fir and an increase in white birch and aspen have occurred. These changes are attributed to the high frequency of man-caused fires since 1848. A reduction in tamarack is probably the result of an invasion of the larch sawfly.

Thimbleberry has replaced American yew as the prevailing understory shrub. Proliferation of thimbleberry probably followed fires in the late 1800's and the failure of American yew to replace it is the result of heavy moose browsing on this highly palatable species.

Isle Royale National Park

CONTINUING STUDIES OF MOOSE-PLANT RELATIONSHIPS AT ISLE ROYALE NATIONAL PARK (CX-6000-6-R058)

-- Peter Jordan, University of Minnesota, St. Paul

Production of winter browse and its utilization by moose was estimated from four sites on the island for winter 1976-77. A new two-stage, optimal-allocation sampling scheme was employed. Total production among all browse species acceptable to moose was highest in a sugar maple forest; however, winter moose density there was not correspondingly high. In fact, greatest moose density occurred where total production was relatively low. The contradiction was apparently due to moose responding to key browse species and to sets of species available rather than to total forage. Among the four sites, the most favored combination appeared to be in a boreal, coastal forest where reasonable amounts of highly preferred mountain ash, mountain maple, and white birch could be combined with balsam fir.

Numbers of moose overwintering were estimated from spring counts of pellet groups on 327 permanent plots. From this, the pre-parturition level in 1977 was estimated as 1550 (2.82/km^2) based on a defecation of 20.9 groups/moose-day, or as 1450 (2.64/km^2) by a method (Jordan and Wolfe 1980) in which present counts were calibrated by previous aerial surveys.

Pellets of snowshoe hares were found at 19 of 30 sampling locations and on 17 percent of all plots (277) examined. These animals were sparse or absent in a number of forest types and, where present, were localized, probably in relation to available cover.

By comparing some Isle Royale forest stands with similar forests on the adjacent mainland, the intermediate-size classes of palatable tree species, e.g., fir, aspen, white birch, and mountain ash, was shown to comprise far less of the species' population on the island than on the mainland. This effect appeared to be due primarily, if not entirely, to the long-term impact of moose--they were present at relatively high densities on the island and sparse to absent at the mainland sites. Also, among the moose-palatable tree species on the island, individuals with a dbh from 5 to 15 cm were found to be virtually absent, while such was not the case for a non-palatable species, white spruce. Their implications of moose impact on the long-term dynamics and form of the Isle Royale forests were discussed.

No effects upon moose or the aquatic vegetation they eat from lamprecide treatments in Washington Creek were discovered. Study limitations precluded monitoring of seasonal trends in the amounts of sodium taken up by aquatic macrophytes. The recent work of others suggests that these seasonal changes are of relatively low magnitude.

Isle Royale National Park

CONTINUING STUDIES OF MOOSE-PLANT RELATIONSHIPS RELATIVE TO ECOSYSTEM DYNAMICS AT ISLE ROYALE (PX-6000-7-0622)

-- Peter Jordan, University of Minnesota, St. Paul

In this phase of continuing studies of moose in the Isle Royale ecosystem, primary emphasis was on feeding strategies of moose in summer and certain aspects of sodium dynamics in aquatic environments used by moose. Through feeding trials with moose on the mainland, it was tested whether the diverse diet of free-ranging Isle Royale animals was selected by necessity or by choice. The experimental animals, when offered ad libitum the same species that were being selected by moose on the island, consumed them in about the same proportions as did the free-ranging animals. From this it was concluded that diversity selection is part of the moose's inherent feeding behavior. Implications of this, both to habitat choice by moose and to influences on plant-community structure, were discussed. Further efforts to develop an efficient technique for inventorying production of browse used by moose in winter and amounts actually consumed did not yield successful results.

For a typical beaver pond it was found that moose by removing most of the macrophyte standing crop, which has a high concentration of sodium had but

a minor effect on overall sodium flux. The macrophytes contained but 0.5 percent of the total sodium moving through in 1 year. Also, sodium contained in the substrate, is but 2.7 percent of the annual flow-through. On the other hand, it was suspected with some supporting evidence, that macrophyte cropping by moose reduced autochthonous inputs to the substrate and consequently reduced substrate exchange capacity; this in turn was believed to reduce the potential for aquatics to grow and to take up sodium. Moose created turbidity in ponds as they move around to feed. Evidence was presented to support the assumption that turbidity, by blocking light and by coating plants with fine sediments, reduced macrophyte production. On the other hand, moose probably prolonged the ability of submerged aquatics to exist in mature ponds by their trampling of pond edges. This set back the invasion of emergents which otherwise would have displaced the submergents that were so valuable to moose. Limited studies of production of aquatics and their consumption by moose showed a pattern similar to that found earlier. Protected stands averaged 28.3 ± 5.1 g/m^2 in late summer while matched, adjacent grazed areas averaged $1.5 + 0.6$ g/m^2. A test of whether cropping of macrophytes during the growing season served to stimulate additional production showed that it did not; in fact heavy cropping possibly depressed total annual production.

Isle Royale National Park

CONTINUING STUDIES OF THE ECOLOGY OF MOOSE AT ISLE ROYALE NATIONAL PARK WITH EMPHASIS ON THEIR INTERACTIONS WITH TERRESTRIAL AND AQUATIC PLANT COMMUNITIES (CX-6000-8-R110)

-- Peter Jordan, University of Minnesota, St. Paul

During the final phase (1978-79) of the series of Park Service research contracts supporting ecological studies at Isle Royale by the University of Minnesota, major accomplishments were made in the area of sodium dynamics in aquatic ecosystems. This mineral, critical to moose and obtained by them through aquatic feeding, was found to be taken up by aquatic plants as though it was essential to the plants' growth--a new finding. Also, it was shown that sodium enters the plant only via the substrate, and that exchange capacity of the substrate, probably related positively to organic content, influenced sodium holding capacity which in turn influenced amount of the element taken up by the plants. Implications of this relative to longevity of beaver ponds were discussed.

Continued efforts to inventory browse and its utilization by moose in winter were reported, though island-wide estimates were not achieved. The annual estimates of moose and hare populations by pellet counts were reported. Recommendations on fire management and on the potential danger of moose to visitors were provided to the Park Service.

Isle Royale National Park

ECOLOGICAL STUDIES OF WOLVES ON ISLE ROYALE (CX-6000-6-R045; CX-6000-7-R040; CX-6000-8-R101; CX-6000-9-R023; CX-6000-0-R013; CX-6000-1-0015)

-- Rolf O. Peterson, et al., Michigan Technological University, Houghton, Michigan

The wolves of Isle Royale have been the focus of continuous research since 1958. This research has contributed much to our understanding of the ecology of the wolf and especially its relationship to a naturally-regulated moose population. Over the past decade the wolf population has been steadily increasing, while the moose population has likewise declined. In 1980, the wolf population reached an all-time high of 50 individuals, while the moose population was estimated at 650-700. In 1981, the most dramatic wolf decline in the history of the research project occurred, as the population fell from 50 to 30 individuals. In 1982, wolves declined further from their recent historic peak and reached the lowest level documented for the species since its arrival on Isle Royale in the late 1940's. Conversely, moose calf abundance was the highest ever documented at Isle Royale and about three times higher than the average of recent years. Swelled by almost 200 calves, the moose population increased to over 700 in 1982. If wolves exhibit a moderate rebuilding of numbers within a couple of years, as expected, this predator-prey system should soon approximate that described 25 years ago, suggesting a predator-prey cycle with an extended period of fluctuation.

Isle Royale National Park

HIKING TRAIL AND CAMPGROUND USE AT ISLE ROYALE NATIONAL PARK

(PX-6000-9-0888)

-- C. Richard Crowther and Robert P. Chadwick, Michigan Technological University, Houghton, Michigan

During the summer of 1980, a study of trail and campground usage on the northeastern half of Isle Royale, where periodic congestion of trails and campgrounds appeared to be most pronounced, was conducted. National Park Service personnel suspected that the arrival of up to 120 passengers each Tuesday and Friday afternoon on the Ranger III (a Park Service operated boat carrying passengers on biweekly trips between Houghton, Michigan, and Isle Royale) and the gathering of a like number for embarkation on Wednesday and Saturday mornings, might be creating undesirable congestion on trails in campgounds. Counts of hikers were obtained through use of ten automatic trail counters which were installed on segments of the trail system. Counts of campers using campgrounds associated with these trails also were obtained.

These data revealed some relationships between hiking and campground use and the Ranger III schedule. However, several problems in data collection and great variability of trail use from day to day and from week to week rendered the results highly tentative.

Trail use was heaviest near Rock Harbor and became progressively lighter with increasing distance from that point to the center of the island. Weather had little effect on trail use. Campground use during July and August was heavy, but not excessive, in relation to capacity.

Suggestions for reducing any such trail congestion included greater utilization of boat transportation about the island, making possible more rapid and convenient dispersion of backpackers from Rock Harbor and longer, more varied hiking tours; reducing the number of passengers permitted on the Ranger III; reduction of Ranger III trips to one per week; and greater use of alternative means of transportation to and from Isle Royale.

Isle Royale National Park

PAST AND PRESENT FORESTS OF ISLE ROYALE NATIONAL PARK (PX-6000-5-0584; PX-6000-6-0722)

-- Dennis M. McKaig, Michigan Technological University, Houghton, Michigan

Beginning in 1975 forest data were transcribed and tabulated from the Original Land Office Survey of Isle Royale National Park. This data set was then stratified and the boreal conifer association compared with three modern samples of this association. Survey data from the sugar maple-yellow birch association were compared with one modern sample of that type. Percent species composition (relative density, diameter distributions, and point-to-tree distance distributions) were utilized for these comparisons. Maps of the vegetation for both periods were prepared to facilitate areal comparisons. A review of the suggested methods for the analysis of surveyor bias was also presented. The modern boreal forests showed a marked reduction in the percent composition of balsam fir and a concomitant increase in paper birch. Aspen was shown to have increased somewhat while white cedar and tamarack declined over this period. The sugar maple-yellow birch association seemed to have increased somewhat in area. The changes in species composition indicate that the modern forests are successionally less mature than in 1847. This is attributed to the combined effects of fire, changes in herbivores, and insect attack.

Isle Royale National Park

POST-FIRE SUCCESSION AND TREE SPECIES REPRODUCTION ON ISLE ROYALE (CX-6000-6-R040)

-- Robert Janke, Michigan Technological University, Houghton, Michigan

Successional trends following fire in the upland boreal type forests of Isle Royale National Park were studied in the summers of 1975 and 1976. In particular, trends which affect the inflammability of the forest were sought. Sampling points were located in stands ranging in age from 40 years (corresponding to a catastrophic fire in 1936) to about 225 years. Following fire, relative densities of balsam fir (Abies balsamea) and white spruce (Picea glauca) both tended to increase with increasing stand age. These tendencies reflect the shade-tolerant nature of these two species. The shade-intolerant white birch (Betula papyrifera), on the other hand, tended to decrease in relative density as stand age increased. Since this species is less ubiquitous than the other three major species, it is possible that factors other than stand age may be important in explaining the relative density of this species.

One of the major factors in determining the inflammability of a forest is the basal area of coniferous tree species. The data from this study indicated that inflammability increases as the forest increases in maturity. Analysis of seedling and sprout establishment versus various fire-related parameters was also investigated.

Isle Royale National Park

STUDIES ON ECHINOCOCCOSIS (HYDATID DISEASE) ON ISLE ROYALE (PX-6000-9-0874)

-- L. David Sibley, Northern Michigan University, Marquette, Michigan

This investigation centered on the distribution and prevalence of taeniid eggs (Echinococcus and Taenia eggs) in the Isle Royale National Park environment. Wolf and fox scat samples, as well as water samples and samples of soils from selected hiking trails, were collected to assess the overall dispersal of taeniid eggs in the natural environment and the potential risk for human infection. In 1979, the wolves exhibited a higher percent of infection (26 percent) than in 1980 (11 percent). The results suggested that the prevalence of taeniid eggs in wolf scats varied from year-to-year. The data also suggested that taeniid eggs are found almost everywhere on the Island and may be a potential health risk to park visitors. No taeniid eggs were found in fox scats. Recommendations to reduce the risk of hydatid infection were presented.

Isle Royale National Park

STUDIES ON ECHINOCOCCOSIS (HYDATID DISEASE) ON ISLE ROYALE (PX-6000-1-0226)

-- Lewis E. Peters, et al., Northern Michigan University, Marquette, Michigan

This report presented findings from the analysis of wolf and fox scat, soil, water, and vegetation collections made in 1981 and was essentially a continuation of an 1979-80 investigation on the distribution and prevalence of taeniid eggs in the Isle Royale National Park environment. Results show the incedence of taeniid eggs in wolf scats was lower in 1981 than in either 1979 or 1980. No taeniid eggs were found in fox scats. Examination of water samples from streams and lakes yielded only one taeniid egg in over 60,000 liters sampled in 1980 and 1981. The recovery of eggs in several soil and vegetation samples indicated that they persist in the terrestrial environment; persons should give at least as much care to avoid possible infection from soil or vegetation as from water. Serological examinations of persons with possible exposure to hydatid infection were negative.

Isle Royale National Park

THE ECOLOGY OF THE BOREAL FOREST-TYPE OF ISLE ROYALE NATIONAL PARK

(CX-6000-7-R038)

-- Robert Janke, Michigan Technological University, Houghton, Michigan

This ecological study (June 1977-June 1978) examined the ground cover species of the boreal forest type of Isle Royale National Park and two recent burns. The ground cover study focused on the relationship of vascular ground cover species to forest successional stage. The recent burns studied were on Card Point and near McGenty's Cove. Both were natural fires which were permitted to burn under the park's new "let-burn" policy. The succession studies demonstrated that, following fire, continuous changes take place in the tree layer, the soil, and in the vascular ground cover layer. In the tree layer, white birch and quaking aspen gradually give way to balsam fir and white spruce. Ground cover plants such as fireweed, red raspberry, and jewelweed are replaced by plants such as Canada dogwood, blue-bead lily, and twinflower as the forest approaches maturity. Fire is, without question, a natural environmental factor of the boreal forest essential for perserving the dynamic nature of this ecosystem. Based on the study's findings, the "let-burn" policy for natural fires on Isle Royale National Park should be continued.

Isle Royale National Park

THE ECOLOGY OF THE SPRUCE-FIR FOREST TYPE OF ISLE ROYALE NATIONAL PARK (CX-6000-5-0196)

-- Robert A. Janke, Michigan Technological University, Houghton, Michigan

During the summer of 1975, data was obtained on the kinds of soil microhabitats that exist in 1936 burn areas and in old (pre-1900) burn areas, and the tree species that utilize each microhabitat type as seedbed. Using transect data, a comparison was made between the soil microhabitat characteristics of the 1936 burn area and those of the older burns. For the old burns, litter depth and the amounts of decayed wood, moss, and moss on decayed wood were greater than that of the 1936 burn. Rock exposure was considerably greater in the 1936 burn than in the older forests, reflecting the great amount of erosion which took place after the severe 1936 fire. Results showed a low seedling density of fir in the 1936 burn which may be due to a lack of seed source.

The high seedling density of birch in the old burns was undoubtedly related to its high germination rate on decayed wood and moss. Birch reproduction in the 1936 burn was very low. White spruce seemed to reproduce equally well in both areas. Its reproduction was found to be favored by both the shallow litter layer of the 1936 burn and the abundance of decayed wood and moss in the old burns.

Isle Royale National Park

THE STRUCTURE AND FUNCTIONING OF ISLE ROYALE ECOSYSTEMS: WASHINGTON CREEK (PX-6000-0-0456)

-- J. Robert Stottlemyer, Great Lakes Area Research Study Unit, Michigan Technological University, Houghton, Michigan

A series of studies were initiated in the summer of 1979 on watershed ecosystems located within Isle Royale National Park, the Keweenaw Peninsula on the south shore of Lake Superior, and in the Pictured Rocks National Lakeshore. The goal of these long-term studies is to obtain baseline data on the structure and functioning of northern ecosystems, and how they vary as a result of differences in vegetation composition, vegetation succession, edaphic factors, and precipitation inputs. Precipitation quantity and quality and, in the Lake Superior Basin in particular, its seasonal distribution are important ecological variables. This report summarizes data collected to date on the neutralization of acid precipitation in low-order streams in the upper portions of small watersheds with widely differing substrates, and examines some historical data from Washington Creek which imply that acid loading has occurred in the Lake Superior Basin for at least the last 15 years.

Ozark National Scenic Riverways

BLACK REDHORSE POPULATION DYNAMICS IN THE UPPER CURRENT AND JACKS FORK RIVERS, MISSOURI (MT-6000-0-C576)

-- Thomas Clay See, University of Missouri, Columbia

Black redhorse in the upper Current and Jacks Fork Rivers, Missouri, were sampled by electro-fishing during 1980 and 1981. Downstream population densities were twice that of upstream densities on a volumetric basis. Current River populations possessed lower biomasses but higher densities than the Jacks Fork River populations possibly due to a lower and more variable discharge in the Jacks Fork River. Higher mortalities were present in the Current River population than those of the Jacks Fork River and thus a lower percentage of older fish possibly due to higher gigging pressure. Early and late season movements were seen with only a few individual movements recorded in summer and winter. Growth rate exceeded the state average in both rivers but Jacks Fork River black redhorse grew faster in length but not in weight than Current River fish. This resulted in greater length at annulus but lower Wr values in the Jacks Fork River than in the Current River. Wr values showed strong seasonal trends with high values in the early season, low later in the season, and intermediate in summer. Cohort production estimates were higher in upstream sites on both rivers possibly due to lower densities. Annual production was lower on the Jacks

Fork River possibly due to environmental factors. Both rivers showed highly variable year class strengths with the Jacks Fork River year classes being more variable. Gigging pressure and harvest was greater in the Current River than in the Jacks Fork with 18 percent of the harvestable sized black redhorse (greater than 260 mm) having gig scars in spring of 1980 while only 11 percent of those in the Jacks Fork River of that size were scarred. Giggers were selective for larger fish and overharvest of the population does not appear to be occurring. Short-term reductions in numbers of black redhorse in heavily gigged areas are not a severe problem with such a mobile population of black redhorse in these rivers.

CANOEISTS' COMPARISONS OF FLOAT TRIP EXPERIENCES ON THREE OZARK RIVERS (PX-6000-8-0923)

-- Kenneth C. Chilman, Southern Illinois University, Carbondale, Illinois

This 1979 study was one of a series of studies in the Ozark National Scenic Riverways (ONSR) river recreation research program, involving a search for critical factors in determining recreation carrying capacity. These factors aid management in developing a rationale for limiting recreation use at certain levels or in certain ways. The purpose of this study was to obtain information on visitor's comparisons of their float trip experiences on three well-known Ozark rivers--the Current and Jacks Fork Rivers (Ozark National Scenic Riverways), the Eleven Point National Scenic River, and the Buffalo National River.

Results of specific comparisons of ONSR with the Buffalo and Eleven-Point indicate these rivers were perceived as generally similar. Some differences were noted in difficulty of floating, scenic attributes, and densities of floaters. The study results also indicate a rather localized ONSR river user population. This was not surprising in light of residence statistics from earlier studies indicating a high proportion of visitors from the St. Louis area and Illinois.

From this initial study no specially distinctive features of ONSR were identified with the exception of crowded floating conditions, that should be reflected in ONSR management objectives. Rather, the impression gained indicated that maintaining the scenic natural environments of the three rivers may be most important.

CAVE MANAGEMENT INVESTIGATIONS ON THE OZARK NATIONAL SCENIC RIVERWAYS, MISSOURI: PHASE I (PX-6000-8-0918)

-- Thomas Aley, Ozark Underground Laboratory, Protem, Missouri

The Riverways contain about 150 caves, some of which are very significant. Based upon estimates of the number of visitor days of non-guided cave use, total cave use within the Riverways exceeds that at any other National Park Service administered area in the United States.

This 1978-79 study provided a detailed assessment and management recommendations for 26 caves. Seven of these caves were found to provide habitat for federally listed endangered animal species. Nine of the caves (or groups of caves) contained features of sufficient quality that visitors should be encouraged to see. Six caves contained safety hazards; recommendations were made for minimizing these hazards. In addition, several of the caves were found to hold known or suspected archeological remnants.

CAVE MANAGEMENT INVESTIGATIONS ON THE OZARK NATIONAL SCENIC RIVERWAYS, MISSOURI: PHASE 2 (PX-6000-9-0828)

-- Thomas Aley, Ozark Underground Laboratory, Protem, Missouri

This 1978-79 study assessed 60 caves on the Ozark National Scenic Riverways, drew management conclusions, and made recommendations for management. This study also integrated the previous work from Aley (1978-79) which involved a similar assessment of 26 other caves.

Major attention was given to biological, archeological, and esthetical resources of the caves in the Riverways. The caves represent major natural and recreational resources; some of these resources are being damaged by present use patterns.

Ozark National Scenic Riverways

HYDROLOGIC STUDIES OF SPRINGS EAST OF THE CURRENT RIVER IN MISSOURI (CX-6000-1-0229)

-- Thomas Aley and Catherine Aley, Ozark Underground Laboratory, Protem, Missouri

The study area is bounded on the south and west by the Current River, on the west by Route C in Texas County and Route CC in Dent County, on the north by Route H west of Salem and Route 72 east of Salem, on the northeast by Route 72, on the east by Route 21, and on the south by the township line between T28N and T29N. The size of the study area is 827.8 square miles, of which 500.6 square miles lie within the Current River topographic basin. Much, but definitely not all, of the study area contributes water to springs on the Current River.

This study (1981-82) incorporated hydrologic information from previous work in the area and developed two detailed maps of hazard areas. Hazard areas were found in locales where the hydrologic functioning of the land and the existing or potential use of the land combine to create a threat of springwater contamination. Each identified hazard area was visited, hydrologically evaluated, and discussed.

Several groundwater traces were also conducted in the area. Based upon the groundwater tracing work and hydrologic and geologic considerations, generalized recharge areas were drawn for the larger springs which drain the study area. Additional groundwater tracing work is urgently needed to delineate the northern boundary of the recharge area for Welch and Montauk Springs and the eastern boundary for the Blue Spring recharge area. Because of land use, all of these areas have potentially adverse water quality implications for these springs.

HYDROLOGIC STUDIES OF SPRINGS, OZARK NATIONAL SCENIC RIVERWAYS

(CX-6000-6-R065)

-- Thomas Aley, Ozark Underground Laboratory, Protem, Missouri

The study area is bounded on the south by the Jacks Fork River, on the northeast by the Current River, and on the west and northwest by Missouri Highways 132 and 37. The size of the study area is 592 square miles. Essentially all of this area contributes water to springs on either the Jacks Fork or Upper Current Rivers.

This study (1976-78) incorporated hydrologic information developed in previous work in the area, and developed two detailed maps of hazard areas. Hazard areas were found in locales where the hydrologic functioning of the land and the existing or potential use of the land combine to create a threat of springwater contamination. Each identified hazard area was visited, hydrologically evaluated, and discussed.

Several successful groundwater traces were also conducted in the area. Dyed water was successfully traced to Montauk Spring, Welch Spring, Pulltite Spring (and other springs in this spring complex), Round Spring, and Current River Spring.

Ozark National Scenic Riverways

RIVER RECREATION RESEARCH CONDUCTED AT OZARK NATIONAL SCENIC RIVERWAYS, 1970-77: A SUMMARY OF RESEARCH PROJECTS AND FINDINGS (PX-6000-7-0812)

-- Leo Marnell and David Foster, Ozark National Scenic Riverways; Kenneth Chilman, Southern Illinois University, Carbondale, Illinois

The steady rise in river use at Ozark has been a central concern of the National Park Service. Annual increases of 10 to 15 percent in recreational canoe float trips on the Current and Jacks Fork Rivers in Missouri have occurred since these rivers were designated Ozark National Scenic Riverways in 1964. The attractions of the Ozark Mountain scenery and clear, free-flowing rivers, coupled with the relative safety of floating these rivers, have made this park very popular. Matters of special concern to management include (1) the numbers and trends of recreational visitors to Ozark Riverways, (2) visitor impacts on the Riverways' natural resources, and (3) the quality of recreation experienced by visitors.

In 1972 a field research program was carried out to systematically explore the complexities of the river use situation at the Riverways. Although some Riverway research projects had been carried out prior to 1972, the decision to institute a comprehensive river research effort was based on the knowledge that (1) the Riverways' ecosystems were complex; (2) the Riverways

as a management unit was relatively new; and (3) individual managers and specialists transfer to other locations, thus necessitating a repository of information for management continuity. A moratorium on increases in numbers of canoes rented by the 16 National Park Service concessionaires was imposed for the anticipated duration of the research program.

The first priority was the need to know how many visitors used what portions of the Riverways at what particular times. An innovative adaptation of time-lapse photography instrumentation was successfully developed by the Park Service to provide quantitative measures of river use at a reasonable cost. Observational data recorded by local residents were used to check instrumentation estimates. In addition, a floater information card survey, administered through the cooperation of 16 canoe rental outlets in 1974 and 1975, provided data on party size, origin and destination points of the trip, trip duration, types of camping, and floater residence.

A systematic evaluation of visitor impacts on the Riverways' natural resources was undertaken in 1972. A two-year study contracted through the School of Forestry, Fisheries, and Wildlife Resources at the University of Missouri-Columbia evaluated visitor impacts on vegetation and soils along the Riverways. Water quality studies were contracted with the U.S. Geological Survey and with a consulting hydrologist.

The impact of increasing numbers of river visitors on the recreation experiences of other Riverways visitors was investigated in a series of visitor-interview studies. Local fishermen as well as canoe floaters were interviewed. These studies were accomplished through cooperative efforts with the University of Missouri-Columbia and Southern Illinois University-Carbondale. In addition, one special study on the safety aspects of Riverways recreation was contracted with the University of Missouri-Columbia.

SMALLMOUTH BASS POPULATIONS IN THE OZARK NATIONAL SCENIC RIVERWAYS

(MT-6000-0-C577)

-- W. Glenn Covington, University of Missouri, Columbia

The smallmouth bass (Micropterus dolomieui) is the primary game fish of the Ozark National Scenic Riverways (ONSR). This research was conducted to gather information on the smallmouth bass population characteristics: to determine food habits; to determine the quality of the smallmouth bass habitat; and to develop management options that will optimize recreational fishing benefits in the ONSR.

Smallmouth bass population density estimates, at two sites on both the upper Current and Jacks Fork Rivers, ranged from 34 to 304 fish per hectare. Sites on the Jacks Fork River consistently had higher population density than on the Current River. Bass ranged from 62 to 495 mm (2.4 - 19.5 in.) on the Jacks Fork River and from 70 to 395 mm (2.8 - 15.6 in.) on the Current River. Cumulative spring Proportional Stock Density (PSD) values ranged from 15 to 35 percent. Cumulative spring Relative Stock Density-35 values showed the difference between rivers with values of 15 and 17 percent at the sites on the Jacks Fork River and values of 9 and 12 percent at the sites on the Current River. Estimated total annual mortality for bass age

III and older differed slightly between rivers with the Current River having a rate of 43 percent and the Jacks Fork River a rate of 37 percent. Bass up to age X were captured on the Jacks Fork River but only up to age VIII on the Current River. Year class strength appeared to be more variable on the Current River. Growth in length was relatively slow at all sites with approximately six growing seasons required for the bass to reach 305 mm (12 in.). Bass were found to be in better condition on the Current River. Estimated population biomass for fish age III and older ranged from 10.11 to 43.44 kg/ha. Production estimates were substantially larger at the sites on the Jacks Fork River than on the Current River.

To analyze food habits, a new relative importance index was developed which combined food item weights and calories. Food habit analysis showed adult bass to feed almost exclusively on crayfish and fish, with younger bass also utilizing some insects (mayflies and stoneflies). Most of the crayfish ingested appeared to be yearlings.

Crayfish densities were consistently higher on the Current River. Densities of crayfish between 20 and 40 mm TL ranged from 699 to 3,933 per hectare.

The Jacks Fork River had higher quality habitat than the Current River. Preferred smallmouth bass habitat appeared to be steep banks, undercut banks, root wads, logs, and boulders.

Effects of habitat, water temperature, and recreational use were discussed along with management options, in an attempt to help maintain a quality smallmouth bass fishery in the Ozark National Scenic Riverways. Options included habitat manipulation and user regulations.

Ozark National Scenic Riverways

SUBSURFACE HYDROLOGY AND ION SOLUTION CHEMISTRY RELATED TO EFFLUENT DISPOSAL SITES IN THE MISSOURI OZARKS (PX-6000-5-0551)

-- Larry C. Tennyson, University of Missouri, Columbia

The subsurface water regime and cation/anion behavior in the upper profile of the major soil types located at a proposed sewage effluent irrigation site were investigated to determine the feasibility of using these typical Ozark soils for wastewater disposal. Three soils (Doniphan, Crider and Secesh) located at Sweezie Hollow, Big Spring Park, Ozark National Scenic Riverways were sprinkler-irrigated with groundwater (7.62 cm per week) from June through August 1976. Soil moisture, chemical and tracing data were used to evaluate soil water behavior. Soil moisture tension and percent moisture by volume were monitored. Calcium, Mg, Na, V, Mn, Al, Cl and Br concentrations in solution were quantified by neutron activation analysis. Sodium bromide tracers were applied in irrigation water.

Soil moisture was above field capacity in the Doniphan and Crider soils during the irrigation season. The Br tracer moved through the upper 0.9 m of profile in these soils within 3.5 hours after irrigation. Definitive absorption capacity of the soils for Br was not observed in laboratory tests. However, the presence of Br above background levels in soil water for 3 weeks after

injection of the tracer indicated some residence time for this ion in the Doniphan and Crider soils. Soil moisture increased in the Secesh soil during irrigation; however, moisture content was comparatively lower than the other soils.

Exchange equilibria studies showed that the three soils had retention capacity for Ca and Mg. Calcium and Mg concentrations increased in Doniphan and Crider soils during the study. A general decreasing trend was observed for these cations in the Secesh soil. Soil water levels of these cations were continuously lower than irrigation water concentrations, indicating that renovation of these ions was occurring in the three soils studied.

A net removal of Na and Cl was observed in the three soils. Vanadium levels decreased in the Doniphan and Crider soils. A well-defined trend for V in Secesh soil was not observed. Manganese in Doniphan and Crider soil water remained fairly constant. A decreasing trend for Mn occurred in the Secesh soil. Aluminum in solution fluctuated; however, definitive trends were not observed in the three soils studied. Increases in soil pH were measured at 0.3 m in the Crider soil and at 0.6 m and 0.9 m in the Secesh soil profile.

Soil moisture retention and cation/anion renovation potential were greater in the Doniphan and Crider soils compared to the Secesh soil.

THE ECONOMIC IMPACT OF THE OZARK NATIONAL SCENIC RIVERWAYS (PX-6000-6-0830)

-- Charles D. Oberbeck and Jerry G. West, University of Missouri, Columbia

This study (1976-77) described and evaluated the changes in selected economic indicators for Carter, Shannon, and neighboring counties for the periods prior to and following the establishment of the Riverways. Evaluations of the changes in land values (assessed and market values) in Carter and Shannon counties, the impact of the Riverways on the fiscal capacities of the Carter and Shannon County governments, and the impact of the Riverways on tourist visitation to the area were presented. The average per diem expenditure of users of the Current and Jacks Fork Rivers and the contribution of these expenditures to the economy of Carter and Shannon Counties were estimated.

THE IMPACT OF FLOATERS ON THE OZARK NATIONAL SCENIC RIVERWAYS

(CX-6000-3-0086)

-- Steven Wayne Sutton, University of Missouri, Columbia

An environmental impact analysis of the effects of floaters on the Current River and Jacks Fork River in the Ozark National Scenic Riverways was conducted from 1973 to 1975. The objectives were to (1) classify riverway environments by resource type, (2)determine the kinds and intensities of recreation use, and (3) determine the effects of floater use on vegetation and soil condition. Concentrated floater recreation was found to produce measurable changes in certain environmental parameters. Both soil and vegetation were shown to be altered depending on the type of soil and the intensity of use. One plant, Carex spp., was shown to be abundant on compacted, heavily used sites and thus indicative of current or impending site deterioration. Management recommendations were presented for modifying the recreation use and for preserving the natural resources of the Riverways.

Pictured Rocks National Lakeshore

A REPORT ON DEER POPULATIONS IN BEAVER BASIN, PICTURED ROCKS NATIONAL LAKESHORE, WINTER 1976-77 (CX-6000-6-R054)

-- William L. Robinson and Albert G. Spaulding, Northern Michigan University, Marquette, Michigan

Between January 2 and April 30, 1977, the winter ecology of white-tailed deer (Odocoileus virginianus) was studied in the Beaver Basin, Pictured Rocks National Lakeshore, Michigan. An estimated 443 deer were present in late December and early January as compared to 624 in 1974-75 and 651 in 1975-76. A total of 110 deer were found to have died in the winter of 1976-77. This compares with estimates of 122 and 141 dead deer in 1974-76 and 1975-76, respectively. By late April, nearly all surviving deer had moved out of the basin. Overall results indicated that the available browse utilized by deer in Beaver Basin was not adequate to sustain more than 200-300 deer. From the 24 deer carcasses observed in a relatively fresh state from January through April, six had been killed by predators.

Pictured Rocks National Lakeshore

A STUDY OF POPULATIONS AND BEHAVIOR OF WHITE-TAILED DEER IN BEAVER BASIN, MICHIGAN (CX-6000-5-0198)

-- Lloyd H. Fantor, Northern Michigan University, Marquette, Michigan

A two-year study was conducted during 1974-1976 on the wintering white-tailed deer population in Beaver Basin of the Pictured Rocks National Lakeshore. Due to supplemental feeding from 1960 to 1976, the deer population was being maintained at an artificially high level. The number of deer yarding in the Beaver Basin deeryard was estimated at 624 in 1974-75 and 651 in 1975-76. The results of the study showed that supplemental feeding did not affect deer movements to or from the yard; rather, the movements were dependent on weather conditions. Winter mortality during the phasing-out of supplemental feeding was estimated at 122 deer in the winter of 1974-75 and 141 in 1975-76. A browse survey study showed 64.2 percent consumption of natural food within the yard in addition to 22 tons of supplemental feed. The natural carrying capacity of the yard, based upon browse availability, was estimated at less than 150 deer. Based upon these results, it was recommended that the deer population be reduced to a level compatible with the natural carrying capacity.

Pictured Rocks National Lakeshore

A SURVEY OF AVAILABILITY AND CONSUMPTION OF DEER BROWSE ON BEAVER BASIN, PICTURED ROCKS NATIONAL LAKESHORE (PX-6000-7-0391)

-- William L. Robinson, Northern Michigan University, Marquette, Michigan

A browse survey was conducted in Beaver Basin, Pictured Rocks National Lakeshore, during the winter of 1976-77. The objectives of the survey were to gather quantitative information on how much natural browse was available to deer in their winter yarding area (1,360 acres) within Beaver Basin and to measure the amount of browse consumed by deer during the winter. Fifty-seven sample plots were distributed in each of five habitat types: hardwoods constituting 591 acres and 43.7 percent of the study area; swamp conifers, 513 acres and 38 percent of the study area; mixed conifers and hardwoods, 175 acres and 13 percent of the area; openings, 54 acres and 4 percent of the area; and upland conifers, primarily mature hemlocks, covering 27 acres or 2 percent of the area. Overall results indicated that available browse in the area utilized by deer was not adequate to sustain more than 200-300 deer. Judging from both browse conditions and the physical condition of deer and their mortality rates, it appeared the Beaver Basin deer population was well above the natural carrying capacity.

Pictured Rocks National Lakeshore

FINAL REPORT ON DEER RESEARCH IN BEAVER BASIN, WINTER 1978-79

(PX-6000-8-0777)

-- Steven L. Jones, William F. Jensen, and William L. Robinson, Northern Michigan University, Marquette, Michigan

The winter ecology of white-tailed deer (Odocoileus virginianus) was studied for the fifth consecutive year in Beaver Basin, Pictured Rocks National Lakeshore, Michigan. An estimated 193 deer entered Beaver Basin in early winter of 1978-79 compared with 651 in 1975-76. Of the 193 deer, 87 (46 percent) were estimated to have died, based upon a sample of 70 carcasses found. The decline in deer numbers was accompanied by a large reduction in the total area occupied by the deer in February and March, and colonization of a small new area near Beaver Creek. Browse available in November was estimated at about 42,000 lbs. compared with 113,000 lbs. available to the deer in the same area in November 1975. White cedar browse declined in that period from about 92,000 to 10,000 lbs. In addition to observations of deer, detailed notes were made of observations of 15 other mammal species and 23 species of birds in an effort to describe interactions among members of the winter community in Beaver Basin.

PLANT COMMUNITIES, HABITATS, AND SOIL CONDITIONS OF GRAND SABLE DUNES, PICTURED ROCKS NATIONAL LAKESHORE, MICHIGAN (CX-6000-5-0190)

-- David P. Bach, Michigan Technological University, Houghton, Michigan

The plant communities, habitats, and soil condition of Grand Sable Dunes, Pictured Rocks National Lakeshore, were identified and described in June of 1975. Vegetation data on ground cover, shrub, and tree species were collected from 106 spaced quadrats. The data were tabulated according to six sand movement habitats. Between-habitat differences in species composition and coverage were noted. The described plant communities were: (1) active dunelands, (2) gravel lags, (3) stabilizing dunelands, (4) pioneer woodlands, and (5) second growth forest. Of the sampled communities, the active dunelands exhibited the greatest sand movement, the fewest species, and was characterized by marram grass (Ammophila breviligulata). The pioneer woodlands received only a slight dusting of fine sand, had the greatest species richness, and was normally characterized by even-aged stands of jack pine (Pinus banksiana). The stabilizing dunelands, which are normally treeless and characterized by little bluestem grass (Andropogon scoparius), were intermediate in sand movement and species richness. A comparison of soil conditions between the communities indicated that decreases in sand movement

and increases in time since stabilization were accompanied by decreases in surface soil pH and bulk density and increases in organic horizon thickness. Based on vegetation and soil changes, a possible successional sequence is: active duneland - stabilizing dunelands - pioneer woodlands.

THE BIOGEOCHEMISTRY OF SELECTED ECOSYSTEMS WITHIN PICTURED ROCKS NATIONAL LAKESHORE: YEAR 2 (PX-6000-0-0455)

-- J. Robert Stottlemyer, Great Lakes Area Research Studies Unit, Michigan Technological University, Houghton, Michigan

A series of studies was initiated in the summer of 1979 on watershed ecosystems located within Isle Royale National Park, the Keweenaw Peninsula on the south shore of Lake Superior, and in the Pictured Rocks National Lakeshore. The goal of these studies was to obtain baseline data on the structure and functioning of northern ecosystems and how they vary as a result of differences in vegetation composition, vegetation succession, edaphic factors, geologic substrate, and precipitation inputs. Precipitation quantity and quality and, in the Lake Superior Basin in particular, its seasonal distribution are important ecological variables. This report summarizes data collected to date on the neutralization of acid precipitation in low-order streams in the upper portions of small watersheds within the Pictured Rocks National Lakeshore.

Pictured Rocks National Lakeshore

THE DEER OF BEAVER BASIN: ECOLOGY AND POLITICS OF A MAN-MADE IRRUPTION (PX-6000-0-0452)

-- William L. Robinson, Lloyd Fanter, Albert G. Spaulding, Steve L. Jones, and William F. Jensen, Northern Michigan University, Marquette, Michigan

A study was conducted during six winters (1975-80) in Beaver Basin, Pictured Rocks National Lakeshore, to determine the effects of removal of supplemental artificial feeding on the numbers and behavior of a free-ranging population of white-tailed deer (Odocoileus virginianus) and on the vegetation in their winter yard. Upon cessation of supplemental feeding, deer numbers declined from an estimated 650 to 160 in 3 years. Malnutrition, augmented by coyote (Canis latrans) predation, was the major cause of the deer decline. As deer numbers diminished, so did the size of the deeryard, with deer maintaining estimated densities of 56/km^2 in the central yarding area and abandoning peripheral areas. Vegetation changes in the central yard included a 95 percent reduction of available highly palatable and preferred white cedar (Thuja occidentalis) and a 300 percent increase in less palatable balsam fir (Abies balsamea). Predation by coyotes was disproportionately high in areas of low deer occupancy. A hypothesis was presented to explain the size and shape of winter deeryards

as an interaction between centripetal influences of cover and predation and centrifugal effects of food available and social interactions among the deer. Political and judicial decisions (counter to the recommendations of biologists) did not permit a special harvest of deer in Beaver Basin and were likely responsible for the observed heavy losses of deer to starvation and the consequent reduction of the long-term capacity of the vegetation to provide browse. The magnitude of the irruption of deer was clearly caused by the influence of man in his attempts to provide short-term relief from mortality by removing predators and providing supplemental food.

THE RELATION OF SCOUR CHANNELS WITHIN PICTURED ROCKS NATIONAL LAKESHORE TO THE GLACIAL GEOLOGY OF THE GREAT LAKES REGION (CX-6000-5-0175)

-- Christopher W. Drexler and William R. Farrand, University of Michigan, Ann Arbor

The age and extent of the Post-Duluth glacial lakes and the positions of their outlets were traced along the south shore of Lake Superior from Keweenaw Bay to the Pictured Rocks National Lakeshore during 1975-77. Two outlet channels were found in the Lakeshore, these being preserved today as the bedrock valleys containing Chapel and Little Chapel Lakes. The origin of these outlets was discussed. Management recommendations were presented for geological features needing complete preservation and limited protection.

Pictured Rocks National Lakeshore

VEGETATION ANALYSIS AND AN ANALYTICAL MODEL OF THE BEAVER BASIN DEER YARD (CX-6000-7-R045)

-- William F. Jensen, Northern Michigan University, Marquette, Michigan

During the 1960's and early 1970's, a free-ranging population of white-tailed deer (Odocoileus virginianus borealis) in Beaver Basin, Michigan, was fed with commercial deer rations. The National Park Service obtained ownership of the yarding area in 1974, reduced supplemental feeding in 1974-75 and 1975-76, and ended it in the winter of 1976-77.

The objectives of this thesis were to (1) estimate the quality and quantity of available deer browse, (2) evaluate the changing composition of the deer herd, (3) describe coyote-deer relationships, and (4) estimate future deer populations in the yard by means of an analytical model.

Available browse in the conifer swamp areas declined by an estimated 85 percent between 1975 and 1979, with white cedar (Thuja occidentalis) declining 96 percent. Balsam fir (Abies balsamea) production increased by 215 percent. Contents of 23 deer rumens indicated a high usage of white cedar by adults, while fawn diets were heterogeneous in browse species content.

January deer numbers dropped from an estimated 647 in 1977 to 164 in 1980. During this period deer densities declined from an estimated 153 to 61 deer/km^2. Winter mortality ranged from 20 percent to 56 percent. Adult survival rates ranged from 53 percent to 95 percent while fawn survival rates ranged from 30 percent to 63 percent. Coyote (Canis latrans) activity and group size tended to increase with the increase of available deer carcasses.

As a means of estimating future trends in the Beaver Basin deer population, a computer model was developed. From this model the winter carrying capacity of the yard was estimated to range between 100 and 200 deer. Analysis indicated that the carrying capacity of the yard may have dropped 14 percent as a result of the decline in available browse.

A REPORT ON MANAGEMENT OF NATIVE PRAIRIE AREAS, PIPESTONE NATIONAL MONUMENT (PX-6000-7-0811)

-- Roger Q. Landers, Iowa State University, Ames, Iowa

The objectives of this study were to determine the nature of the vegetation of Pipestone National Monument prior to European settlement, to delineate present vegetation boundaries and to advise on longterm management which would enhance the preservation of the monument. To accomplish these objectives, tree-ring studies were used to determine the approximate age of trees and their responses to environmental stress. The vigor and diversity of prairie vegetation in various sectors were surveyed in relation to present management. Observations were made during the summers of 1975 and 1978.

All evidence suggested that prairie vegetation dominated the presettlement landscape of the monument except for the rocky areas and stream edges. Most of the trees sampled came from established sprouts that were suppressed by fires for decades but protected and allowed to grow up around 1880. The present vegetation on the monument can be grouped into the following categories: (1) bluestem prairie, (2) smooth brome and bluegrass successional, (3) xeric, (4) marsh, (5) oak-elm woodland, and (6) shrub. The present prairie management program using prescribed fire seemed to be achieving the goal of enhancing the natural setting of Pipestone.

EVALUATION OF CATLINITE RESOURCES, PIPESTONE NATIONAL MONUMENT (PX-6000-0-0726)

-- G. B. Morey, Minnesota Geological Survey, St. Paul, Minnesota

Much of the monument is characterized by a thin mantle of glacial drift of possibly Kansan age. In general, the drift is less than 10 feet thick and consists dominantly of oxidized light-olive-brown, clayey, calcareous till with scattered pebbles and cobbles of basalt and quartzite.

Bedrock underlying the drift is assigned to the Sioux Quartzite; it strikes to the north, dips to the east at angles of 5° to 10°, and consists predominantly of orthoquartzite with lesser amounts of quartz-rich siltstone, clayey siltstone, silty mudstone and catlinite.

The Sioux Quartzite contains a variety of sedimentary structures indicative of sedimentation by fluvial processes associated with a braided-stream system that flowed in a predominantly southward to south-southeastward direction.

The sandy and silty units in the Sioux channel deposits formed during periods of low water, whereas the catlinite deposits formed only during major floods as vertical accretion deposits. Such deposits tend to be

quickly eroded by laterally migrating river channels. Consequently, the sedimentological model predicts that the catlinite beds will have patchy and discontinuous distributions.

Geologic mapping and the analysis of subsurface data obtained by the U.S. Geological Survey in 1979 and the Minnesota Geological Survey in 1980 have identified numerous catlinite units that range in thickness from 1 to 2 inches to approximately 2 feet. Many of the thin catlinite beds have very limited distributions, but the thicker units have a broadly curvilinear geometry and can be traced for distances of 700 to 800 feet in the strike direction and 300 to 400 feet in the downdip direction. Thus their distribution is consistent with the inferred distribution of vertical accretion deposits in a braided stream system.

EROSION CONTROL, LOWER SAINT CROIX NATIONAL SCENIC RIVERWAY (PX-6000-7-0624)

-- Peter Olin, University of Minnesota, St. Paul

This study (1977-79) emphasized that erosion is a natural wearing process, but when it is compounded by heavy use or overuse it can become a major environmental problem. On the St. Croix and Namekagon Rivers the major erosion problem exists along the river banks. This occurs primarily at river access points, at campsites, and at steep sand banks. Location, design, maintenance, and rehabilitation factors for erosion control at campsites and access points were discussed. Guidelines for erosion control were presented for use and user modification, siting and site modification, and maintenance.

INVENTORY AND ANALYSIS, SAINT CROIX NATIONAL SCENIC RIVERWAY (PX-6000-4-0156)

-- Peter Olin, University of Minnesota, St. Paul

The objectives of this resource inventory (1974-76) were to produce a documented series of overlay maps showing basic physical and cultural conditions within and surrounding the National Scenic Riverway and to produce analysis maps that combine and consolidate the characteristics of each resource into natural units which indicate the feasibility and desirability for planned types of development. Resource maps included topography, bedrock geology, surficial geology, slope analysis, soils, vegetation, ownership patterns, cultural patterns, and river environment. The analyses consisted of physical suitability (recreation, structural development, campsites, and access points), qualitative experiences on the river and at campsites, and cultural proximity. An annotated bibliography for the St. Croix and the Namekagon Rivers was compiled.

LOWER SAINT CROIX RIVERWAY: USER AND RESOURCE CONDITIONS (PX-6000-7-0421)

-- Robert Becker and Bernard J. Niemann, Jr., University of Wisconsin, Madison

This two-year study (1977-78) was designed to develop a better understanding of the Riverway and its users. Riverway managers determined that three areas of information were needed: (1) the effects of users upon other riverway users; (2) the effects of riverway users upon the resources; and (3) the effects of the resources on the users. The study showed that the Riverway is composed of two parts as demonstrated by the types of users, the perceptions of the resources, and the characteristics of the Riverway itself. The results also indicated that use is increasing, users are being displaced, and the resource is being degraded.

RECREATIONAL BOATING USE PATTERNS DURING 1981, LOWER SAINT CROIX NATIONAL SCENIC RIVERWAY (PX-6000-0-0783)

-- Roy F. Weston, Inc., St. Paul, Minnesota

The 1981 study of boating on the Lower Saint Croix River focused on total boating activity and the contribution to total boating generated by the riparian landowners along the river. Riparian landowners are composed of individual riparians that own or rent their residences, riparian commercial/industrial landowners, riparian institutions, and riparian marina operations.

Riparian boating habits were determined by a personal interview survey that was administered over a 16-week period during the summer use season. Coincident with the survey were aerial observations to document the total level of boating and the number of boats ramped at each of the access points along the river. Boat rampings were determined by using 8-mm photography in conjunction with the overflights.

The survey found that riparians preferred to enter the river most frequently during weekends and holidays as well as during the peak hours of the day (12:00 noon to 5:00 p.m.). Individual riparians did not stay out as long,

nor beach as often, as riparian marina operators or nonriparian boaters. Party size for individual riaprians was smaller than for the riparian organizations.

The survey also documented differences between the individual riparian boaters and the nonriparians that enter the river through the marinas, boat ramps, or from the Mississippi River.

Sleeping Bear Dunes National Lakeshore

CONTINUED MONITORING OF GULL REPRODUCTIVE SUCCESS AT SOUTH MAINTOU ISLAND (PX-6000-9-0886)

-- William E. Southern, Linda K. Southern, Sue F. Elston, and Fred A. Heiny, Northern Illinois University, DeKalb, Illinois

Since 1975, researchers from Northern Illinois University have monitored the reproductive success of ring-billed gulls (Larus delawarensis) and herring gulls (L. argentatus) on South Manitou Island. The island is part of Sleeping Bear Dunes National Lakeshore. In 1975 and 1977, the South Manitou Island ring-billed gull and herring gull colonies were censused on 20 May and 21 May, respectively. During the breeding seasons of 1976 and 1978-1981, weekly censuses of the colonies were conducted. A steady decline of active nests and numbers of eggs for both species has been recorded for the 7-year study period (82.7 percent for ring-billed gulls; 72.4 percent for herring gulls). No ring-billed or herring gull chicks survived to fledge during the 1981 breeding season. As in previous years, foxes caused abandonment of the colonies during part or most of many nights during incubation and brooding stages. Occasional attempts have been made to discourage or eliminate foxes from the vicinity of the gull colonies. Playing transistor radios at night was effective in deterring foxes but labor intensive; chick shelters, aversive conditioning

with lithium chloride, and most hunting and trapping attempts proved to be ineffective. In 1977, however, the trapping of two foxes in May was probably at least partly responsible for the lack of fox activity in the colonies during May and June. Unless fox predation is controlled, the colonies will cease to exist in the near future.

Sleeping Bear Dunes National Lakeshore

ECOLOGICAL STUDY OF SLEEPING BEAR DUNES NATIONAL LAKESHORE: PART II - MAINLAND PORTION (CX-6000-4-0153)

-- Paul W. Thompson, Cranbrooks Institute of Science, Bloomfield Hills, Michigan

The purpose of this 1974 study was to describe, identify, and evaluate the many distinctive biotic communities and physical features, particularly those related to glacial geology, which characterize the Sleeping Bear Dunes National Lakeshore. In order to protect and preserve adequate examples of these features, a number of Natural Area Tracts were proposed. To the extent possible, the tracts were designed to include several different natural areas and features in a single unit. The dedication of these tracts will preserve some of the most outstanding natural areas and natural features of the Lakeshore. Maps showing the major physical features of the Sleeping Bear region were included.

Sleeping Bear Dunes National Lakeshore

GIANT WHITE CEDAR RESEARCH FOR 1978, SOUTH MANITOU ISLAND, SLEEPING BEAR DUNES NATIONAL LAKESHORE (PX-6000-8-0166)

-- Michael Scott, Michigan State University, East Lansing, Michigan

Reproduction of cedar within the forest was found to be almost exclusively confined to stumps and logs. Samples and observations from logged areas indicated that logging was not a successful stimulus for cedar reproduction. This fact, along with the preponderence of larger trees, indicated that cedar will eventually be replaced in this forest. Importance values and size structure analysis suggested that this replacement will be by sugar maple and white ash. Although the cedars were not reproducing successfully in the forest, the study found that they establish quite readily on exposed sands and clays. During the descriptive phase of this study, no cedar tree over approximately 95 feet in height was measured. This conflicted with previous reports of trees reaching 100 feet and more.

Sleeping Bear Dunes National Lakeshore

LIMNOLOGICAL INVESTIGATION OF FLORENCE LAKE, SOUTH MANITOU ISLAND, MICHIGAN (CX-6000-4-0157)

-- John E. Gannon and Jack E. Stockwell, Biological Station, University of Michigan, Pellston, Michigan

A general limnological survey of Florence Lake was conducted in September 1974 and in March, May, and September of 1975. Morphometric features of the lake were determined. The survey included physiochemical data on temperature, light transparency, pH, dissolved oxygen, total alkalinity, several cations, nutrients, and chlorophyll a. Biological data were collected for phytoplankton (net), zooplankton, benthic macroinvertebrates, and fish.

The available limnological data indicated that the lake is mesotrophic. There was no evidence of any human impacts on the rate of eutrophication.

Sleeping Bear Dunes National Lakeshore

MANAGEMENT STRATEGIES FOR REDUCING PREDATOR-CAUSED MORTALITY IN THE SOUTH MANITOU ISLAND GULL COLONIES, SLEEPING BEAR DUNES NATIONAL LAKESHORE (CX-6000-4-0143; PX-6000-4-0797)

-- William E. Southern, Northern Illinois University, DeKalb, Illinois

A two-year study (1975-1976) was conducted to determine the reasons for the reportedly low reproductive success of gulls nesting at South Manitou Island in the Sleeping Bear Dunes National Lakeshore. Reproductive success of Ring-billed Gulls was less than eight percent in 1975 and almost zero in 1976. Herring Gulls produced essentially no young either year. There was a corresponding decline in the number of pairs of gulls using the colony sites in 1976--a 24 percent (1,240 nests) reduction for Ring-billed Gulls and a 34.8 percent (165 nests) reduction in the case of Herring Gulls. Predominate factors contributing to these losses were disturbances and surplus killing by red foxes. Perhaps as many as seven foxes made frequent nocturnal raids on the colonies during all stages of the nesting cycle.

Various methods of reducing fox-caused mortality were tested, including radios and chick shelters. None of these appeared successful enough to warrant continued use. Control of foxes by hunting or trapping appeared to be the only practical method to avoid the probable extinction of both gull colonies.

Sleeping Bear Dunes National Lakeshore

MONITORING GULL REPRODUCTIVE SUCCESS AND INDUCED PREY AVERSION IN RED FOXES - SOUTH MANITOU ISLAND (PX-6000-8-0352)

-- William E. Southern, Lise A. Hanners, and Mei-Yao Louis, Northern Illinois University, DeKalb, Illinois

The 1979 breeding season for ring-billed and herring gulls on South Manitou Island was essentially a complete reproductive failure. The ring-billed colony should have produced at least 2,755 young and the herring gulls should have produced about 522 young under normal conditions. Instead, no young were produced in either colony. In the case of ring-billed gulls, each year of unsuccessful productivity has been followed by a loss of about 1,000 breeding pairs from the island. Some recruitment of gulls produced in other colonies was occurring but the rate was not equal to the desertion rate. Furthermore, the loss of essentially all young at South Manitou eliminated the possibility of individuals returning to their natal colony at the time of first breeding. As a result, the South Manitou ring-billed gull colony has steadily decreased in size since 1975. As only 1,931 breeding pairs remained in 1979, it was clear that continued predation by foxes could result in gull abandonment of the site. A hunting and trapping program was therefore recommended, as well as continuation of the LiCL conditioning program begun in 1978.

Sleeping Bear Dunes National Lakeshore

OBSERVATIONS ON THE WINTER ECOLOGY OF RED FOX (Vulpes fulva) ON SOUTH MANITOU ISLAND, MICHIGAN (PX-6000-5-0711)

-- Jack E. Stockwell and John E. Gannon, Biological Station, University of Michigan, Pellston, Michigan

Objectives of the study were to estimate the size of the red fox (Vulpes fulva) population, determine food habits, range and movement, and assess the ecological interrelationship between the fox and other organisms on South Manitou Island, with emphasis on the fox-gull interaction. The red fox population of South Manitou Island included approximately five to seven individuals in March 1976. Range and movement of the red fox involved the entire island, but activities were most heavily concentrated in the northern portion. Winter food sources for fox consisted primarily of apples, edible flotsam (namely alewives), and rabbits, supplemented with mice and birds. Although there was no clear evidence that gulls were used as a food source during March, the proximity of hunting and denning areas to the gull colony makes fox-gull interaction inevitable. Easy accessibility of the colony and its concentration of prey (gulls) was probably the main motivating factor for gull kills, rather than fox population size.

If the National Park Service wishes to protect South Manitou Island as a wilderness area, both fox and gull populations should be permitted to determine their natural ecological balance without human intervention. Both the fox and gull populations on South Manitou Island have undoubtedly experienced extreme fluctuations and have probably become nonexistent at times. However, if preservation of the gull colony is a more valuable goal, the Park Service may wish to institute a management program to eliminate the fox population on the island.

Sleeping Bear Dunes National Lakeshore

REPORT ON THE FEASIBILITY OF PLANTING NATIVE GRASSES AT SLEEPING BEAR DUNES NATIONAL LAKESHORE (PX-6000-8-0924)

-- Joyce Ann Powers, Prairie Ridge Nursery, Mt. Horeb, Wisconsin

A three-day visit to Sleeping Bear Dunes National Lakeshore in late October of 1978 was made to look at sites being considered for planting native grasses and wildflowers and to identify the weed species that might cause difficulties in the initial stages of grassland establishment. Recommendations of what native species to plant, along with suggestions on how to establish them under prevailing field conditions, were presented.

Sleeping Bear Dunes National Lakeshore

RESPONSE OF THE MANITOU GULL COLONIES TO AN IMPLEMENTED MANAGEMENT PROGRAM (PX-6000-7-0457)

-- Stephen R. Patton, Northern Illinois University, DeKalb, Illinois

The ring-billed and herring gull colonies on South Manitou Island were censused on 20 and 21 May and monitored 4 May through 19 July, 1977. Two thousand six hundred and eighty-six active ring-billed nests (i.e., contained eggs) were recorded in 1977; this indicated at least 5,372 breeding adult gulls at the South Manitou colony site. This total represented a 31.7 percent reduction since 1976 and a 48.1 percent reduction since 1975. There were 466 active herring gull nests in 1977 at the colony, only 1.7 percent less than that recorded in 1975. Transect data indicated hatching rates for both ring-billed (87.9 percent) and herring gulls (61.7 percent) were greater than those recorded in 1975 and 1976. Despite predation by a red fox for 19 days, ring-billed fledging success (86 percent) was greater than that recorded during the 2 previous years. Herring gulls experienced fledging rates similar to ring-bills in 1977. Fox trappers hired by the National Park Service to remove foxes may have caused sufficient disturbance in the colony area to inhibit visits to the colony by foxes.

Sleeping Bear Dunes National Lakeshore

THE WHITE-TAILED DEER OF NORTH MANITOU ISLAND, MICHIGAN (CX-6000-8-R134)

-- David J. Case, University of Michigan, Ann Arbor

The white-tailed deer population on North Manitou Island (NMI), Michigan, was studied between June 1980 and May 1982. The deer herd was introduced to the island in 1926 and supplementally fed from 1937 to 1977. The last deer hunt prior to this study was conducted in 1977.

Population size was estimated by a pellet group survey and from line transect analyses of data collected on direct counts. The prehunt and prefawn 1980 population sizes were estimated at about 800 and 1,400, respectively. The prefawn and prehunt 1981 population sizes estimates were approximately 300 and 2,000 deer.

Hunting as a mortality factor was not significant during this study. No quantitative data were available on prenatal or neonatal fawn mortality although both types probably occurred. Death due to winter thermal stress and starvation was by far the most prominent mortality factor affecting the deer herd. Extensive dead deer surveys, utilizing a variety of techniques, were conducted in 1980, 1981, and 1982. A total of 740 carcasses believed to have

died of winter starvation between 1977-78 and 1981-82 were located. Estimated winter mortality was 882±168 (0.95 confidence interval) in 1977-78, 81±15 in 1978-79, 186±36 in 1979-80, 261±221 in 1980-81, and 1585±837 in 1981-82.

Forage utilization was determined from the twig and vegetation surveys and from rumen content analysis of 31 deer collected in October of 1980. Preferred species of woody browse, common as a forage of northern deer especially in winter, were nearly absent from NMI and probably did not constitute an important dietary component during any season including winter. Graminids were an important food source during all seasons, but may have been more important to deer on NMI in winter and spring than to deer in other areas because of the lack of woody browse. Although quantitative estimates were not available, observations of feeding deer indicated they relied heavily on woodland ephemerals and graminids as spring food sources.

Summer foods of NMI deer, in addition to graminids, consisted of forbs and the sprouts of woody trees and shrubs. Important forbs included spotted knapweed, sheep sorrel, and ferns. Sugar maple was the most important woody sprout. In the fall a large portion of the diet consisted of apple fruit with lesser quantities of acorns and beechnuts. The leaves of sugar maple and cherry were also utilized heavily. Graminids, again, were important food sources.

The effect of deer overbrowsing on vegetative structure and composition on NMI was assessed by comparing vegetation inside and outside a 5 x 5 m deer exclosure and by examining low scale aerial photographs. Deer overbrowsing

has effectively suppressed the reproduction of deciduous tree species other than American beech. Herbaceous vegetation on the island has also been impacted. Old field succession has, to a large degree, been prevented by deer overbrowsing.

It is recommended that the deer herd on NMI be reduced to and maintained at low levels for a number of years. It is felt that vegetative recovery on NMI will take place only under this type of management. It is anticipated that a balance or equilibrium will not be achieved between habitat and deer on NMI unless the deer herd is reduced. The deer herd and habitat on NMI should be closely monitored to assess the success of management programs and to ensure that the information needed to determine yearly harvest levels is available.

Voyageurs National Park

ECOLOGICAL ANALYSIS OF THE PLANKTON COMMUNITIES OF VOYAGEURS NATIONAL PARK (CX-6000-8-R133)

-- Jack R. Hargis, University of Minnesota, Duluth

Baseline information to delimit biological criteria for water quality management was gathered in the Voyageurs National Park over three summer periods: 1978-81. Physical, chemical, and biological features were noted for the four large lakes in the park: Kabetogama, Namakan, Sand Point, and Rainy, and for twenty smaller lakes within the park boundaries. Temperature, water clarity, dissolved oxygen concentration, pH, specific conductance, hardness, alkalinity, and plant nutrient concentrations represent the physical and chemical attributes measured at each station. Chlorophyll _a_ concentrations, zooplankton population densities, and zooplankton community structures were also measured. Similarities and differences between lakes, based on these features, have been used to suggest management categories for maintenance of lake water quality. These features were interpreted relative to lake susceptibilities to visitor use and other likely water quality impacts. A photographic identification file of the zooplankton was prepared.

Voyageurs National Park

LICHENS OF VOYAGEURS NATIONAL PARK (PX-6000-7-0922; PX-6000-8-0922)

-- Clifford M. Wetmore, University of Minnesota, St. Paul

Over 8,000 lichens were collected at 128 different localities within the park during 11 weeks in 1978 and 1979. All lichens were identified and the 403 taxa known from the park were listed. Several areas of special interest to the lichen flora were noted. Numerous new state records were found within these collections and all but seven of the species collected by Bruce Fink in 1901 were recollected. Some of the rare lichens were found to be "rare" probably because of the logging and forest fires during the past 80 years. There were no lichens endemic to the park. As winter food for caribou, lichens would probably not be a limiting factor in the success of any reintroduction of woodland caribou to the park. The scarcity of the orange lakeshore lichen (Xanthoria elegans) was studied and found to be probably due to lack of wave splash. The lichen flora was rich in fruticose speices, suggesting that no air pollution was present. Lichen communities are subject to physical damage by human activity and have been damaged in some locations in the park. Recommendations were presented regarding the location of campsites and trails, preservation of special areas important for their lichens, treatment of lichens in the park interpretive programs, and establishment of more detailed monitoring programs using the lichens.

Voyageurs National Park

PRIMARY PLANT COMMUNITIES IN VOYAGEURS NATIONAL PARK, MINNESOTA

(CX-6000-7-R020)

-- Vilis Kurmis, Lawrence C. Merriam, et al., University of Minnesota, St. Paul

This three-year study (1977-79) was designed to inventory and classify the primary plant communities of Voyageurs National Park and relate their preservation requirements to park usage and management. A total of 120 stands were described in a reconnaissance survey; 46 of these stands were selected for intensive examination through the establishment of permanent plots. The following primary communities were identified and studied: upland shrub-lichen, scrub oak, jack pine, red pine, white pine, aspen, paper birch, fir-spruce-birch, ash-elm, black ash, white-cedar, black spruce, leatherleaf bog, shrub carr, and marsh. The synecological coordinates method was employed to evaluate environmenal regimes. Moisture-nutrient coordinate axes were used for community ordination and classification in ecological vegetation types. The results showed that the predominance of aspen will decrease under protective management. However, the aspens' ability to reproduce vegetatively in response to natural disturbances (wind, spruce budworm) assures its role as a future community component.

Voyageurs National Park

RESOURCES BASIC INVENTORY - PRIMARY DEVELOPMENT AREAS, VOYAGEURS NATIONAL PARK, MINNESOTA: PART I - ECOSYSTEMS ANALYSIS; PART II - ANNOTATED BIBLIOGRAPHY (CX-4000-3-0057)

-- Lawrence C. Merriam, Vilis C. Kurmis, and Michael A. Loesch, et al., University of Minnesota, St. Paul

This 1973 study examined the natural resources, present developments, and uses of four development areas within the authorized Voyageurs National Park and provided information on potential and future effects of the present land use patterns. Subdivisions of the study covered: topographic and physical features including soil types, geologic history and patterns; basic vegetation types; basic faunal system; basic aquatic life system; water quality; basic climatological patterns; cultural developments and human use; and potential and future effects. A specially-prepared annotated bibliography of the basic literature on the subjects of the study concerning Voyageurs National Park constituted Part II of the study report. This bibliography served as the reference listing for the ecosystem analysis.

Voyageurs National Park

RESOURCES BASIC INVENTORY--PRIMARY DEVELOPMENT AREAS, VOYAGEURS NATIONAL PARK, MINNESOTA: ECOSYSTEM ANALYSIS-KETTLE FALLS (CX-6000-4-0158)

-- Lawrence C. Merriam, Vilis C. Kurmis, et al., University of Minnesota, St. Paul

An ecosystems analysis was conducted on the Kettle Falls proposed development area within Voyageurs National Park during July-September, 1975. The study concerned the natural resources, present developments and uses of the nearly 100-acre Kettle Falls development area located in the remote northeastern end of the Kabetogama Peninsula. Information was obtained on the potential and future effects of proposed developments or continued present land use patterns. Subdivisions of the study covered: (1) basic vegetation types; (2) impact on wildlife; (3) basic aquatic life systems; (4) water quality; (5) cultural developments and human use; and (6) potential and future effects.

Voyageurs National Park

THE FIRE AND LOGGING HISTORY OF VOYAGEURS NATIONAL PARK (CX-6000-7-R054)

-- Michael A. Coffman, Lawrence Rakestraw, and James E. Ferris, Michigan Technological University, Houghton, Michigan

This two-year project (1978-1980) documented the original vegetation, historic and modern fire patterns, logging impacts, and successional patterns of Voyageurs National Park. Present vegetation, fire evidence, logging evidence, and relevant historic records were investigated. A map of the original vegetation types was prepared from the original survey notes taken in 1881-1894. Comparison of this map with the current type map showed significant vegetation shifts from predominately pine and spruce-fir forest to predominately aspen forests today. The presettlement fire regime was the primary factor maintaining the pine types, while logging was the primary factor effecting the establishment of the aspen types. Five general site types were identified using Bray-Curtis ordination and synecological coordinates. These site types ranged from jack pine sites to very wet swamp conifer sites. These different types had differing fire and logging histories and their successional dynamics reflected these differences. In the absence of fire or other major disturbances, most stands will eventually climax in spruce-fir types.

Voyageurs National Park

THE INCIDENCE OF *Parelaphostrongylus tenius* AND OTHER HELMINTH PARASITES IN CERVIDS OF VOYAGEURS NATIONAL PARK 1977-1978 (PX-6000-8-0218)

-- Rick J. Rowe, Rainy River Community College, International Falls, Minnesota

The incidence of *Parelaphostrongylus tenius* and other helminth parasitism was studied in white-tailed deer (*Odocoileus virginianus*) and moose (*Alces alces*) within and immediately around Voyageurs National Park during 1977 and 1978. The results are based on the analyses of 382 deer and 16 moose pellet samples collected by Voyageurs National Park officials. Incidence of *P. tenius* in white-tailed deer pellets was 55.2 percent and in moose pellets 6.25 percent. Incidence of other helminth parasites in white-tailed deer pellets was 51.8 percent and in moose pellets 68.75 percent.

TIMBER WOLF (*Canis lupis*) FOOD HABITS, VOYAGEURS NATIONAL PARK, 1977-1978 (PX-6000-7-0921)

-- Jeffrey T. Hardwig, Rainy River Community College, International Falls, Minnesota

The food habits of the eastern timber wolf (*Canis lupis*) in Voyageurs National Park were studied during 1977 and 1978. The results presented in this report are based on the analysis of 175 wolf scats collected by Voyageurs National Park officials and are intended to show the dependence of the wolf on the various food sources in the park. Analysis revealed 187 prey type occurrences. Prey selection switched from primarily adult white-tailed deer (*Odocoileus virginianus*) in the winter to primarily fawns and beaver (*Castor canadensis*) in the spring and summer. An additional sixteen small wolf or coyote (*Canis latrans*) and seven red fox (*Vulpes fulva*) scats were analyzed. White-tailed deer were the most abundant food sources utilized by those animals.

Wilson's Creek National Battlefield

HISTORICAL BASE AND GROUND COVER MAP WILSON'S CREEK NATIONAL BATTLEFIELD (MT-no number)

-- Edwin C. Bearss, Denver Service Center, National Park Service

This 1978 study provided Wilson's Creek National Battlefield with an updated Historical Base and Ground Cover Map and supportive documentation. Such a map and study were needed to provide management with data necessary to accomplish the Master Plan's goal of restorating the vegetative cover to its historic appearance, circa 1861. Beginning in January 1978, all published material on the battle and on the Wilson and Porter Townships (on file at the Library of Congress, State Historical Society of Missouri, the Springfield Public Library, the Arkansas History Commission, and the Park Library) were reviewed and pertinent data extracted. Manuscripts, maps, letters, books, etc., on file at the National Archives and the Suitland Records Center were examined, as were manuscript collections of the University of Missouri and the Arkansas History Commission. Legal documents were selectively perused, along with the Springfield Public Library's extensive and invaluable local history clipping file.

Multi-park

A FOREST TYPE MAP OF PICTURED ROCKS AND APOSTLE ISLANDS NATIONAL LAKESHORES FROM THE ORIGINAL GENERAL LAND OFFICE SURVEY RECORDS (CX-6000-5-0222)

-- Douglas J. Frederick and Lawrence Rakestraw, Michigan Technological University, Houghton, Michigan

Using the 1841-1857 General Land Office survey notes of the Pictured Rocks and Apostle Islands National Lakeshores (both on the south shore of Lake Superior), vegetation type maps of considerable detail were drafted during 1975-76 from bearing tree, soils, and topographic information. Results of the statistical tests on section and quarter corner trees showed some bias by the surveyors for selecting certain species and diameters. U.S. Geological Survey maps and county soil survey maps were used in conjunction with the survey notes for final forest vegetation typing. A computer mapping technique using the same source information was described and compared with manual methods. Using these maps along with the accompanying information from the original notes on topography, soils, site quality, disturbances, and human presence, a general comparison was made with present conditions. Significant vegetation changes resulting from man's incursions were found to have occurred on both lakeshores.

Multi-park

A REPORT ON THE STATUS AND MANAGEMENT OF NATIVE PRAIRIE AREAS IN NATIONAL PARKS AND MONUMENTS IN THE MIDWEST REGION (PX-6000-5-0546)

-- Roger Q. Landers, Iowa State University, Ames, Iowa

This study summarized observations made during the summer of 1975 on the prairie remnants and established prairie species of the National Parks and Monuments in the Midwest Region (from Indiana to western Nebraska and Minnesota to southern Missouri). It described the status of management success in achieving park objectives dealing with prairie vegetation in park landscapes. Most of the areas were not within the top ten most popular and well known national parks. They were found to have little in common except for their connection with a regional vegetation that was once predominately prairie. How the current natural vegetation fits into the scheme of things within each park is a central question in their management.

Multi-park

BASIC NATURAL RESOURCES INFORMATION FOR THE LAKE SUPERIOR AREAS OF THE NATIONAL PARK SYSTEM (CX-6000-5-0168)

-- Michigan Technological University, Houghton, Michigan

From September 1974 to June 1975, information was collected from various sources concerning the natural resources of National Park System areas in the Lake Superior region. These areas include Isle Royale National Park, Pictured Rocks National Lakeshore, and Apostle National Lakeshore. For the Apostle Islands, a bibliography was produced covering the following categories: climatology-meteorology, geology, vegetation-botany, zoology-fauna, aquatic biology, and resources management. For the other park areas, separate bibliographies were not produced; instead, bibliographic information was collected and contributed to a computer program concerning the Lake Superior basin.

Multi-park

COMPILATION OF INFORMATION CONCERNING PROPAGATION AND GROWTH REQUIREMENTS OF THREATENED AND ENDANGERED PLANT SPECIES NATIVE IN THE NORTH CENTRAL REGION (PX-6000-7-0923)

-- Harold Pellett and Peter Ascher, Landscape Arboretum, University of Minnesota, Chaska, Minnesota

The natural distribution of the endangered or threatened plant species of the North Central region was studied (1977-79) to determine those species where survival is threatened throughout their range of distribution. A thorough literature review was undertaken to find out what is known about the natural reproduction, propagation methods, and growth requirements of these species. This information was needed to develop or improve propagation techniques and cultural requirements for preserving the threatened and endangered species. The information should also be extremely valuable in assessing the current management practices in national parks and forests and other natural areas and relating the effects of these practices to the survival of the plants in the region.

Multi-park

DEVELOPMENT OF TECHNIQUES FOR PROPAGATION AND PRESERVATION OF THREATENED AND ENDANGERED NATIVE ORCHIDS (PX-6000-8-0925)

-- P. D. Ascher and P. J. Myers-Strangis, University of Minnesota, St. Paul

The objective of this study (1979-80) was to define the conditions required by terrestrial orchids from seed germination to growth of the adult plant. Special emphasis was placed on species growing in the northeastern region of North America so that the information acquired could be applied to local threatened and endangered species. Using aseptic culture techniques, 17 species from nine genera were germinated on a complex medium. All species which germinated did so only in the dark and germination took from 1 to 8 months. Continued incubation on the germination medium, even with regular transfer to fresh medium, was eventually lethal. However, seedlings transferred upon the formation of roots to a simple tissue culture medium supplemented with 0.2 percent activated charcoal continued development, many producing leaves. Addition of activated charcoal to the germination medium increased germination percentages but was deleterious to continued development. However, excellent development occurred when seedlings were germinated on the complex medium containing activated charcoal. Five of the eight species which produced leaves after transfer to the simple tissue culture medium, supplemented with activated charcoal, continued growing after transfer from aseptic conditions to sphagnum moss.

Multi-park

HISTORICAL SURVEY OF PEREGRINE FALCON EYRIES IN NATIONAL PARK SERVICE LANDS BORDERING LAKE SUPERIOR (CX-6000-5-0170; CX-6000-6-R026)

-- Frank B. Isaacs, Michigan Technological University, Houghton, Michigan

A study of the history, current status, and reintroduction possibilities of the peregrine falcon in the Apostle Islands National Lakeshore, Isle Royale National Park, and Pictured Rocks National Lakeshore was conducted in 1975 and 1976. Two eyries were documented in both Isle Royale National Park and Pictured Rocks National Lakeshore. No records of peregrines nesting in the Apostle Islands National Lakeshore were found. The peregrine was found absent as a breeding species from all three parks. Three areas of Isle Royale National Park, the Palisades, Passage Island, and Feldtman Ridge, were described in detail and the information was submitted to the Federal Peregrine Falcon Recovery Team. The Grand Portal Point area of Pictured Rocks National Lakeshore was identified as an abandoned eyrie and was also submitted for consideration as a possible reintroduction site. It was found that reintroduction at any of the sites would not be feasible until DDE and PCB levels in the Lake Superior ecosystem drop significantly.

Multi-park

REPORT ON RELEASE OF CAPTIVE-PRODUCED PEREGRINES IN THE UNITED STATES (PX-6000-6-0610)

-- Tom J. Cade, Cornell University, Ithaca, New York

This study was carried out by the Peregrine Fund, Laboratory of Ornithology and the Section of Ecology and Systematics, Division of Biological Sciences, Cornell University, during 1974-76 to develop feasible methods for releasing and establishing domestically produced peregrine falcons in nature. The main emphasis was on the use of hacking as a technique for release in the eastern United States and on the results obtained in 1976. Several conclusions regarding these methods were briefly discussed.

Multi-park

TERRESTRIAL ORCHID SEED GERMINATION *In Vitro* ON A DEFINED MEDIUM (PX-6000-7-0924)

-- James E. Henrich, Dennis P. Stimart, and Peter D. Ascher, University of Minnesota, St. Paul

Seeds of 29 terrestrial orchid species representing 15 genera were surface sterilized by immersion in 0.5 percent sodium hypochlorite containing a wetting agent, washed, sown on a completely defined, semisolid embryo culture medium containing macro- and microelements, sucrose, amino acids, and vitamins, and incubated in the dark at 25° C in 1978. Six months after sowing, 16 species from nine genera germinated and continued development while 13 species from 10 genera failed to germinate. Species of *Cypripedium*, *Goodyera*, *Platanthera* and *Spiranthes* differed in response; one or more of each germinated and one or more did not. Seedling development was similar for most germinating species and progressed to the formation of a shoot or shoot initial in all but one. Apparently the mycorrhizal association thought to be required for terrestrial orchid seed germination and early seedling development can be replaced with aseptic culture on a completely defined medium for many terrestrial orchids.

Multi-park

THE ROLE OF DISEASE IN ENVIRONMENTAL AND ECOLOGICAL MANAGEMENT OF NATIONAL PARKS (CX-6000-6-R025)

-- F. A. Wood, et al., University of Minnesota, St. Paul

Studies initiated in 1972 provided the National Park Service with baseline data on the impacts of air pollutants and disease on vegetation in the parks. Six research areas were emphasized: (1) ecology of dwarf mistletoe with emphasis on dwarf mistletoe of black spruce, (2) impact of photochemical air pollutants on plant species commonly found in parks, (3) the establishment of background levels of air pollution within the park system, (4) an evaluation of the pollution of rainfall with emphasis on acidity, (5) the role of viruses and mycoplasmalike organisms in wild areas, including their impact on park ecosystems, and (6) survey of diseases of aquatic plants and an evaluation of the effect of such diseases in aquatic populations. A system for determining the nature and importance of various diseases in National Parks was developed. Finally, a shift was made during 1975-1976 to concentrate on research areas 2-4 relating to air pollutants and their impacts on park vegetation.

MAPS

Apostle Islands National Lakeshore

COLOR DIGITAL MAP OF VEGETATION COVER-STATES GENERATED FROM A LANDSAT I COMPUTER COMPATIBLE TAPE (PX-6000-8-0689)

OAK ISLAND SITE LIMITATIONS FOR CAMP AREAS (CX-6000-5-0221; CX-6000-6-R049)

OAK ISLAND SITE LIMITATIONS FOR PATHS AND TRAILS (CX-6000-5-0221; CX-6000-6-R049)

OAK ISLAND SITE LIMITATIONS FOR PICNIC AREAS (CX-6000-5-0221; CX-6000-6-R049)

OAK ISLAND SITE LIMITATIONS FOR SEPTIC TANK FIELDS (CX-6000-5-0221; CX-6000-6-R049)

OAK ISLAND SOIL MAP (CX-6000-5-0221; CX-6000-6-R049)

RASPBERRY ISLAND SOILS MAP (CX-6000-5-0221; CX-6000-6-R049)

ROCKY ISLAND SOILS MAP (CX-6000-5-0221; CX-6000-6-R049)

THE ORIGINAL VEGETATION OF APOSTLE ISLANDS NATIONAL LAKESHORE (CX-6000-5-0222)

THE ORIGINAL VEGETATION OF PICTURED ROCKS NATIONAL LAKESHORE (CX-6000-5-0222)

THE PRESENT VEGETATION OF APOSTLE ISLANDS NATIONAL LAKESHORE (CX-6000-5-0222)

YORK ISLAND SOILS MAP (CX-6000-5-0221; CX-6000-6-R049)

Ozark National Scenic Riverways

LANDSTAT LAND COVER MAP OF THE CURRENT RIVER BASIN (PX-6000-8-0535)

Pictured Rocks National Lakeshore

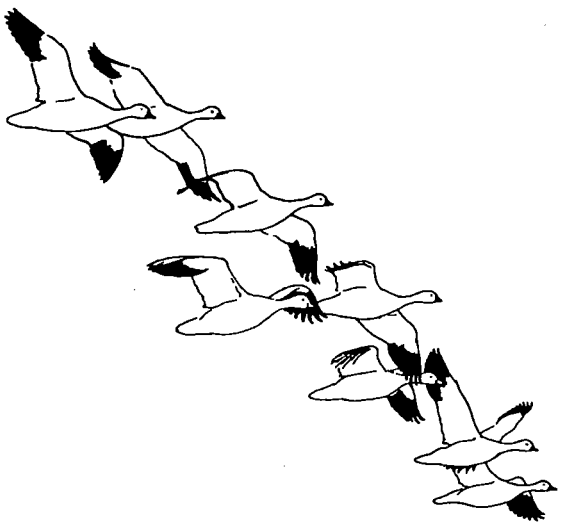
VEGETATION COVER MAP OF PICTURED ROCKS NATIONAL LAKESHORE BY COMPUTER ANALYSIS OF LANDSTAT DATA (PX-6000-9-0626)

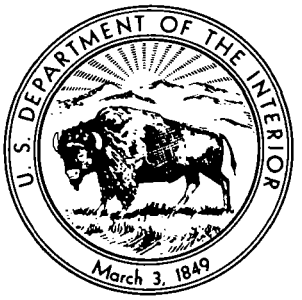
CHECKLISTS

Apostle Islands National Lakeshore

A BOTANICAL SURVEY OF OAK ISLAND, APOSTLE ISLANDS NATIONAL LAKESHORE, WISCONSIN: CHECKLIST OF VASCULAR PLANTS (CX-6000-6-R049)

APPENDIX A: CX AND PX LISTED BY PARK AND YEAR





As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environment and cultural value of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

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