

AN ECOLOGICAL SURVEY OF NATURAL AREAS
IN CENTRAL MISSOURI

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CHAPTER I

INTRODUCTION

The present study is a preliminary attempt to inventory, analyse and evaluate the remaining natural areas of Missouri and to determine the rates and causes for the destruction of areas.

"Natural area" as used in this report is an area "where, at least at the present, natural processes are allowed to predominate, not significantly influenced by deliberate manipulation or accidental interference (to any great extent) by man." This is the definition given by Dr. F. R. Fosberg, Chairman of the American Association for the Advancement of Science - Council Study Committee on Natural Areas as Research Facilities (A.A.A.S. 1963).

A second, excellent but sensus strictus definition is that of the Society of American Foresters defining natural area as "an area set aside to preserve permanently in unmodified condition a representative unit of the virgin growth of a major forest type primarily for the purposes of science, research, and education. Timber cutting and grazing are prohibited and general public use discouraged" (A.A.A.S. 1963). (Roberts (1965) believes that the use of "virgin" is too restrictive and will retard or prevent continued establishment of areas.) The Society of American Foresters definition cannot be followed in this study as it

implies that natural areas are: (1) already insured permanent preservation, (2) a representative of virgin growth, and (3) either a major forest or range type. The Missouri areas surveyed in this study were potential sites for preservation and most of these would not qualify as representatives of virgin conditions. A variety of types other than major forest and range types are of enough significance to be included in this survey (e.g., aquatic habitats, physiographic land forms, relict areas and type localities).

Wilderness, as defined by the Wilderness Act (Public Law 88-577), is undeveloped land which: (1) appears to have been affected primarily by the forces of nature, (2) has an extent of at least 5000 acres, (3) may contain ecological, geological or other features of scientific, educational, scenic, or historic value. In essence, wilderness is a natural area, but not all natural areas are of large enough size or sufficiently unmodified to be termed wilderness. The terms are nearly synonymous, but the natural area definition as given by Fosberg (A.A.A.S. 1963) is broader in two ways: (1) size - a wilderness area contains at least 5000 acres, whereas a natural area has no prescribed maximum or minimum size, and (2) past disturbance does not necessarily exclude an area from the natural area classification. This liberal definition of natural area is forced upon us for in many states it is impossible to find undisturbed areas. This

is especially true of the eastern states where the concept and need for natural areas originated. Missouri is approaching the point where standards must be lowered if we are to preserve anything as a natural area.

There are few remaining opportunities to set aside more wilderness or virgin areas. A virtue of natural areas is their smaller size, thus they can be established more readily than wilderness areas.

Awareness of the need for preservation of natural areas is evident in most of the United States. Due to this recent recognition and because of the current emphasis on land use planning, many states have undertaken surveys and are planning for the preservation of their natural area remnants. At least 23 state governments are considering the establishment of a natural area system; while at least 6 states already have active programs (A.A.A.S. 1963). There has also been action by local governments and community groups to preserve areas. However, this has been scattered and limited to a few examples.

An adequate system of natural areas should be planned on a broad enough scale to include representative samples of the entire ecological spectrum of the region for which it is designed (Leopold 1941 and 1949, Dowling 1964). The need for planning and instigating an active program for land preservation is immediate in most states.

Missouri is one of the states most urgently in need of immediate action. It is presently in rapid transition from rural to urban economy and is undergoing rapid industrial and human population expansion, with a resulting increase in demands for land. Land formerly left natural is now in demand for real estate, recreation and other uses. Missouri, in comparison with other states is criticized because its state park system has not been "rounded out to include significant scientific and historic sites and a few outstanding natural areas" (National Park Service 1964).

There has long been a need for a thorough inventory of areas of outstanding natural interest and scientific value in Missouri. Such an attempt was initiated by the prominent plant taxonomist, Julian Steyermark, in the 1950's when he formulated a listing of 125 areas of exceptional floristic value. However, a wide variety of other types of areas have not received similar inventory. An adequate survey and appraisal of all types of areas is needed as basic knowledge for planning to insure that sites that are representative or of a fragile nature are not destroyed.

The writings of Aldo Leopold have played a prominent role in developing an understanding of the importance of wilderness and natural areas to science, and especially conservation. Leopold (1949) pointed out that:

"The . . . most perfect norm is wilderness. Paleontology offers abundant evidence that wilderness maintained itself for immensely long periods; that weather and water built soil as fast or faster than it was carried away. Wilderness, then, assumes unexpected importance as a laboratory for the study of land-health."

As natural areas shrink in number and size their significance becomes greater as the only natural controls against which to measure the effects of modern practices or various experimental treatments in applied sciences (e.g. silviculture, wildlife management, range management).

There has been a gradual, but definite, evolution in the natural sciences from the era of taxonomic and morphological studies to a growing present-day emphasis on the community as a whole (ecosystem studies, productivity, radiation ecology).

This, in part, may be a reflection of the growing demands of the present day and the future. Although we are presently in an era where human population growth, crop surpluses, and economic wealth exist concurrently, productivity is being recognized as an important field of research; as, likewise, are studies comparing virgin and non-virgin conditions in order to determine the properties of each that are beneficial or basic to production and to life.

In order to preserve civilization itself, it seems necessary to preserve natural ecosystems. Life and sustenance of life are largely experimental, with natural areas

serving as our only check or control against which to measure the magnitude and meaning of changes induced by man. To insure adequate preservation of a representative sample of natural ecosystems is no small job and one which is still far from having been accomplished.

ACKNOWLEDGMENTS

A study of this magnitude could not have been accomplished without the interest, assistance and special talents of many people.

I have been fortunate to be able to work under the expert guidance of Dr. William H. Elder, whose awareness of the problems involved made the study take on new significance. To him I am greatly indebted for ideas and encouragement throughout the study and for suggestions in the preparation of this manuscript.

I am also grateful for the stimulating ecological thought and suggestions gained from Dr. Richard O. Anderson, Dr. Robert S. Campbell, Dr. Clair L. Kucera, P. Bruce Dowling, Dr. S. C. Kendeigh, Dr. F. R. Fosberg, Dr. Oscar Hawksley, Dr. Richard F. Myers, Kent D. Hall, and Dr. Wm. A. Albrecht.

Both the national office and the state chapter of The Nature Conservancy have made data available to me which formed the real framework of this study. It was, in fact, the interest and cooperation of these people which gave incentive to the study.

Personnel of the Missouri Conservation Commission have been most helpful in supplying information and suggestions. In particular, Bill T. Crawford as Chairman of the Missouri Chapter of The Wildlife Society's Committee for Inventory of

Natural Areas has been helpful in discussing state-wide natural area needs, the ways in which a state natural area system might be instigated, and in helping to design my research so that it could supplement the future action of the Committee for Inventory of Natural Areas.

Valuable help was given by Adele N. Wilson, of the Resources Program Staff of the Department of Interior, who generously supplied pertinent information regarding natural areas.

Earl Neller made a tremendous contribution to my knowledge of Missouri caves and their ecology and generously provided skilled assistance and equipment to enable entering those which afforded obstacles. Thanks also must go to many colleagues in wildlife biology and to members of Chouteau Grotto Chapter of the National Speleological Society who assisted in field surveys or contributed information about certain areas. Dr. M. G. Mehl, Dr. and Mrs. Carl Chapman and Don Nicholson have been resources for identification of paleontological, archaeological and geological specimens as well as in providing and documenting information on specific areas.

The many landowners on whom I depended varied somewhat in their initial willingness to allow access, but almost without exception, they exhibited a generosity and willingness to share their land with others. Many of them

had problems with litter, destruction of property, or damage to the natural feature itself.

This study has been made possible through the financial assistance of an Edward K. Love Fellowship.

CHAPTER II

REVIEW OF LITERATURE

The Use of Natural Areas for Research

The importance of natural areas to ecological studies was recognized in the early 1900's by most of the founders of American plant and animal ecology (Shelford, Shreve, Braun, Weaver, Clements, Cowles). Shelford, et al. (1926) in *The Naturalist's Guide to the Americas* presents the most outstanding early contribution documenting the value of natural areas to the sciences.

The significance of natural areas in research and teaching is further delineated in *Proceedings of the First National Symposium on College Natural Areas* (Dowling and Ross 1963). In addition to listing the natural areas owned or used by colleges of the United States and the types of research being conducted on these (as obtained by questionnaire) it surveys the overall progress and problems of natural area use for college research. Over half of these areas have been established since 1958, indicating a new awareness of the need for establishing this type of research facility. In general the amount of research produced on an area is proportional to the size of the area and its proximity to the campus.

In 1962 the Council of the American Association for

the Advancement of Science appointed a Council Study Committee on Natural Areas as Research Facilities. The committee's objectives were "to study and report on the regional distribution of reserves, the types of habitat inadequately represented, the institutional needs, the urgent problems, the needed legislation, and the possible role of A.A.A.S. and affiliated organizations in this field." The report of the committee (A.A.A.S. 1963) thoroughly documents the research value of natural areas. It contains an inventory of existing natural area preserves of the United States, a bibliography of over 2400 papers based on natural area research, analyses of the use of natural areas by various scientific disciplines, and analyses according to the geographic region, biotype, and ownership.

The use of natural areas by various scientific disciplines is discussed in this report. Some of the conclusions are: (1) ecology studies use natural areas to a much greater extent than most other disciplines, (2) applied research makes substantial use of natural areas, but by no means as much as might be expected, considering the economic importance of soundness of conclusions in this field, (3) zoology makes a somewhat greater use of natural areas than botany, (4) of the many disciplines using natural areas (Table I) those scientists making substantial use of natural areas in their research (with more than 40 known published

TABLE I
ALPHABETICAL LIST OF SCIENCES
THAT USE NATURAL AREAS IN THEIR RESEARCH
(BASED ON BIBLIOGRAPHY PUBLISHED IN A.A.A.S. 1963)

An asterisk indicates those sciences known to have more than 40 publications where research was conducted on preserved natural areas.

Agriculture	Geography	Physiography
Animal anatomy	Geology*	Physiology*
Animal autecology*	Glaciology*	Plant anatomy
Animal behavior*	Herpetology*	Plant autecology*
Animal morphology	Hydrology	Plant morphology
Animal pathology	Ichthyology*	Plant pathology
Animal synecology*	Limnology*	Plant synecology*
Bacteriology	Malacology	Productivity
Bioecology*	Mammalogy*	Radioecology
Biogeography	Marine biology	Range management
Botany of vascular plants*	Meteorology	Soil science
Bryology*	Microclimatology	Speleology
Climatology	Mineralogy	Systematic botany*
Ecology (sensus strictus)*	Mycology*	Systematic zoology*
Embryology	Ornithology*	Trophic ecology
Entomology*	Paleontology	Vegetation geography*
Faunistics*	Palynology	Vegetation management
Floristics*	Parasitology*	Wildlife management*
Forestry*	Pesticide research	
	Phycology	

papers) in the order of the magnitude of their use include: animal autecologists, floristic botanists, ecologists (sensus strictus), faunistic zoologists, ornithologists, vascular plant botanists, plant synecologists, mammalogists, entomologists, geologists, foresters, bioecologists, animal synecologists, animal behaviorists, systematic zoologists, plant autecologists, ichthyologists, wildlife managers, parasitologists, mycologists, limnologists, systematic botanists, physiologists, glaciologists, herpetologists, bryologists, and plant geographers.

Tucker Prairie (Univ. of Mo. 1959) is an outstanding example of the research contributions natural areas can provide. In six years the area has provided research for more than 12 publications and theses.

On a world-wide basis, the concept of natural areas and natural area research has been well advanced in Russia (U.S.S.R. Acad. of Sci. 1957 and 1960), Britain, Sweden, France, Czechoslovakia, Poland and Japan (A.A.A.S. 1963). In Africa vast expanses have been set aside as game refuges, some of which could remain as natural areas if their protection and preservation can be achieved by the new African governments. Southern and Southeast Asia, Australia and Latin America have made little progress in establishing natural areas or in promoting basic ecological studies.

Russian and British ecologists appear to have a

natural area concept which evolved separately but concurrently and along a similar line as that in the United States. In Russia, reserved plots are considered of great scientific importance as experimental controls and their establishment is considered "a prime State concern."

Values Other Than Research

Many values have been ascribed to natural areas besides research values. Perhaps equally as important are the educational and demonstrational values.

Beyond this, there is aesthetic value in natural beauty. This is often reflected in art, photography, landscape design, music, literature, and infinite other means of expression. An individual may (spiritually) "absorb" natural beauty, which again may be reflected in his attitudes. That the civic, social and psychological health of people in urban communities profits from natural lands and open areas is a well accepted doctrine that has guided metropolitan open space and green belt programs such as Cleveland's "emerald necklace."

Another little realized value of natural areas is that of providing an historic and anthropologic reference point so that future generations may know through what kinds of country the pioneers traveled or attempted to homestead-- the oak-hickory forest of the Osage Indian, the tall grass prairie, the cypress-tupelo swamp--all important parts of

our state and national heritage. Leopold (1949) points to this interdependence and significance in his statement, "Wilderness is the raw material out of which man has hammered the artifact called civilization." The influence of natural environment on the settlement of Missouri is discussed by Ellis (1929).

Biotic and Geographic Factors

Natural areas can be classified according to features, such as those of a geological, floristic or faunistic nature.

A number of ecologists have attempted to map climax plant and animal communities of the United States. Vegetation maps have been provided by Shreve (1917), Shantz and Zon (1924), Weaver and Clements (1938), Kùchler (1964). The geographical distribution of animal communities, or plant and animal communities combined ("Biotic Provinces" or biotic areas), have been studied by Shelford, et al. (1924) and by Kendeigh (1954, 1961).

In addition to these maps which give an index to large scale zones of plant and animal life in Missouri, there are two other sources of information on the floristic composition of Missouri vegetation. Steyermark (1963) discusses plant regions of Missouri and roughly shows regional divisions on a state map (Figure 1) These vegetational types are listed in Table V.

Further description of the floristics and forest

associations within the Ozark Plateau are found in Steyermark (1940). Sauer (1920) presents a detailed account of various geographic factors within the Ozark Plateau, including those physiographic, geologic, economic and historic.

The most detailed natural vegetation map of Missouri is by Kucera (1961) who also discusses the principal species of each vegetation type (Table V).

The History of Post-settlement Land Use in Missouri

McKinley (1960) compiled an extensive "Chronology and Bibliography of Wildlife in Missouri." The many references therein document that within historic times and due largely to man-made changes, there has been a rapid loss of wilderness and natural areas, accompanied by wreckless exploitation of land, forests and wildlife. Many native species of plants and animals have been extirpated in Missouri or are dangerously near extinction. Likewise, some physiographic features of the natural landscape (e.g. oxbow lakes, free-flowing rivers, floodplain forest, virgin pine) are also in jeopardy.

In the course of the settlement of Missouri the following activities have altered the natural habitats:

- | | |
|--------|---|
| 1700's | Fur trade |
| 1800's | Settlement along major streams and in forested portion of state |
| | Beginning of timber harvest |

- Beginning of market hunting
- Introduction of livestock and domestic animals
- Introduction of many exotic plants and animals
- Construction of grist mills by springs and streams
- 1850-1930 Drainage of swamp and overflow lands
- Construction of roads and railroads
- 1880's Settlement and farming of prairie begun
- Prairie sod first broken in Missouri (History of Saline County 1881). The absence of trees, water and millseats was thought to delay prairie settlement--McKinley 1960.
- 1936 Construction of Bagnell Dam and subsequent planning for additional dam construction on rivers.

Recent problems affecting Missouri may include: large-scale pollution of streams and springs, air pollution, use of pesticides, radiation, human population problems. Secretary of Interior, Stewart Udall in "The Quiet Crisis" (1963) points to these and other land use problems of national importance.

Surveys of Other States

Surveys to locate and evaluate natural area sites have been conducted in a number of states--Illinois (Evers 1963), California, Maine, Michigan, Minnesota, New Hampshire. Most of these reports have not been published, but are typed

or mimeographed and restricted in distribution. In general these surveys have been conducted by a group of scientists with varied backgrounds, to assure that the interests of any scientific discipline were not overlooked in the survey and evaluation of areas.

Previous Missouri Surveys

The first known survey of Missouri natural areas was part of a survey of the entire North American continent begun in 1917 by a committee of the newly formed Ecological Society of America (Shelford 1926). This committee was charged with the "listing of all preserved and preservable areas in North America in which natural conditions persist." It was the conviction of members of the Ecological Society that they should take steps to preserve or make available for study as much of the original biota of North America as possible. This group later founded The Nature Conservancy, an organization for this express purpose.

The survey was designed to include "all preserved areas and areas available for study, in natural condition, preserved areas in a semi-natural condition, such as forest preserves, bird and game sanctuaries, and second growth areas undergoing succession."

The information on Missouri areas (in Shelford 1926) was compiled by A. C. Burrill, et al., and includes description of the rapid loss of undisturbed lands and species of

wildlife. The degree of modification of flora and fauna was separately evaluated. The degree of disturbance is indicated for each area, as based on an 8-point scale where original natural conditions are indicated by 1, and various degrees of modification up to 8 which is cleared land (Table II).

TABLE II
TYPE, NUMBER AND DEGREE OF DISTURBANCE
OF NATURAL AREAS IN MISSOURI AS REPORTED IN
SHELFORD, ET AL. 1926

<u>Type</u>	<u>Areas Listed</u>	<u>Degree of Disturbance (Range of Values)</u>	
		<u>Flora</u>	<u>Fauna</u>
Prairie	4	2-4	3-4
Ozark forests	11	1-4	2-4
Lowland and overflow lands	5	1-8	4-8
Mississippi bluffs and bottomlands	<u>3</u>	3-7	3-7
	<u>23</u>		

These evaluations of disturbance indicated that the fauna appeared to be as much, and usually more, disturbed than the flora in all 23 areas.

The report of the American Association for the Advancement of Science (1963) contains a state by state inventory of natural areas known to have legal assurance of preservation. Table III shows those areas listed for Missouri plus two recent additions.

TABLE III

PRESERVED NATURAL AREAS IN MISSOURI

<u>Name</u>	<u>Type of Natural Area</u>	<u>Ownership</u>	<u>Acreage</u>
Carsonhurst	Oak-hickory forest	Nature Conservancy	55
Current-Eleven Point River Scenic Area	Hardwood forest	U. S. F. S.	20,239
Current River Natural Area	White oak forest	L. Drey	20
Holly Ridge	Native holly	Nature Conservancy	40
Hyer Memorial Woods	Virgin white oak	Nature Conservancy	30
Peterson Azalea Memorial	Western disjunct azalea	Nature Conservancy	3
Lily Pond	Upland sinkhold pond	Nature Conservancy	9
Tucker Prairie	Tall-grass prairie	Univ. of Missouri	142
Dixon Tract	Forest along Current River	U. S. F. S.	320
Ederer Tract	Forest along Current River	U. S. F. S.	<u>40</u>
			20,898

There are 20,898 acres of preserved natural areas of five biotic types in Missouri (Table III). However only one or perhaps two of these areas are large enough to maintain any type of homeostasis from disturbances occurring on adjoining property. No attempt was made by the A.A.A.S. Committee to inventory areas that should be considered prospects for preservation. However, the report points up certain inadequacies: habitats lacking representative examples, size inadequacies, poor statewide distribution of preserved areas, and travel distances from universities so great as to limit research use.

The National Park Service (1964) published a report entitled "Parks for America" that includes an inventory of existing and potential parks and recreational facilities for each state. The recreational value of areas is the major consideration. However, it is suggested that certain areas be added to the state and local park systems under the titles of Scientific Monument and Nature Preserve, which hopefully would put certain restrictions on the extent to which they would be developed for recreation. The report is of value as a reference although it is not scientifically oriented. It does strongly urge that the Missouri State Park system be expanded to include significant scientific sites and a few outstanding natural areas.

Fairly extensive data on the unique floristic areas

surveyed by Steyermark, have been a major contribution to an inventory of prospective natural area sites. The unpublished list of these sites was compiled by him for The Nature Conservancy. Some of these areas were later listed with more detail (in Steyermark 1940, 1963).

The Missouri Geological Survey sponsored research by Beckman and Hinchey (1944) and published a survey of the large springs of Missouri. This useful guide needs expansion to include all known Missouri springs. So far our springs have received little research attention, although they provide exceptional opportunities for biological investigation.

For many years the caves of Missouri were largely unstudied and unknown. Rapid strides have been made within the last decade to inventory and map the many caves of the state. Missouri has at least 27 commercial caves--more than twice that of any other state. This commercialization has hastened or encouraged research at times (especially archaeological and geological) and in other instances eliminated cave fauna and prevented biological research. The first account of Missouri caves was a book entitled "Cave Regions of the Ozarks and Black Hills" by Luella Owen (1898). A few other semi-scientific publications appeared in the early part of the twentieth century. However it was not until the publication of "The Caves of Missouri" by J. H. Bretz (1956) that the real basis for a comprehensive and scientific-

ic evaluation was layed. This handbook includes information on more than 400 caves, with geological theories on the origin of particular caves and cave formations. No biological or archaeological data are included.

To supplement Bretz, the Missouri Geological Survey and, more recently, the Missouri Speleological Survey have published, with limited distribution, several revised lists. The most recent of these is the "Catalogue of the Caves of Missouri" (Vineyard 1964) which contains the name and location of 1402 caves in 73 counties of the state. It is still not complete, as caves are being rapidly discovered--more than 300 new ones have since been reported.

Cave fauna of Missouri has been studied by Hubricht (1950), Mohr (1950), Mittleman (1950), Hawksley (1959), Nicholas (1960), Myers (1964) and others.

CHAPTER III

DESCRIPTION OF STUDY

This study was an attempt to survey and evaluate areas in terms of ecological or other scientific values. It has included: (1) compiling and updating a list of natural areas, (2) visiting and evaluating each in terms of the amount of disturbance it has undergone, (3) evaluating each in terms of its uniqueness or representativeness as a natural community, (4) consideration of the abundance and distribution of ecological types and (5) consideration of the main causes for past destruction and apparent future threats.

The study was undertaken with the view that all types of areas deserved consideration. No attempt was made to specialize, but rather to round out and supplement Steyermark's floristic sites with other types of areas. These included areas that are faunistically unique or meet the habitat requirements of certain animal species that are rare or limited in distribution or that seasonally need specific sites for reproduction or other phases of the life cycle (e.g. heron rookeries, caves suitable for bat hibernation or nursery colonies). The study also was designed to include areas of interest to geology, soil science, and archaeology. On these three latter types there was often found equally interesting biota.

The identification and use of plant names follow those given by Steyermark (1963).

A list and description of the prospective natural area sites known and surveyed in central Missouri was prepared and is filed with the Missouri Cooperative Wildlife Research Unit of the University of Missouri.

Portion of State Surveyed

Leads were assembled on areas from all parts of the state through personal communication or search of published references.

It became necessary to limit field work to a restricted region in which it would be possible to work intensively in following up leads on areas and making personal observations. An area consisting of 19 counties in central Missouri was chosen for this purpose and is outlined in Figure 1. These 19 counties represent a diversity of natural area types. According to Steyermark (1963), the junction (or ecotone) of three major physiographic and biotic regions occurs in this area: (1) glaciated prairie (including salt springs), (2) unglaciated prairie, and (3) the Ozark region, (Figure 1).

Span of Study

The field work was undertaken during a 13-month period from May, 1964 to June, 1965. From 800-1300 miles

per month were traveled during the first six months, with only about half as much travel in the last seven months. Additional miles of walking or searching were often required to reach areas. Every previously known lead was followed through, and an effort was made to locate new areas. A total of 46 areas, many of which had multiple natural area features, were surveyed. Some areas could be visited only once due to their remoteness, while others were visited from two to four times in gathering data and observing seasonal changes. Data sheets were kept for each area and included the following:

Date of field trip(s):

Name of Area:

Name of County:

Directions on how to get there:

Exact topographic location:

Acreage:

Ownership(s):

Description (physiography, dominant plant species, etc.)

Fauna and Flora observed (abundance, distribution, or other comments)

Sources of Area Leads

Leads on natural area sites came from many different sources. Both the national and state offices of The Nature Conservancy contain file cards on potential natural area

sites recommended by Steyermark (unpubl. list) and Shelford et al. (1926). Most of the areas investigated were those suggested by Steyermark.

Parks for America (National Park Service 1964) contains some additional natural area possibilities. Information on areas was solicited from groups such as the Missouri Chapter of The Nature Conservancy and Missouri Speleological Survey. It was also solicited from individuals in other fields of science such as geology, archaeology, botany, paleontology, fishery biology. A number of potential areas were discovered because they had already produced significant research (e.g. Camp Creek Salt Springs, Vaughn Cave, Carroll Cave, Mary Lawson Cave, Graham Cave). Searching scientific literature and county histories yielded some information. Scanning topographic maps has been helpful in locating marshes, oxbow lakes, springs and karst. Observing the landscape while driving on roads, or on one occasion from a low-flying plane, yielded little but reinforcement of the impression of the extent to which nearly all of the landscape of central Missouri has been modified.

Methods of Evaluation

Evaluating amount of disturbance. The amount of past disturbance of an area was evaluated in several ways.

(1) The past land use history was discussed with the landowner or nearby residents whenever possible. (2) In most

instances the disturbance was so great that it was obvious what factors had been involved and how recently. (3) Plant indicators of burning, logging and grazing were used. In forest areas the species composition of overstory and understory was important. The herbaceous flora of the forest floor especially contains many sensitive indicator species. Orchids and ferns (excepting the bracken fern--Pteridium latiusculum) require a moist, organic soil and exhibit such a narrow range of tolerance that they are completely absent from areas that have been disturbed by burning and logging. Legumes, annuals and other heliophytes and pre-climax species are especially characteristic of disturbed areas. Helpful references on index plant species include Shantz and Zon (1924), Steyermark (1940), Curtis (1959), Phillips Petroleum Company-Pasture and Range Plants series (1959). Quantitative comparisons of various species populations were used more than the mere presence or absence factor. According to Odum (1959) and Curtis (1959) this is more reliable. Curtis (1959) summarizes disturbance by stating that "in degraded areas, the degree of replacement of the original components is largely proportional to the amount of disturbance." The difficulty encountered in Missouri is that there are not adequate examples of undisturbed areas left to form a basis for our knowledge of the original component species of communities under the influence of various soil

and topographic factors. Often we do well if we can merely deduce the original life form and dominant species.

The use of animal indicators has not been studied well enough to permit general use. Overgrazing, logging and burning are known to each have specific affects on the kinds and numbers of arthropods and soil invertebrates (Kendeigh 1961:128-135).

Evaluating an area in terms of its qualities as a unique or a representative sample. This is a subjective type of judgment based on the extent to which the area is undisturbed, and the extent to which it represents a unique feature or a good representative remnant of original conditions. In thus "grading" the areas I used three classes. A top-priority area would rank in class I. Areas greatly disturbed and of little or no value as a natural area ranked III. Areas with the rank of II had been at least moderately disturbed, but still might recover under protection.

Other considerations. The abundance and distribution of each habitat type in Missouri was considered in the scoring of each area (Chapter V). The various causes for disturbance or destruction were noted for each area and each ecologic type. Future threats to areas were noted when they seemed imminent.

CHAPTER IV

TYPES OF NATURAL AREAS

Review of Previous Classifications

Previous descriptions of Missouri natural areas have concerned themselves with the uniqueness of each area and its values as an individual unit. Certain broad subdivisions of Missouri based on topographic and floristic formations have been used, but there is no general, all-inclusive system, other than the one suggested in Table VI, for grouping and classifying the diverse types of areas found in Missouri.

Geologic factors. In considering geological formations, agricultural production, and natural vegetation, Missouri is frequently divided into four regions: (1) northern glaciated plains, (2) western plains, (3) Ozark highlands, (4) southeastern lowlands.

On the geologic time scale, eight periods of rock formation are well represented. These occur in the four major regions of Missouri as indicated in Table IV, (Beveridge 1964, Missouri Geological Survey 1964). The geographic distribution is shown on the Geologic Map of Missouri (Figure 2).

TABLE IV

GEOLOGIC AGE OF UPPER ROCK STRATA IN THE
FOUR MAJOR PHYSIOGRAPHIC REGIONS OF MISSOURI

PERIODS	REGIONS			
	Glaciated Prairie	Western Plains	Ozark Highlands	Southeastern Lowlands
Precambrian			X	
Cambrian			X	
Ordovician			X	
Silurian- Devonian	X	X		
Mississippian	X	X		X
Pennsylvanian	X	X		
Cretaceous				X
Tertiary- Quaternary	X	X		

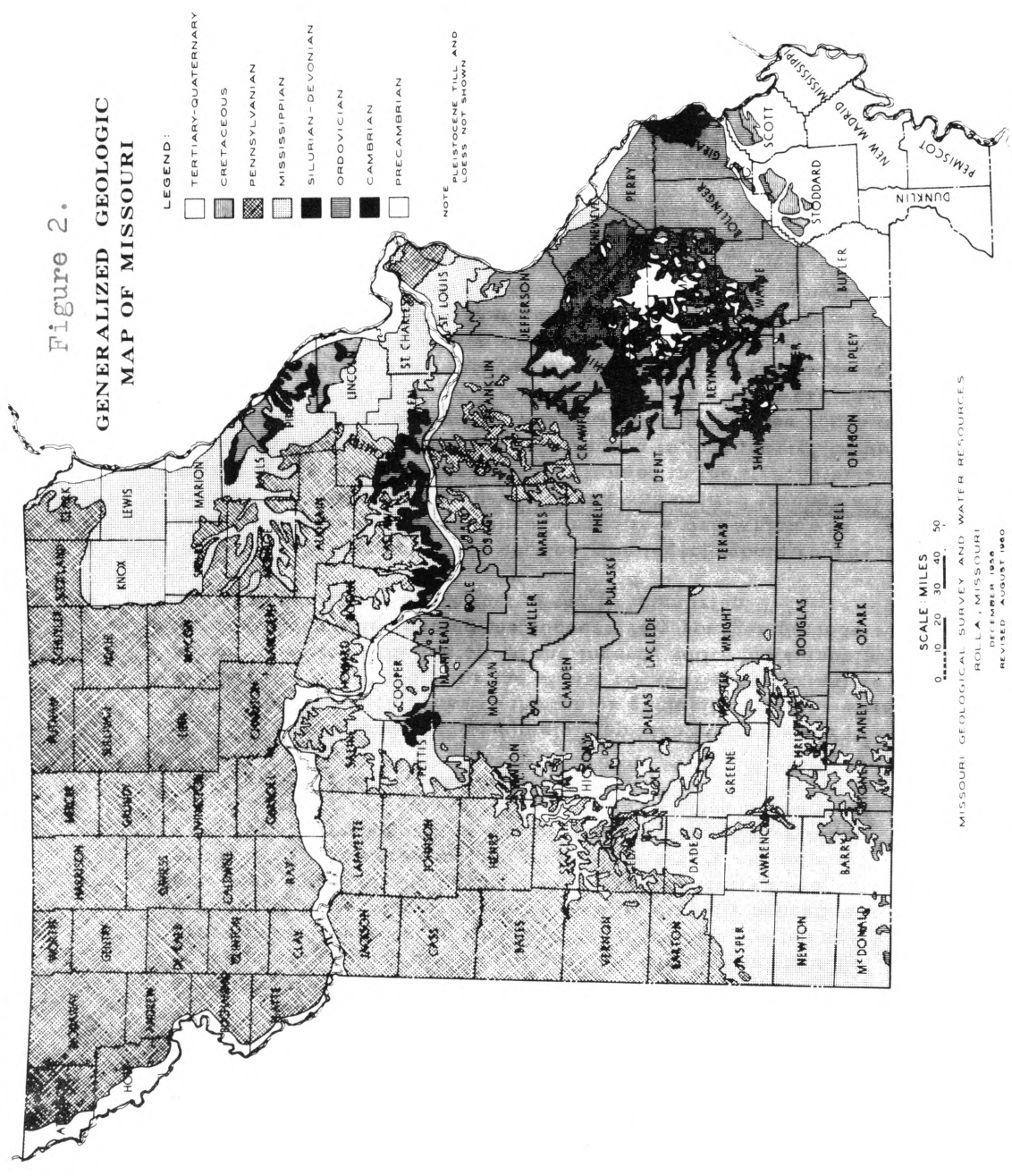


Figure 2.
GENERALIZED GEOLOGIC
MAP OF MISSOURI

- LEGEND:
- TERTIARY-QUATERNARY
 - ▒ CRETACEOUS
 - ▤ PENNSYLVANIAN
 - ▥ MISSISSIPPIAN
 - ▧ SILURIAN-DEVONIAN
 - ▨ ORDOVICIAN
 - ▩ CAMBRIAN
 - PRECAMBRIAN

NOTE
PLEISTOCENE TILL AND
LOESS NOT SHOWN

SCALE MILES
0 10 20 30 40 50

MISSOURI GEOLOGICAL SURVEY AND WATER RESOURCES
POLA J. MISSOURI
MISSOURI GEOLOGICAL SURVEY
REVISED AUGUST 1980

Rock strata formed during the various geological periods show individualities in the development of various natural area features as follows:

Precambrian:

Pine-oak
Granitic rock and soils
Massive granite boulders
Iron deposits.

Cambrian:

Pine-oak
Sandstone
Dolomite with earliest fossil records (porifera, crinoids, brachiopods, gastropods, trilobites, arachnids) and with lead deposits.

Ordovician:

Deciduous forest (four mesophytic forest associations but no pine-oak)
Caves and other karst features are best developed and mostly limited to this region
Dolomite, limestone, sandstone, chert and many fossils.

Silurian-Devonian:

Deposits were nearly all eroded away by or before the Mississippian Seas
Some shale deposits remain in which 14 species of fossil fish have been found.

Mississippian:

Oak-hickory-prairie ecotone
Caves and other karst features.

Pennsylvanian:

Tall grass prairie
Shale, limestone, sandstone, coal, clays, and many fossil deposits of Pennsylvanian Seas.

Cretaceous:

Crowleys Ridge
American beech, holly
Sands and clays.

Tertiary-Quaternary:

Loessial deposits - grama grass, soapweed (Kucera 1961)
Alluvial deposits - oak-gum-~~cy~~ press.

Residual soils and topography are largely determined by the development and subsequent breakdown of rock strata. These factors share a close relationship with the formation of a mature soil profile and its accompanying floristics, as well as other natural area features. Soils, and consequently vegetation types, do not always assume the same pattern of distribution as the various parent rock materials. This is due to mixing and distributive actions (e.g., glaciation, aeolian, alluvial and colluvial factors) and, to the microclimatic affects of physiography.

Floristic types. As Steyermark (1940) has pointed out, the floristic types of Missouri are closely related to physiography and the parent rock materials from which the soil is formed. The flora is rich and diversified, reflecting climatic changes and the subsequent invasion of species whose centers of origin were to the north, south, east and west. Many of these remain as part of the present flora or as isolated relict communities. In addition, the Ozark region, itself, is a center of origin for numerous endemic species (Steyermark 1963).

The floristic types of Missouri have been classified in various ways as summarized in Table V.

Steyermark uses the three broad physiographic divisions of Missouri as the basis for further floristic division and refinement. He maintains that there is no single

TABLE V

FLORISTIC REGIONS OF MISSOURI

Kucera (1961):

Tall grass prairie
 Upland forest
 Pine woods
 White River cedar glades
 Flatwoods, swamp
 Floodplain forest
 Grama grass, soapweed
 American beech, holly

Shantz and Zon (1924):

Tall grass
 Oak-hickory
 Oak-chestnut
 Oak-pine
 Cypress-tupelo-red gum

Küchler (1964):

Oak-hickory
 Oak-hickory-bluestem prairie
 mosaic
 Oak-hickory-pine
 Southern floodplain forest
 (oak-sour gum-cypress)
 Cedar glades
 (juniper-oak-poverty grass)
 Cross timbers
 (Quercus-Andropogon)

Steyermark (1940, 1963):

Prairie region
 (1) Loess mounds
 (2) Unglaciated
 (3) Glaciated
 Southeastern lowlands
 (1) Cypress swamp
 (2) Maple-beech
 Ozark region
 (1) Oak-hickory assoc.
 (2) Oak-pine assoc.
 (3) Sugar maple-bitternut
 hickory
 (4) Sugar maple-white oak
 (5) Red maple-white oak

climax forest type for the Ozark region, and that only the polyclimax theory holds for Missouri. Steyermark observed that in Missouri different types of soils within a limited region appear to result in entirely different associations and climaxes. He quotes Tansley's explanation of the poly-climax theory: "...some rocks, owing to the simplicity of their composition, produce soils which can never form the normal climatic mature profile, and these may or may not bear the typical climatic climax vegetation."

Thus Steyermark recognized five climax associations in the forests of the Ozarks and refers to these as edaphic rather than climatic climaxes, because, he maintains, the climate has not differed, but the rock strata have differed in mineral composition. He points out that on acidic substrates, such as chert, sandstone or granite, associations culminate in oak, hickory, southern yellow pine, red maple, sour gum and dogwood. This is as characteristic a climax association as that of sugar maple, chestnut, oak (Quercus prinoides) and other species favored by limestone-derived soil.

Steyermark (1940) recognizes a "maple-beech forest formation" which is restricted to Crowleys Ridge and covers a small area in which more alkaline soils predominate. Kucera (1961) recognizes this same region as "American beech, holly." Numerous species characteristic of the

more eastern Appalachian flora are now isolated on Crowleys Ridge at the westernmost limits of their distribution.

Both Kucera (1957, 1961) and Steyermark (1963) recognize the White River glades of southwest Missouri, which contain flora normally more western and southern in distribution.

The dry loessial hills of northwest Missouri support grama grass, yucca and other species normally more characteristic of the Great Plains (Kucera 1961).

The flatwoods, swamp or Southeastern lowland region contains southern Coastal Plain species.

The grouping of floristic types used by various botanists (Table V) shows that they primarily differ in names but agree closely on the types and their respective floristic composition.

Faunistic factors. Classification of natural areas and habitat types according to the fauna has been rather superficially imposed upon extensive vegetation formations without working on refinement down to state or regional levels. Nothing like the refinement of soil and vegetation types exists for animal communities. Only a few pioneering attempts of this sort have been made by Shelford, Kendeigh and others. However, we know that many invertebrate species are very narrow in their ranges of tolerance (Daubenmire 1959:30-35), resulting in such a limited

distribution that they would be reliable indicator species.

It is often assumed that the distribution of the fauna will coincide with that of the vegetation (its life form or physiognomic structure). This usually obtains but is not altogether correct. The barriers that affect the distribution of animals are often different from those affecting the dominant plant species.

Physical factors are usually not considered as carefully by zoologists as they are by botanists. Exceptions to this are found in limnological studies, although few of these studies in Missouri have been based on natural communities. The lack of study of natural aquatic communities, coupled with their vulnerability to pollution, creation of reservoirs, release of non-native fish species, and a multitude of other disturbances, promotes the danger that some of these species may become extinct before they are known or studied.

Natural habitat preservation is vital to many species. Figure 3 indicates some species that appear to be restricted to or favored by particular habitats in Missouri (Elder, unpubl.).

Types of Natural Areas Occurring in Missouri

The following listing was designed as a general, but

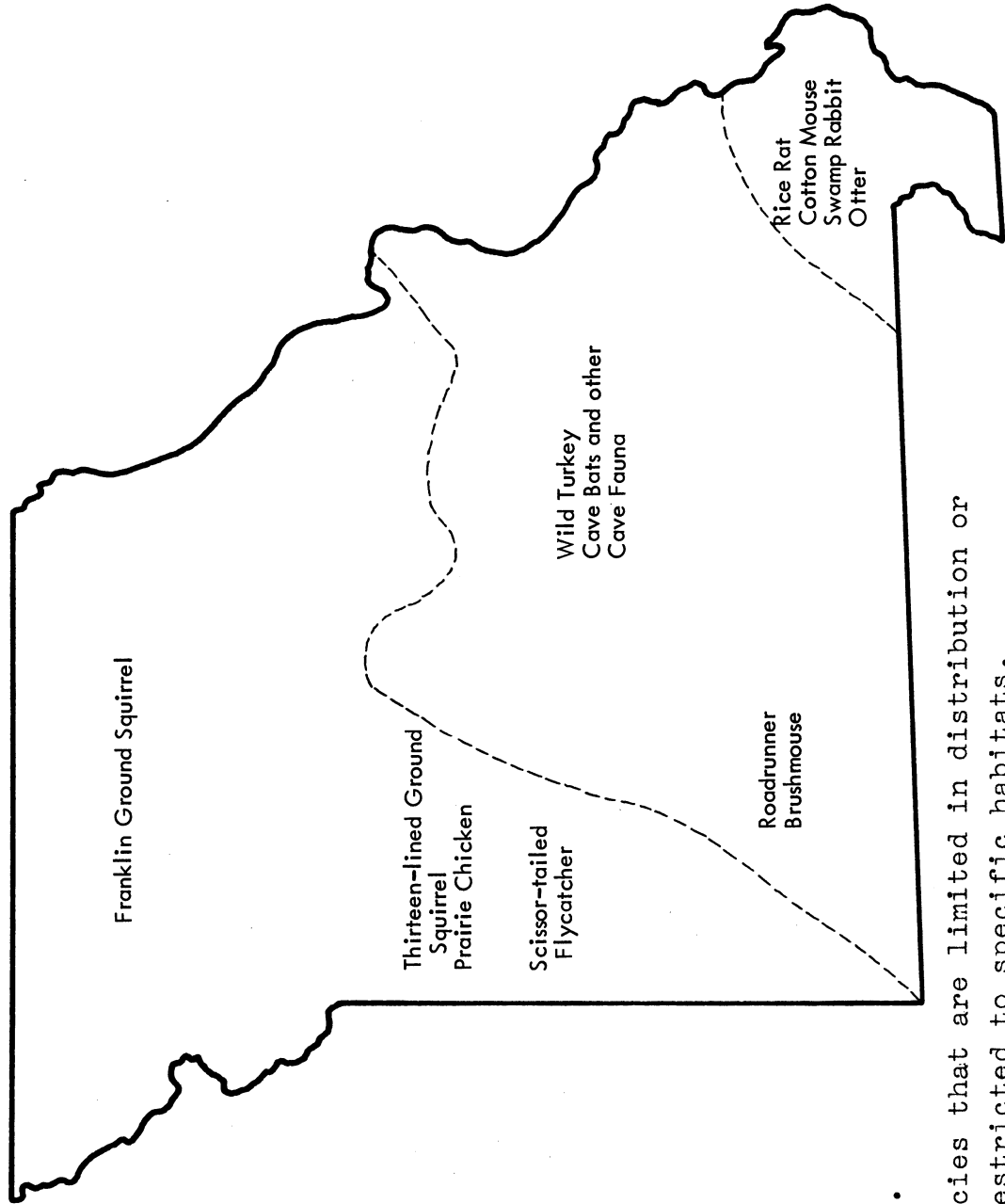


Figure 3.
Some species that are limited in distribution or restricted to specific habitats.

inclusive reference system for classifying the great variety of natural area types of the United States (based on a list compiled by Dowling, Fosberg and Sherman unpubl., and on the Society of American Foresters (1954) list of forest types). The numbers assigned provide a system of designating areas that allow for additions, expansion or further refinement. It also provides a means for tabulation on key-sort or I.B.M. cards.

The classification of vegetation (forest, shrubland, grassland and desert) is based on climax types. Under the broader definition which does not restrict natural area to those currently in climax, various successional stages could also be included. However successional stages are not commonly thought of as natural areas. (As pointed out by Roberts (1965), some of these subclimax areas are certainly worth preserving and it is true that as time progresses we are becoming less and less able to find unaltered environments.) Successional stages are omitted here however, for the sake of simplicity. One exception may be the inclusion of type 201, riparian thickets. Thickets of button bush, willow, cottonwood, birch, or with hazel are generally thought of as successional stages, but it is possible that thickets may be a climax type or at least an arrested stage of seral development in southeastern Missouri lowlands. Here snow-bell (Styrax americana), pumpkin ash (Fraxinus tomentosa) and button bush (Cephalanthus occidentalis) are

TABLE VI

DISTINCTIVE TYPES OF NATURAL AREAS
IN MISSOURI AND THE UNITED STATES

* Those found in Missouri
** Those found in the central Missouri study area

<u>FOREST TYPES</u>	
Western	
001. Douglas-fir	210. Misc. shrub types (e.g. Coastal sage)
002. Hemlock-Sitka spruce	211. Coastal live-oak yaupon scrub
003. Redwood	212. Purple sage (<u>Salvia carnos</u>)
004. Ponderosa pine	213. Creosote bush
005. Western white pine	214. Greasewood (<u>Sarcobatus</u>)
006. Lodgepole pine	215. Blackbrush (<u>Coleogyne</u>)
007. Larch	216. Bitterbrush (<u>Purshia tridentata</u>)
008. Fir-spruce	217. Alkaline Scrub (<u>Allenrolfea comm.</u>)
009. Pinyon pine-juniper	218. Screw-bean groves
010. Hardwoods	219. Shadscale (<u>Atriplex</u>) scrub
Eastern	
011. White-red-jack pine	
012. Spruce-fir	
013. Longleaf-slash pine	
014. Lobl.-shortleaf pine	
*015. Oak-pine	<u>GRASSLANDS</u>
**016. Oak-hickory	301. Tundra, alpine grasslands
*017. Oak-gum-cypress	302. Short grass
**018. Elm-ash-cottonwood	**303. Tall grass prairie
019. Maple-beech-birch	304. Mixed grass
020. Aspen-birch	305. Palouse (bunchgrass prairie)
021. Tropical forest	306. Coastal grassland (saw grass)
022. Miscellaneous forest	307. Dune grass
<u>SHRUBLANDS</u>	
*201. Riparian thickets	**308. Riparian grassland, wet meadow
202. Dwarf for. (mixed, e.g. dune for.)	**309. Glade
203. Dwarf for. (conif.)	
204. Dwarf for. (hardwood)	<u>DESERTS</u>
205. Ericaceous shrubs (evergreen shrub)	401. Cacti, succulent community
206. Savanna	402. Desert pavement
207. N. desert shrub (sage)	403. Alkali, other mineral salt flats
208. S. desert shrub (mesquite)	404. Sand dune
209. Chaparral	405. Low desert
	406. High desert (steppe)

TABLE VI (Continued)

<u>RELICT AREAS, TYPE LOCALITIES</u>	<u>COASTAL WETLANDS</u>
**501. Paleontological sites	701. Tidal flats
**502. Archeological sites	702. Salt marsh
**503. Relict plant assoc.	703. Intermittent overflow lands
**504. Type localities	704. Mangrove
**505. Threatened plant communities or species	705. Brackish waters, shores
**506. Threatened animal communities or species	706. Underwater habitats
**507. Breeding ground sites of animal species	707. Inlets, tidal streams
**508. Geological type localities	708. Uplands, isolated by coastal wetlands
	709. Misc. coastal wetlands
<u>FRESHWATER WETLANDS</u>	<u>WATERWAYS & SHORELINES</u>
**601. Springs	**801. Islands
**601a. Salt or mineral springs	802. Coral assoc.
**602. Eutrophic lakes	**803. Beach (e.g. spits)
**602a. Oxbow lakes	**804. Stream features
**602b. Sink lakes	**805. Rocky shorelines
603. Oligotrophic lakes	**806. Other shorelines
604. Acid water (dystrophic) bogs	807. Bays, estuaries
605. Alkali, other mineral lakes	808. Marine communities
**606. Marsh	809. Arctic features
**607. Temporary water areas	810. Misc. waterways, shorelines
608. Large lakes	
**609. Underwater communities	<u>LAND FORMS</u>
**610. Succession stages misc. fresh water wetlands	901. Volcanic features
	**902. Erosion features
	**903. Karst
	**904. Caves
	**905. Rock outcrops or formations
	**906. Peaks, hilly terrain
	**907. Glacial features
	**908. Alluvial deposits
	**909. Unusual edaphic or substratum features
	910. Misc. land forms

common, stable, shrub associates.

According to the list shown, 38 distinct types of natural areas occur in Missouri. All but two major divisions, deserts and coastal wetlands are represented. The 38 types found in Missouri represent 35%, or more than one-third of the total 106 types for the entire United States. This is a much greater number and variety of area types than have been found in most states, especially those of the midwestern and western region.

Within the more intensively surveyed area of central Missouri 35 of the 38 types were found; the only ones missing were 015 oak-pine, 017 oak-gum-cypress, and 201 riparian thickets. Many of these 35 types are represented only by greatly disturbed examples.

Statewide, preservation has so far hardly begun to represent this great ecological spectrum. Of the 38 types of area that occur in Missouri, only 4 (examples of oak-hickory forest, one prairie area, one sink lake and two relict plant areas) are assured any perpetuity.

CHAPTER V

RATES AND CAUSES OF DECLINE IN AREAS

Rates of Decline of Missouri Areas

Areas were evaluated according to amount of disturbance using three class divisions: (I) relatively undisturbed, (II) moderate to heavily disturbed, (III) destroyed. Those of value as a natural area were in the categories I or II. In the 19 counties surveyed, there was no apparent concentration of damaged or undamaged areas in any one county or locale. But certain counties showed more widespread damage to natural landscape due to poor conservation practices or due to intensive land use (as in some of the prairie areas of Saline and Dallas counties).

No prospective natural area sites were known or found in four of the counties: Carroll, Chariton, Pettis and Osage. The first three are in prairie regions and rival the southeastern lowlands and northwestern loessial soil region as leading crop producing counties. Although Osage County does not rank especially high in crop production, it is a high livestock producing area. All four of these counties have more than 90% of their total area in farm land as compared with other counties in the study area that range from 50-90% farm land (Univ. of Mo. 1955). Osage County does contain some steep Ozark terrain and borders the Gasconade River. It may yet contain a few worthwhile

Seventeen of the 46 central Missouri areas included in this survey had been located and described by Steyermark between 1940 and 1955. At the time of his observations the areas were all undisturbed. Current field observations in this study showed that many of these areas have since been damaged by disturbances. In Table VII these 17 areas are grouped according to ecological types to permit comparisons with the amount of disturbance.

Table VII

DEGREE OF DISTURBANCE, AS RELATED TO
ECOLOGICAL TYPES BASED ON A 17
AREA SAMPLE

Degree of Disturbance	Type of Area and Number of Examples					Total areas
	Ravine	Cave &/or Spring	Sink Pond	Bluff Prairie	Limestone barren	
I	3	1				4
II	3	1	1	1	1	7
III	1	1	1	1	1	6

Certain types are subject to greater disturbance than others. Ravines are usually subject only to light or moderate disturbance (class I or II). Areas containing a source of water, regardless of whether it is a stream, lake or spring, are usually subject to severe disturbance (class II or III). Sink ponds, bluff areas and a spring, reflected heavy damage. Prairie, glades, and floodplain forest also are among the types that are severely disturbed.

The extent of deterioration of the central Missouri natural areas is graphically shown in Figures 4 and 5 using data obtained in current field observations. Figure

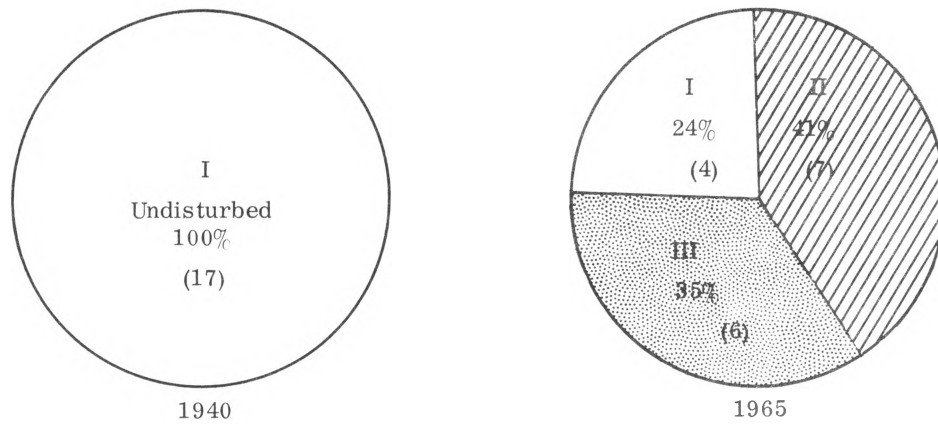


Figure 4. Extent of deterioration of 17 areas within 25 years. (First Surveyed by Steyermark 1940-1955).

The amount of disturbance is designated as follows:

- I Undisturbed natural areas
- II Damaged seriously but still of natural area value
- III Destroyed areas, no longer of value as natural areas.

Number of areas in each category is shown in parentheses

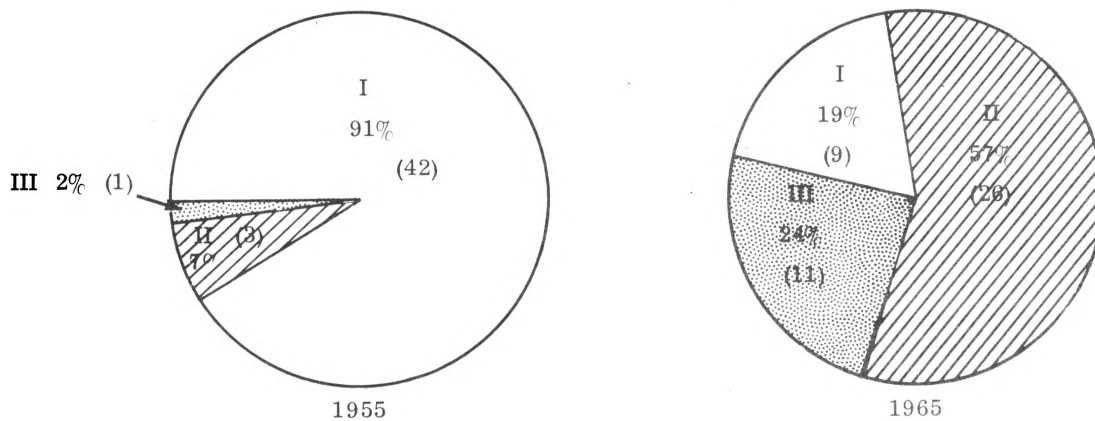


Figure 5. Extent of deterioration of 46 areas within the last 10 years (1955-1965). Estimate of the time at which damage had occurred was made on each area during the field survey. (The 17 areas shown in Figure 4 are included.)

4 shows the extent of change during a 25 year period to the 17 areas, observed as undisturbed by Steyermark in 1940 or later, as compared with present conditions on the same areas. Figure 5 shows the extent of degradation within the last 10 years as based on 46 central Missouri areas (including the 17 areas shown in Figure 4). Four of the 46 areas (9%) were damaged prior to 1955. (These were two salt spring areas, once subject to commercial development and more recently to damage from livestock, plus two marsh areas.) Causes of damage or destruction to these 46 areas are indicated in Table VIII. Woods, where light logging occurred more than 20 years ago, and caves, once mined for saltpeter, were still considered eligible for class I rating if they did not show other degrading effects.

According to Figure 4, there has been a 76% loss of undisturbed, class I areas within the last 25 years. Figure 5 indicates that a 72% loss of class I areas has occurred within the last 10 years. The rate of loss has obviously accelerated in recent years. Consequently, the same 10 year period (1955-1965) shows almost a nine-fold increase in class II areas, and an eleven-fold increase in class III areas. If areas continue to disappear at the same rate (instead of faster, as we would expect), class I natural area sites will suffer another 72% reduction in the next 10 years, with only 5% remaining in an undisturbed condition. That is, only 2 of these class I areas might remain for future study or preservation.

Causes of Damage or Destruction

The major causes of damage or destruction to natural areas in central Missouri are shown in Table VIII. Each type of natural area is vulnerable to particular types of disturbance. Even though the sample size is not adequate to draw firm conclusions, the causes for damage and destruction of various area types confirms my observations of disturbance factors throughout the state.

Most of nine forest areas observed were chosen by Steyermark because of their rich flora. They are mesic sites, such as ravines and north-facing slopes, and subject to few disturbances other than logging. The dry upland oak-hickory forest type that characterized much of the Ozark area is not represented in Table VIII except by glades. Major disturbances in the upland oak-hickory and glades are: (1) fire (2) logging, and (3) grazing. These three disturbances repeatedly occurred together and were of about equal severity.

Since early settlement, prairie areas have provided ideal ready-cleared and fertile farmland for livestock and crop production (Albrecht 1957). Not a single good example (other than Tucker Prairie) was found in central Missouri. There is one moderately grazed prairie or prairie-glade site near Columbia with a number of worthwhile natural features (Boone County, Lewis and Clark Cave).

In spite of the abundance of springs in Missouri, it

TABLE VIII

CAUSES OF DAMAGE OR DESTRUCTION TO ECOLOGICAL TYPES

Parentheses are used to designate the number of observations of an area type and/or causes for damage.

<u>Type of Area</u>	<u>Causes of Damage or Destruction</u>
OAK-HICKORY FOREST(9)	1. Logging (9) 2. Flood and flood debris (2)
ELM-ASH-COTTONWOOD (1)	1. Logging
PRAIRIE (2)	1. Grazing 2. Plowed for crop production
GLADES (6)	1. Fire (5) 2. Logging (5) 3. Grazing (5)
SALT SPRINGS (4)	1. Livestock 2. Commercialization
OXBOW LAKE (1)	1. Livestock and clearing land for crops
MARSH (3)	1. Livestock 2. Logging 3. Drainage for crop use
UPLAND POND(BUFFALO?)(1)	1. Livestock and dozing
SINK LAKES (3)	1. Livestock
FRESH*WATER SPRING(11)	1. Recreational 2. Livestock
CAVES (19)	1. Recreational (13) 2. Commercialization (2) 3. Mining (2)
CLIFF AND ROCK FORMATIONS (4)	1. Recreational use (4)
THREATENED PLANT SPE* CIES OR COMMUNITIES (12)	1. Recreational use 2. Roads, flood debris, livestock and crop use

THREATENED ANIMAL SPECIES OR COMMUNITIES (15)	1. Recreational use 2. Commercialization
ROOKERIES (2)	1. Clearing of timber
KARST (4)	
GEOLOGICAL LOCALITIES(1)	
ARCHAEOLOGICAL (6)	1. Recreational use and collecting
PALEONTOLOGICAL (2)	1. Recreational use and collecting
HISTORICAL (1)	

was unusual to find an undisturbed one. Both freshwater and salt-water springs were subject to much disturbance. Springs have provided choice sites for homesteading and their permanent water supply has been ideal for rearing livestock. This has led to serious pollution of unique spring communities and of entire underground water systems. Careless construction of roads has obliterated or changed the course of springs, including one picturesque and well-known spring along Clifty Creek in Maries County.

The only known example of an oxbow lake in central Missouri was destroyed by a recent landowner in an attempt to extend tillable land to the water's edge (Boone County, Brushwood Lake).

Once there were many marshes along the Missouri River. Two of these, in Cooper County, remained until recent years. One of these areas has been drained and cropped and no longer retains natural characteristics other than a good variety of birds. The second, a natural spring-fed marsh, combines the interesting features of both spring and marsh communities, but has been badly damaged by livestock (Cooper Co. Marsh #1 and #2).

Upland ponds (both sinks and those reported to have been buffalo wallows) have likewise been subject to heavy livestock use. One of these ponds was dozed deeper on at least two occasions for water retention. An aquatic, Elatine triandra, known from only two localities in the state, could

not be found at this site where it was once reported by Steyermark. Its disappearance could have been caused by livestock, repeated dozing and resulting changes of pond depth, or competition from invading aquatic plants.

Karst topography is of little economic value, but there have been many attempts to make the land pay taxes by using it for livestock, or cropping in the bottoms of some of the larger sinks. Some sinks are being used as city dumps even though it is unlawful because of the hazards of contaminating underground water supplies.

Caves are subject to a variety of disturbance factors of recent origin. A major factor is the increased recreational use leading to trampling, collecting and disturbance of cave fauna (Myers 1964), geological specimens and paleontological and archaeological remains. The creation of reservoirs has led to flooding of many cave habitats and thus destruction of geological formations and biota. With reservoirs being planned for every stream system in Missouri, this constitutes a most serious threat in the near future. Commercialization has also destroyed original natural features and the biota in some of the most outstanding caves.

Cliff and rock formations are also subject to many kinds of damaging uses: recreational use, resulting in trampling and collecting; road construction (scenic river routes are a threat to many of these areas); grazing; and use as city dumps due to the great capacity and convenience in just dumping "over the bluff."

Recreational use is already widespread and causing damage to many types. Those possessing water or other unique features tend to attract people who, by their number or activities, can cause damage to landscape and biota that is severe and often irreversible.

Kuchler (1964) asserts that in the United States "...man's influences during the past centuries may have had a lasting effect on the potential vegetation of today." This concept of irreversible change blasts the previously clung-to security of taking for granted all that is deemed a "renewable resource." These irreversible changes are attributed to several factors: (1) the introduction and subsequent invasion of exotic plants and animals (2) severe and prolonged overgrazing, (3) the acceleration of soil erosion due to sub-marginal and unwise farming attempts (illustrated too well by the dust bowl area). Shantz and Zon (1924), Shelford (1926, 1963), Kendeigh (1961), and Kuchler (1964) all document irreversible types of damage to natural communities.

Types of Areas That are Fragile

Elton(1958) founded the principle "...that the balance of relatively simple communities of plants and animals is more easily upset than that of richer ones; that it is more subject to destructive oscillations in populations, especially the animals, and more vulnerable to invasions." Even simple

of the southwestern United States do not appear exempt from this fragile nature. Recent research has shown the extent to which desert vegetation has been altered by overgrazing and other disturbances (Niering, Whittaker & Lowe 1963).

In Missouri these simple and presumably fragile communities include prairie, caves, salt and other mineral springs, and freshwater springs. These often tend to be oligotrophic communities, i.e., low in production of biomass as well as low in total number of species. Although, prairie and spring communities are poor in species they show high productivity rates.

Fragile communities include: relict areas for plant and animal species, areas for species of very limited distribution, and areas for endemic species.

Caves may be particularly fragile ecosystems because they are predominantly heterotrophic. (Moore and Nicholas 1964 cite the supplementation of autotrophic bacteria.) Bats move outside of caves to secure an insectivorous diet high in protein, and through their fertile guano are able to support the entire ecosystem of "obligative cavernicoles" in the perpetual darkness. A major concern for cave communities is based on the extent to which bats form an essential link to the entire cave ecosystem. Either disturbance of bats by spelunking or the accumulation of lethal amounts of pesticides from their insectivorous diet, with

subsequent concentration of these chemicals in the fat stored for hibernation, could cause the extermination of a bat population. This would ultimately lead to the loss of the entire cave fauna - isopods, amphipods, cave beetles, diptera, spiders, blind cave salamanders, blind fish and others.

Types of Areas Most Frequently Damaged

It is not practical to attempt to measure accurately the frequency of damage to particular types of areas. Such measures would need to be plotted on a time-area curve and knowledge is too scant on the original distribution of particular area types as well as on the historic time sequence of human disturbance factors. There is some indication (including early historical accounts) that, prior to white man's settlement, prairie disclimax was maintained throughout much of Missouri by frequent fires believed to have been started by the Indians. But other than this, we may assume that the native Indian population caused little or no change in the natural landscape; their population density was low (less than .6 person per mile² as compared with Missouri's present population density of 63 people per mile²). Destruction of natural landscape has occurred at such a rapid rate during the years of white man's settlement in Missouri that it is difficult today to find any undisturbed areas.

Damage to natural communities has been most frequent

in aquatic sites - springs, lakes and streams all show disturbance by homesteading, domestic livestock, mill sites and other developments. Pollution of natural waters is almost universal. Introduced aquatic plants and animals have greatly altered the original composition of most communities. Reservoir construction causes widespread change in an entire stream system, and often eliminates native fish and other species by severely altering the habitat - water depth, temperature, siltation, speed of current and many intra- and inter-specific factors. The Niangua darter (Etheostoma nianguae) is an endangered species as a result of damming of the Niangua River.

Recreational demands on water areas are great, and the continual agitation of water by motorboats and water skiers, affects the biotic community. Aquatic habitats are among the most vulnerable, due to their susceptibility to pollution and the multitude of use-demands placed on them.

As pointed out previously, prairie and glades are exceptionally vulnerable due to the ease of clearing these areas for livestock and crop production. Dallas, LaCede, Morgan and Cole County glades were all subject to farming disturbances (even marginal cultivation attempts).

The dry upland forest of the Ozarks is vulnerable to fire, and burning is a widespread tradition in this region. Basic education has not yet met the challenge of helping these people to learn better conservation practices and to establish traditions against incendiary burning.

Floodplain forest and the cypress-tupelo-sweet gum swamps of southeastern Missouri have been largely drained and placed in crop production. Not a single remnant of the original floodplain forest type is left in Missouri. Construction of reservoirs is a threat to some of the better subclimax floodplain forests.

Caves, besides their fragile nature, due to the precariousness of the trophic level structure, are vulnerable to numerous and widespread disturbances, such as commercial and recreational use, collecting, and flooding following reservoir construction. The fauna is of a more fragile and vulnerable nature than flora according to Elton (1958).

What Constitutes Adequate Preservation?

Adequate preservation is taken to mean the status or act by which an area, through legal procedures, formal dedication, or other means, is provided assurance of perpetuity in the natural state. It is essential to provide the best known legal safeguards to assure perpetuity as a natural area. These may include: (1) the use of restrictive clauses within the deed of property, (2) the use of reverter clauses to a second and similar "watch dog" agency in event that the agency responsible for preservation fails to fulfill its obligation, (3) covenants and trusts, (4) easements. A number of areas with great research potential that were thought to be well preserved in private or state ownership have been lost due to lack

of foresight in providing a continuing policy assuring preservation.

Formal dedication, well-established research, and community programs of an interpretative or educational nature are supplementary means of helping to assure preservation. The establishment of a continuing policy for preservation, and those specific types of use and management necessary and compatible with preservation are important concerns. Such areas should be protected from research and other factors that would damage the original biotic community (e.g. collecting, compaction of soils from investigation activities, introduction of new species, extensive use of herbicides, pesticides, fertilizer or other soil treatments). On some of the established areas a research committee has the responsibility of limiting and deciding on suitable research proposals in order to protect against or minimize damage to the natural community (Dowling & Ross 1963).

Maintenance of natural conditions often requires management. An example of this is Tucker Prairie, which, being located in the forest-prairie ecotone, requires the use of fire to control the invasion of woody plants and to perpetuate prairie species.

National parks and monuments are established for the primary purpose of preservation and they are generally well protected from all disturbances except heavy use by tourists.

The main objective of the Missouri State Park system is to provide recreation (Missouri, State Manual 1963-1964). Preservation receives little or no consideration under the present state system and there is a trend toward landscaping and providing recreational facilities at the expense of natural features. Therefore it can only be concluded that state parks in Missouri do not guarantee permanent preservation of natural features.

Wildlife refuges are established primarily for game management and therefore do not offer any assurance of preservation. Provisions have been made however, for the establishment of preserved natural sites within National Wildlife Refuges. Two natural areas are reportedly set aside in Missouri, at Mingo and Squaw Creek National Wildlife Refuges.

With some species, such as the prairie chicken, the best management practice is the preservation of natural habitat. Thus wildlife management and preservation are often the same.

Even the best safeguards known may not always assure preservation of an area. Thus a portion of Tucker Prairie was lost as road right-of-way shortly after its dedication. But it is essential to provide the best known legal safeguards and a sound, continuing policy to assure perpetuity in a natural state.

CHAPTER VI

SUMMARY

A survey of prospective natural area sites was conducted in Missouri with intensive field work in 19 counties of the central portion of the state. The purpose of the study was to inventory, analyse and evaluate the remaining natural areas and to determine the rates and causes for the destruction of each type of area.

This study involved: (1) compiling a current list of prospective natural area sites, (2) visiting and evaluating each in terms of the amount of disturbance it has undergone, (3) evaluating each in terms of its uniqueness or representativeness as a natural community, (4) consideration of the abundance and distribution of similar areas, and (5) consideration of the main causes for past destruction and apparent future threats. The field work was undertaken during a 13 month period from May, 1964, to June, 1965, with approximately 10,000 miles traveled in surveying areas within the 19 counties. A total of 46 areas, many of which had multiple natural area features, were surveyed. The natural area sites surveyed in central Missouri are listed and described in a list filed separately with the Cooperative Wildlife Research Unit of the University of Missouri.

Areas were evaluated according to amount of disturbance, using three categories: (I) undisturbed, (II)

moderate to heavily disturbed, (III) destroyed. The degree of disturbance paralleled the quality of the area in its ability to serve as a unique or representative sample of a natural community. There were a few exceptions to this where an area was unique enough due to geological features to be considered of value despite destruction of the original communities.

Geological, floristic and faunistic factors were considered in the classification into useable groupings of natural area types. Fauna has not been as well studied and categorized according to type or distribution on a local level; the flora and geologic factors are much better known.

A list designed as a general, but inclusive, reference system for classifying the diverse natural areas of the United States was devised. In this 106 types were recognized and 38 of these were found in Missouri. This is more than one-third of the types found in the entire United States, and is a much greater variety than has been found in most states, especially those of the midwestern and western region.

Of the 38 types occurring in Missouri, only 4 are assured preservation.

Rates of damage and destruction of natural areas and their causative factors were assessed during field work. A 72% decline in undisturbed (class I) areas within the last 10 years was found in the 19 county central Missouri

region. A majority of the disturbance factors appeared recent or had only recently reached disastrous proportions. The data indicates an accelerated rate of loss in undisturbed areas within the last decade, 1955-1965. Even if the rate of loss held constant for the next ten years, we could expect only about 2 class I areas to remain by 1975.

The extent and likelihood of disturbance varies according to the type, each being threatened by a particular kind of disturbance.

Some area types, especially simple communities, are fragile, i.e. they are delicately balanced because they are composed of but a few species in a very specific niche. Their very simplicity robs them of the plasticity and flexibility characteristic of more complex and competitive communities. As Elton has said, they are more vulnerable to invasions and to destructive population oscillations. In some instances the loss of one species would lead to destruction of the community (e.g. bats in a cave ecosystem). In Missouri, these simple and fragile communities include prairie, caves, springs--fresh-water, saline and mineral.

The frequency of damage observed in each type of area was determined by its community fragility and the frequency, extent, and number of damaging factors. Types of areas most frequently damaged are: aquatic sites (springs, lakes, streams), prairies, glades, floodplain forest.

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presented by Mary Alice Sherman

a candidate for the degree of Master of Arts

and hereby certify that in their opinion it is worthy of acceptance.

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