XERARCH SUCCESSION ON ROCK

A dissertation submitted to the Faculty of the College Department of St. Meinrad Seminary in partial fulfillment of the requirements for a Bachelor of Science Degree.

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May, 1963

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INTRODUCTION

The science of the interrelation between living organisms, and between their environment and themselves, is termed ecology. One subdivision, along taxonomic lines, is plant ecology, as studied in this paper.

Typically, in an ecosystem, community development begins with pioneer stages which are replaced by a series of more mature communities until a relatively stable community is evolved which is in equilibrium with the local conditions. The whole series of communities which develop in a given situation is called the sere; the relatively transitory communities are called seral stages, and the final or mature community is called the climax.

Succession initiated on bare rock, rocky slopes, wind-blown sand, and other situations where there is an extreme deficiency of water is termed xerarch, and the different stages of development constitute a xerosere. Similarly, succession which begins in lakes, marshes or elsewhere in water is termed hydrarch, and the different stages of the series or sere constitute a hydrosere.

If succession begins on an area which has not been previously occupied by a community, such as newly exposed rock, the process is known as primary succession. If community develop-

ment is proceeding in an area from which a community was removed, such as a plowed field, the process is called secondary succession.

The remarkable thing about ecological succession is that it is directional. In situations where the process is well known, the seral stage present at any given time may be recognized and future changes predicted. Pioneer stages may be slow to become established, then successive communities may replace each other rapidly, each year sometimes bringing almost an entirely new set of organisms, then the process slows down with the climax being reached very gradually.

If succession is to be recognized as universal and occurring in all habitats, it becomes necessary to ignore time to some extent. A mesic habitat in a given climate will obviously produce a forest much more quickly than a xeric one, especially if the initial habitat is bare rock. All successions in a climatic area progress toward the same climax community. Progress of the succession among habitats of apparently similar characteristics might be at different rates because of the type of soil and the difference in its response to reaction.

The purpose of this study is to determine the present successional stage on three large rocks, from specimens collected and identified, to interpret the environmental influences upon them, and to predict future successional stages.

MATERIALS AND METHODS

The area of this study is located in Section 26, Harrison Township, Spencer County, Indiana, approximately one mile south of St. Meinrad Archabbey, one-fourth mile off Indiana highway 545. The area is bounded on the east by a gravelled county road, on the west by a plateau consisting of a Juglandaceae-Fagaceae-Aceraceae climax forest, on the south by a large hill from which the three rocks being studied are sandstone fragments, and on the north by Swinging Creek in which part of rock number 1 is submerged. The area is rather moist mainly because of the trees located to the west and the creek which runs along the north side of the area.

The rocks were measured with a 50 foot measuring tape, the area was mapped, directions being obtained by a compass, and a model of the area was built according to scale. The general area on the model was represented by artificial grass, and the rocks were made from plaster of paris. The mosses, small plants and shrubs were represented on the rocks by Reindeer moss. The grass and sedge family were indicated by a green plastic material, and the lichens were represented by a water color. The trees were indicated by twigs and Reindeer moss. These were placed exactly on the model where the specimens were found in the process of the survey. The families of these spe-

cimens were represented by spraying the model specimens with a different colored enamel paint. A key was drawn up and placed on the model representing these different families and will be seen in the pictures which appear in the appendix.

Several sources were used for identifying the specimens. The source used for keying these plants was that of Lyman Benson, entitled Plant Classification. Identification was made through several good sources: The New Britton and Brown, Illustrated Flora of the Northeastern United States and Adjacent Canada, by Henry A. Gleason, in 3 volumes; Wild Flowers by Homer D. House; Fruit Key and Twig Key to Trees and Shrubs by William M. Harlow; Fifty Trees of Indiana by T.E. Shaw and J. L. VanCamp.

RESULTS AND OBSERVATIONS

The results will be listed according to the rock from which the specimen was collected, the kinds of herbs and whether it was a spring or fall herb or woody specimen, and then the specimens not found on the rock, but collected in the area. These specimens are tentatively indentified and have been marked and placed in the Henrietta Herbarium for study at a later time.

	SPECIMEN	STEM	SEASON	KIND OF HERBS
Rock #1				
A* Family: Name:	Parmeliaceae-foliose Parmelia/growth form 3 crustose growth forms (Unidentified)	Lichen	Fall	Annual
A Family: Name:	Bryophyta Hypnaceae Hygrohypnum	Moss	Fall	
B Family: Name:	Cruciferae Brassica Campestris L. Field Mustard	Herb	Spring	Annual
C Family: Name:	Compositae Lactuca biennis(Moench) Lettuce Family	Herb	Fall	Biennial
D Family: Name:	Cyperaceae Carex Sedge Family	Sedge	Spring	
E Family: Name:	Phytolaccaceae Phytolacca Americana L. Pokeweed Family	Herb	Spring	Annual
F Family: Name:	Aceraceae Acer Saccharum Marsh Sugar Maple	Woody	Fall	

G	Family: Aceraceae Name: Acer Saccharum Marsh Sugar Maple		Woody	Spring	
H	Family: Sacrophulariaceae Name: Verbascum Thapsus		Herb	Fall	Perennial
Rock #2					
A*	Family: Parmeliaceae Name: Parmelia		Lichen	Fall	
I	Family: Gramineae Name: Anastrophus furcatus (Flat Crab-grass)		Grass	Fall	
J	Family: Compositae Name: Taraxacum officinale (Dandelion)		Herb	Fall	Perennial
K	Family: Phytolaccaceae Name: Phytolacca americana L. (Pokeweed)		Herb	Fall	Annual
L	Family: Balsaminaceae Name: Impatiens biflora Willd. (Touch-me-not)		Herb	Fall	Annual
M	Family: Violaceae Name: Viola Papilionacea Pursh. (Violet)		Herb	Spring	Annual
N	Family: Fumariaceae Name: Dicentra Cucullaria Bernh. (Dutchman's Breeches)		Herb	Spring	Biennial
O	Family: Anacardiaceae Name: Rhus radicans L.		Woody	Fall	
P	Family: Anacardiaceae Name: Rhus radicans L.		Woody	Spring	
Q	Family: Betulaceae Name: Betula nigra (River Birch or Red Birch)		Woody	Spring	

R	Family: Juglandaceae Name: Carya ovata (Shagbark Hickory)	Woody	Spring		
S	Family: Fagaceae Name: Quercus Velutina Lam. (Black Oak)	Woody	Spring		
T	Family: Aceraceae Name: Acer Negundo (Box Elder)	Woody	Spring		
Rock #3					
A*	Family: Parmeliaceae Name: Parmelia	Lichen	Fall		
U	Family: Cruciferae Name: Brasslia Campestris	Herb	Fall	Annual	
V	Family: Compositae Name: Eupatorium urticaefolium (Thistle Family)	Herb	Fall	Perennial	
W	Family: Aceraceae Name: Acer Saccharum Marsh (Sugar Maple)	Woody	Spring		
X	Family: Ulmaceae Name: Ulmus Americana (American, White or Water Elm)	Woody	Spring		
Y	Family: Cruciferae Name: Dentaria laciniata Muhl. (Cut Toothwart)	Herb	Spring	Perennial	

OTHER SPECIMENS

Located Near Rock #1					
Z	Family: Rosaceae Name: Rubus occidentalis	Woody	Fall		
a	Family: Aceraceae Name: Acer Negundo (Box Elder)	Woody	Spring		

Located Between Rocks #1 and #2					
b	Family: Compositae Name: Chrysopsis villosa (Aster)		Herb	Spring	Annual
c	Family: Phytolaccaceae Name: Phytolacca americana L. (Pokeweed)		Herb	Fall	Annual
Located Between Rocks #2 and #3					
d	Family: Rosaceae Name: Prunus serotina Ehch. (Wild Cherry)		Woody	Spring	
Located to the West of Rock #3					
e	Family: Juglandaceae Name: Carya Ovata (Shagbark Hickory)		Woody	Spring	

"Spring" and "Fall" indicates the time of the year that the specimen was collected. This is important in that this area has a long growing season, spring plants are early to rise and flower and the fall plants survive quite some time past the actual flowering season. This is due pershps to the position or environment of the area as a whole, protected by a large hill, shade and at the same time sunlight, plus the fact of the creek running alongside this area.

The trees have not migrated to the center positions of the rocks from the periphery, mainly because of little or no soil formation towards the center of the rocks. Several of the trees on the west end of rock number 2 have been cut off by the telephone company, which has a line directly above this rock.

On rock number 2 the plants were mostly confined to the

west end, mainly because of human factors which are continually disrupting the east end of this rock, such as the throwing of stones and glass bottles upon this end.

Much of the rock (1) was covered with moss (Bryophyta). Rocks 1 and 2 had a considerable amount of grass (Gramineae) on them. The plants on the rocks were not very large, although trees were average in height.

In the appendix are pictures of the rocks and of the model, maps of the area, and a diagram indicating the exact position of the plants on the rocks.

DISCUSSION

I

The first species to become established in an area such as the one studied are those whose seeds or spores are most easily carried by the wind and whose requirements for growth are least exacting. A census taken after a few years usually shows some of the common liverworts and mosses, a dominance of the smaller annual weeds, and probably a few perennials, including some of the trees which have winged fruits. In succeeding years, as the perennial weeds and grasses become established, many of the annuals are crowded out. If the conditions are suitable for the growth of trees, in due time they become large enough to shade the ground and make the habitat unsuitable for many of the smaller plants which arrived earlier. The place of the latter, may in time, be taken by the shade tolerant or spring flowering forest undergrowth.

Xerarch succession on rock follows a definite pattern whose progress is controlled by the rate at which soil forms and accumulates. As soon as rocks begin breaking down, there are numerous small plants which start to grow on the nutrients thus released. Among the first of these are the lichens. When they die and decay, they become a part of the soil.

Mosses and other plants gain a foothold among the crevices

and depressions of the rocks where the lichens have grown and died. They may have migrated long distances by wind-blown spores. Their rhizoids compete with those of the foliose lichens for water and nutrients, and the erect stems often exceed the latter in height. The power of withstanding desiccation is almost as marked among these pioneers as among the lichens. They and the more exacting foliose species of lichens may occur simultaneously, or, indeed, the mosses may sometimes precede foliose lichens, which is the case on these rocks.

Tufted or clumped mosses catch dust and mineral matter from wind and water. This material, combined with the remains of mosses, forms a gradually thickening mat with a periphery of young plants that spreads over bare rock and with a central area that may become thick enough to support larger mosses. Such bushy plants catch and hold still more mineral material. These in turn die, adding their bodies to the crumbled rock to make more soil. Year after year this process slowly develops a mass of soil which becomes increasingly richer and deeper.

When the soil on rocks has built up sufficiently to provide the necessary anchorage and water-retaining ability, seed plants appear on the clumps. A number of hardy, annual herbs, often weeds of field and garden, appear first and are followed by biennials and perennials, of which grasses are most abundant.

Later a shrub stage becomes dominant. By this time, the mats may be several inches thick, and then the trees make their appearance.

On the rocks there are three prominent stages of vegetation: (1) Lichen-moss stage on rocks number 1 and 2. (2) Herb stage which was most noticeable on rocks number 1 and 2. (3) Woody stage on rocks number 2 and 3. In the surrounding area there are two prominent stages of vegetation: (1) the eastern section of the area is mostly in the herbaceous stage. (2) the western section that of a woody stage, mostly Juglandaceae with the entrance of some Betulaceae and Ulmaceae.

The soil-forming and soil-holding reactions of the mosses on rocks number 1 and 2 are so pronounced that various xerophytic herbs, especially short-lived annuals, of which seven species were found, are growing although the drought and sterility of the soil allow only a stunted growth. Their roots are continuing the process of corroding the rock, each year their decaying remains enriching the soil. There were seven hardy annual herbs, two biennial herbs and four perennial herbs, one species of perennial grass, and fifteen woody perennials collected in this study. Thus, biennials and perennials are invading all three rocks. The woody species that are most numerous on the rocks belong to Aceraceae.

II

The obvious uniformity of vegetation in a climax region is the life form of the dominants, which is a product of climate. Thus, the major climax regions are easily recognized: grassland, desert and semi-desert with shrubs predominating, and forest climaxes that are coniferous if northern, deciduous if temperate or broadleaved evergreen if tropical. In addition to life form there is uniformity of genera among the dominants of a climax. Variations of the dominant species are a product of the environmental variations.

Since climax is determined by climate, the distribution and range of a particular climax should be an indication of a region in which climatic factors are equivalent. Climax is a product of all the interacting factors of climate and is, therefore, a better expression of the biological effectiveness of climate than can be obtained by physical measurements.

Plants are dependent on several factors of the climate, including soil, moisture, wind, light, temperature, and growing season, all interrelated. Wind and temperature control the amount of water evaporated from the soil and thus lost to plants. Areas of high rainfall and relatively low evaporation rates, such as certain tropical regions, have a different vegetation from that of areas of low rainfall and high evaporation

rates, such as deserts. The length of the frost-free part of the year is of importance in controlling the distribution of plants and hence community types, for some plants require a longer period for growth and reproduction than others. If the organisms of an area are destroyed, the rate at which they will grow back will be influenced by the amount of rain, light, wind, and other factors of the environment.

Soil humus helps to maintain the essential mineral needs of plants. In the autumn, the tree leaves fall, and many smaller plants die. The plant tissues decompose and the minerals become a part of the soil. This cycle of minerals to living plants and animals and back to soil again, goes on continuously. If plants grow undisturbed year after year, as in a native forest, the soil becomes richer and deeper. The accumulation of litter reduces runoff, moderates soil temperature, contributes humus, releases nutrients, and increases aeration. By these reactions, the habitat of the rocks is being changed, consequently becoming less favorable to the organisms responsible for the changes, at the same time becoming more favorable for species that could exist there previously only with difficulty. Under the changed conditions, new species are competing successfully with the established species and are replacing them.

The area is protected from wind on the south by a large

hill, but cross winds from the east to the west, moving down the valley have some effect on the plants and trees in this area. In general, wind-pollinated plants grow in the open or in exposed places. Even in a forest the trees of the upper strata are characteristically wind-pollinated. Dissemination by spores is characteristic of all plants except spermatophytes. Seeds, fruits, and fragments of plants are effective as disseminules in proportion to the devices that facilitate their transport. Seeds, because of their small size, are apt to be carried farther than fruits, but for all, the kind of adaptation is an important factor in transport. The perfection of the parachute-like papus is seen in the dandelion, (Taraxacum officinale), which was found in this area, and related composites of field and roadside. Many winged fruits do not travel far because of their size, but often the wings (elm, maple) are sufficient to assure transport beyond the shading and competitive effects of the parent tree, as could be the case in this area.

Whatever the initial condition of the habitat, reaction of vegetation tends to result in improved moisture conditions. Xeric habitats become more moist and hydric ones become drier as succession continues. Of the various materials the plant gets from its environment none is more important than water. The very composition of plants attests this, most herbaceous plants

being made up of 70 to 85 percent water and even woody parts of plants consisting of as much as 50 percent water. Plants growing in soil are constantly losing large quantities of water by transpiration. This water must be supplied through absorption by the roots if wilting of the plant is to be prevented. Water, being the most important solvent in nature, is the medium by which inorganic salts and food are transported from one part of the plant to another. Without a constant supply of water, a plant cannot carry on any of its physiological activities such as photosynthesis, respiration, and growth. In this area, the herbaceous plants on rocks number 2 and 3 are growing under conditions of favorable moisture and tend to have loose, succulent tissues with numerous air spaces. Since plants in shaded places are subjected both to lower light intensity and to higher humidity, it is not always possible to separate the effects of one from the other. The west end of the area is very moist because the woody or forest sub-climax stage provides shade to the plants. The hill on the south side provides the area with much moisture as runoff. The creek on the north helps considerably. The eastern section of this area is not as moist as the western. Plants growing under very dry situations tend to be small of stature and compact in form. The stems are short and stout and the leaves small and thick. Light

and dryness both contribute toward such formative effects on plants on rock number 1.

Plants need light to carry on photosynthesis. Trees growing alone in a field are likely to be wide-spreading, and the lowermost branches are alive, frequently close to the ground. Very different are those of the same kind growing close together in a dense forest; such crowded trees are likely to be tall, the branches short, and the lower branches frequently dead because not enough light reaches their leaves. Such is the case in this area, but more so in the area located behind rock number 3, and to the west end of this area where the forest is thick. It seems that the smaller plants, both on rocks 2 and 3 and in the whole area are suited to conduct photosynthesis in the shade of this forest. In the area of rock number 3 the dominant plants cutting off the light from others by more rapid growth over the ground or by growing taller and holding a canopy of leaves over the others are Juglandaceae and Aceraceae.

Man is one of the biotic factors influencing the rocks and the general area. There is a rubbish pile in the area, which, if continued, will fill the entire open area to the east end of the plot. Some of this rubbish, glass bottles, tin cans, etc., are being thrown upon rocks 1 and 2, killing some of the vegetation which is present. Persons have been climbing around on

these rocks, also destroying some specimens. Wild animals have not had much damaging effect on the plants in the area although groundhog holes were noticed under rocks 2 and 3.

The last point that was studied in this area was competition, which is the relationship that exists between individuals of the same or different species when the resources of the ecosystem in which they are living are insufficient to supply the needs of all. Because of the changes wrought by the old community, new species are able to compete with the old species for space. In the new environment, the new species are more successful than the ones whose places they have taken. Thus, on these rocks, the lichens have paved the way for the mosses, and the mosses will eventually eliminate the lichens. The mosses, further contributing their products to the environment, are improving it to the point that the herbs are successfully competing with them.

The results of competition in the general area of survey must be viewed according to a section to the east of rock number 2 and another section to the west of rock number 2. The area to the east of rock 2 resulted in a very aggressive herbaceous stage with the beginning of invasion by the grass stage, with one specimen of grass collected from rock number 2 (Anastrophus furcatus). The herbs, dominant at the present, will be

decreasing because the moisture of the soil is insufficient, and the grasses with deeper roots will invade the area and become dominant. The area west or rock 2 is a woody stage with the recession of herbaceous specimens, the competition for light in this case effecting these herbaceous plants extremely.

III

With the gradual build-up of soil on the rocks, the grasses, which have a more extensive root system than the weeds, are laying the foundation for the woody plants at the present making their appearance at a very fast pace. The present stage of succession on the rocks is that of the herbaceous stage, with the area moving toward a grass or woody stage, presently that of a sub-climax forest of species of Aceraceae. An assurance of a climax forest stage in the future is shown by the presence of 20 woody perennials which were collected in this study.

SUMMARY

Ecological succession is the orderly process of community change, with the sequence of communities which replace one another in a given area. Typically, in an ecosystem, community development begins with pioneer stages which are replaced by a series of more mature communities until a relatively stable community is evolved which is in equilibrium with the local conditions, this final or mature community being called the climax.

The remarkable thing about ecological succession is that it is directional. In situations where the process is well known, the seral stage present at any given time may be recognized and future changes predicted.

The purpose of this study was to survey the area, collecting and identifying the vegetation on the rocks and in the area, recognize the present seral stage, interpret environmental influences, and predict the stage of vegetation which will dominate the area in the future. Plant succession is a continuous process, and the stages overlap to a great extent. It is concluded from the study of this area that the dominance is shifting from the herb stage to the grass and woody stage.

There were four stages found in this area of survey, three of which were very prominent, namely: moss-lichen stage, herb stage, and woody stage. The moss-lichen stage was seen on

rocks number 1 and 2 and to some extent on rock 3. The grass stage was observed both in the surrounding area and on rocks 1 and 2, the only species being Anastrophus furcatus. The herb stage was represented by 13 specimens and the woody stage by 14 specimens. It was also noted that from the 13 specimens of herbs, 7 were annuals, 2 biennials, and 4 perennials. In the woody stage all 14 are perennials.

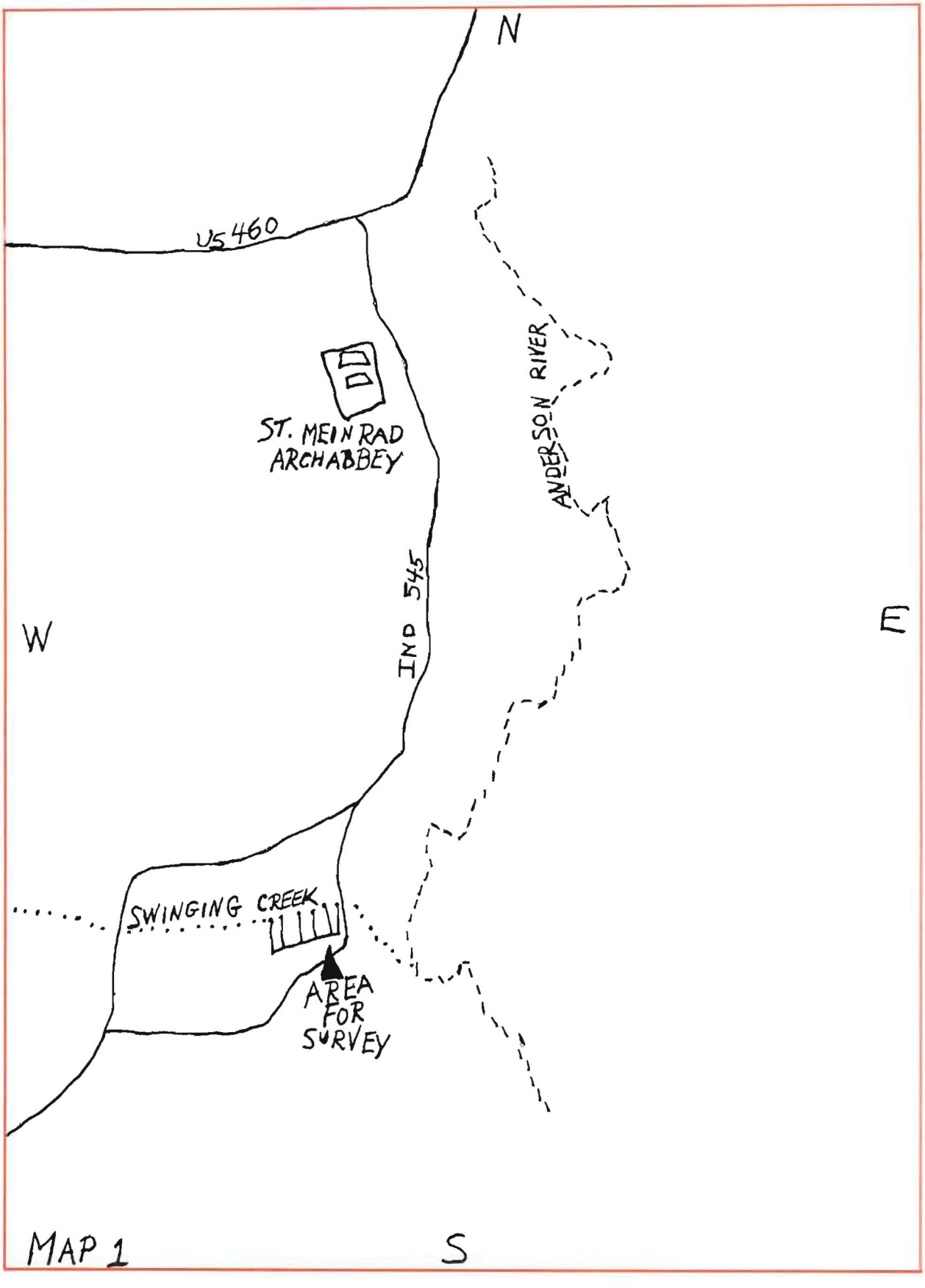
These statistics confirm that lichens and mosses made their appearance first on the rocks, followed by smaller annual herbs, and a few perennials, including some of the trees. In the succeeding years, as the perennial weeds, grasses and herbs have become established, many of the annuals are being crowded out. And as the conditions become more suitable for the growth of trees, in due time they will become large enough to shade the ground and make the habitat unsuitable for many of the smaller plants.

Several factors concerning plant succession on rock were considered in this study. Among the climatic factors discussed were moisture. The plants on rocks number 2 and 3 are growing under favorable conditions of moisture, but those plants on number 1 are confronted with a dry soil. Light is insufficient to the plants on rocks number 2 and 3 because of the thick forest in this area. A large hill on the south protects the area

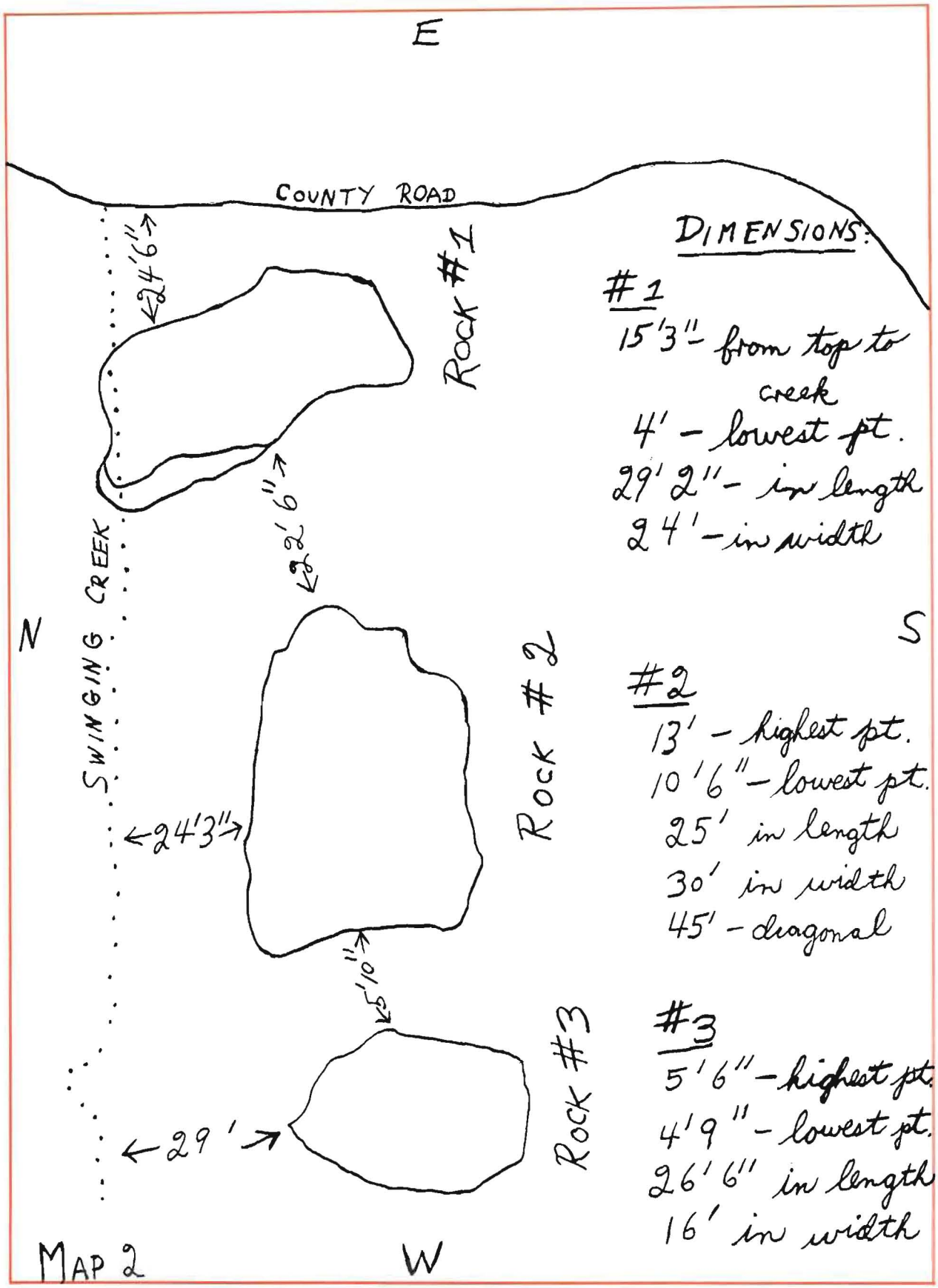
from wind, but the winds from east to west, down the valley, might have some bad effects on the vegetation. Soil is limited on the three rocks.

Among the biotic factors considered in this study were man and competition. Man is damaging the area by litter, some of which is being thrown upon the rocks and destroying the specimens upon them. Several trees have been cut down in the area and upon the rocks by the telephone company because of a line running directly above this area of survey. Competition in this survey was viewed in two sections: (1) east of rock number 2, where there is a very aggressive herbaceous stage, with the recession of the grass stage; (2) west of rock number 2, where there is a woody stage, with the recession of herbaceous specimens. With the appearance of trees in this area, the herbs will eventually wilt and die, mainly because of the competition for light.

To conclude, the vegetational stage in this area of survey, namely, in Section 26 of Harrison Township, Spencer County, Indiana, on three rocks and surrounding community, is presently dominated by the herbaceous and woody stages, rapidly reaching its forest sub-climax of Aceraceae.


N
US 460
ST. MEINRAD ARCHABBEY
ANDERSON RIVER
IND 545
W
E
SWINGING CREEK
AREA FOR SURVEY
S

MAP 1

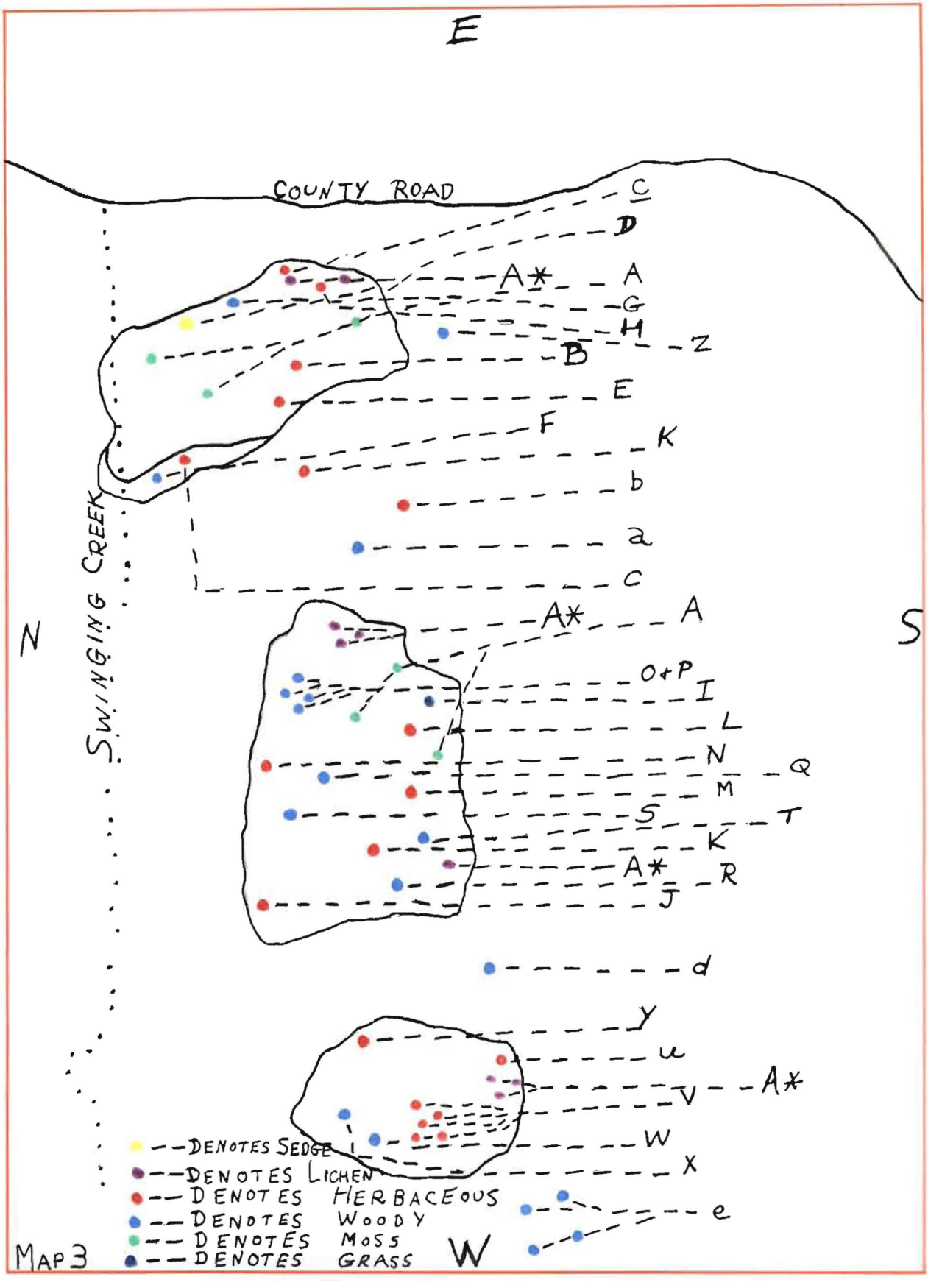


DIMENSIONS:

#1
15'3" - from top to creek
4' - lowest pt.
29'2" - in length
24' - in width

#2
13' - highest pt.
10'6" - lowest pt.
25' in length
30' in width
45' - diagonal

#3
5'6" - highest pt.
4'9" - lowest pt.
26'6" in length
16' in width


E
COUNTY ROAD
C
D
A*
A
G
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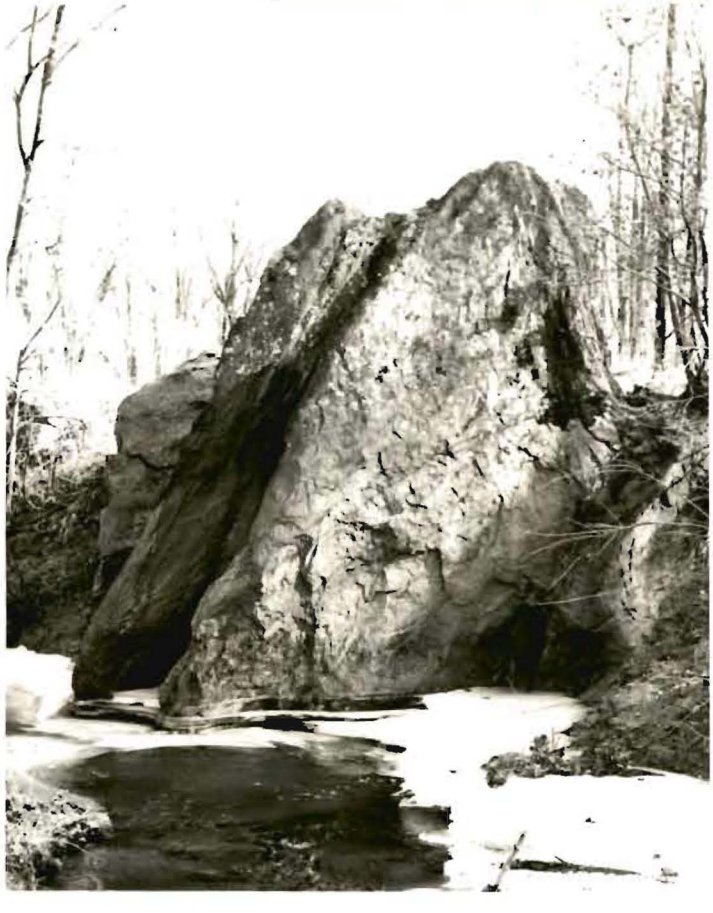
K
b
a
c
SWINGING CREEK
N
S
A*
A
O+P
I
L
N
Q
M
S
T
K
A*
R
J
d
Y
u
V
A*
W
X
e
--DENOTES SEDGE
--DENOTES LICHEN
--DENOTES HERBACEOUS
--DENOTES WOODY
--DENOTES MOSS
--DENOTES GRASS
W
MAP 3

Rock No.1

viewed from east

Rock No.2

Rock No.3



Rock No. 1

viewed from west

model of study

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