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Preliminary study of succession  
on abandoned agricultural uplands  
& its relationship to wildlife  
management.

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A PRELIMINARY STUDY OF  
SUCCESSION ON ABANDONED AGRICULTURAL UPLANDS  
AND ITS RELATIONSHIP TO WILDLIFE MANAGEMENT

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Submitted in partial fulfillment  
of the requirements for the degree  
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3. General Notes . . . . .	17
4. Classification of Areas Studied . . . . .	18
5. Soil Type . . . . .	19
6. Determining Mouse Populations , , , . . . . .	19
7. Tree Age Determination . . . . .	20
8. Growth Rate of Woody Shrubs . . . . .	20
9. Measurement of the Vegetation . . . . .	21
X. Presentation of Data . . . . .	24
XI. Analysis and Discussion . . . . .	36
1. Frequency of Crop-Type Abandonment . . . . .	36
2. Ecological Succession on Corn Land . . . . .	39
3. Ecological Succession on Small Grain Land . . . . .	54
4. Ecological Succession on Hayfields . . . . .	63
5. Conditions on a Twenty-Eight-Year-Old Apple Orchard . . . . .	71
XII. Conclusions . . . . .	73
1. Effect of Farming Practices Upon Wildlife . . . . .	73
2. Value of Abandoned Lands as Sources of Food . . . . .	75
3. Value of Abandoned Lands in Providing Cover . . . . .	77
4. Use of Abandoned Lands by Wildlife . . . . .	80
XIII. Summary . . . . .	86
Bibliography . . . . .	90
Appendix . . . . .	94

## I. Introduction

With vast amounts of agricultural lands being continually retired from cultivation, we are confronted with the task of utilizing these abandoned lands to the best advantage. Such lands were made the subject of an investigation conducted in Washtenaw County, Michigan during the school years 1939-1940 and 1940-1941. An endeavor was made to ascertain some of the major causes for their abandonment and some possible uses for which they are adapted. Special emphasis was placed upon the investigation of ecological succession on abandoned lands and the value of these lands to the field of wildlife management.

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in Washtenaw and Jackson Counties, Michigan. The writer is likewise grateful to Dr. W. C. Steere and Miss Betty Robertson of the Botany Department for aid in identifying plant specimens, and to Professor L. J. Young and Mr. Frank Murray of the School of Forestry and Conservation for their cooperation.

## II. Abandonment of Agricultural Land

### 1. Causes of Land Abandonment

The use of abandoned agricultural land for wildlife management may be dependent to some extent upon the causes for its abandonment. Causes of more or less permanent land retirement may be separated into the following classes; Economic, physical, climatic, biotic, social, and administrative. The following brief account of factors bringing about land abandonment is in part the result of the author's findings and in part a resume of literature on the subject.

Economic factors seem to exert the most powerful influence bringing about abandonment of land. Due to favorable economic conditions much otherwise submarginal land is being profitably utilized. More important of the economic factors to be considered are the following:

1. Loss of markets for agricultural products due

partly to the discontinuance of transportation facilities and partly to a change in the nation's food predilections.

2. Periods of national prosperity causing populations to shift from rural to urban areas.
3. Over-expansion of land in cultivation during periods of high farm prices.
4. Closing of industries from which a cash income supplementary to the farm earnings is obtained.
5. Intensive competition with products from regions which produce them more economically.
6. Excessive cost of clearing suitable land.
7. The setting aside of real estate was found to be the most influential factor causing lands to be withdrawn from cultivation in the immediate vicinity of Ann Arbor and other nearby centers of habitation.
8. The present owners absent due to more desirable conditions elsewhere caused several areas of land to be abandoned about Ann Arbor.
9. Purchase of large estates by wealthy individuals was responsible for suspension of cultivation on several tracts of land throughout Washtenaw County.
10. Excessive property taxes on land adjacent to Ann Arbor was instrumental in bringing about its abandonment.
11. The excessive cost of replacing buildings destroyed by fire was responsible for causing the abandonment of several farms near Ann Arbor.

Physical factors hastening land retirement deal chiefly with the soil and topography. This group includes



the following:

1. Rugged topography prohibiting the use of modern farming machinery and facilitating soil erosion and deterioration.
2. Adverse soil characteristics, such as low fertility, instability, poor drainage, and presence of a hardpan or alkali deposit.
3. Hindrances to cultivation, as for instance boulders or stumps.

Irregularity in the amount of mean annual rainfall and unsatisfactory distribution of such rainfall throughout the year are the main climatic factors instigating land abandonment. During years of abnormal or even normal precipitation large areas of land were opened up in the western Great Plains regions only to be later withdrawn from agriculture in the drouth years, especially 1931 to 1936. Wind erosion of the soil also contributed to land abandonment during these dry years. Weaver and Clements (1938: 113) state that "in some parts of the Great Plains, destructive hailstorms are so frequent that they have caused the abandonment of farms and sometimes whole districts."

An important biotic factor is the cotton boll weevil which entered the United States from Mexico about 1892 and heavily infested the later maturing cotton crops of fine textured soils. Beginning about 1905 numerous tracts

of this soil type have been forced into abandonment in widespread parts of the South. In mountainous sections of Pennsylvania and New England harmful activities of excessive deer populations are said to have caused the abandonment of many farms.

The present owners becoming too old to work their farms, while the younger generation has left home in response to more favorable economic conditions in other parts of the country, is a common social cause of land abandonment in Washtenaw County.

Mismanagement of farm land frequently causes its deterioration and eventual retirement through the practice of an undesirable system of crop rotation or the application of poorly adapted farming methods. These factors have been classed as administrative causes of land abandonment.

## 2. Role of Federal Programs in Land Retirement.

Governmental interest in social conditions associated with submarginal land in scattered parts of the country resulted in the creation of several new agencies and the passing of a variety of Acts designed to correct the situation. The following are some of the more

important Federal programs that deal with this phase of Governmental activity:

1. Farm Security Administration, organized on May 1, 1937, to continue the functions of credit extension to farmers and the rehabilitation of farmers "in place".
2. Bureau of Agricultural Economics, which handles the land retirement program of the former Resettlement Administration.
3. Soil Conservation Service, created April 27, 1935, as successor to the Soil Erosion Service and charged with controlling soil erosion, either by retiring the land from its present use or purchasing it.
4. Agricultural Adjustment Administration, organized in 1933, declared unconstitutional in January, 1936, and now in operation through an amendment to the Act creating it, which is known as the Soil Conservation and Domestic Allotment Act of February, 1936.
5. Taylor Grazing Act of June 28, 1934, which is responsible for correcting maladjustments in the use of our vast range resources.
6. Bankhead-Jones Farm Tenancy Act of July 22, 1937, which was the first agency given the power of purchasing submarginal land and taking it out of agriculture.

### III. Surface Geology as Affecting Land

#### Abandonment in Southern Michigan

The entire surface of Michigan was subjected to glacial forces during the Ice Age of Pleistocene Times.

As a result the state is strewn with both terminal and ground moraines, eskers, kames, lakes, marshes, and kettle holes. Steep topography and adverse soil characteristics associated with morainic deposits have done much to influence agricultural use of the land. The Waterloo Area, located in the northwest corner of Washtenaw County and the northeast corner of Jackson County, is an example of a district in which extreme morainic conditions brought about uneconomic circumstances and caused eventual land abandonment. Where marshes and kettle holes comprise a large portion of the surface area, frequently it has been necessary to change the major type of land use from farming to grazing. In one case, cited to the writer in a conversation with Professor Wight, agricultural abandonment of a kame resulted from the owners removing and selling the underlying gravel deposits.

#### IV. Uses of Abandoned Land

In all parts of the United States, with the exception of regions so rugged or inaccessible as to preclude any type of agricultural development, large tracts of land are reverting to public ownership through their outright purchase or the medium of tax delinquency.

Some possible uses for this land are given below. It should be borne in mind that although the uses have been presented separately, in most cases they can be integrated and applied simultaneously to the same piece of land.

#### Prevention of soil erosion

Vegetative cover normally invades idle agricultural land that is not too severely eroded. That an adequate plant cover retards soil erosion is demonstrated by the work of Umland (1955) near Bethamy, Missouri. This worker showed that on Shelby silt loam with a uniform slope of 8 per cent, 60 tons of soil per acre were washed away from land kept continuously in corn under natural rainfall conditions, while from land kept in alfalfa the loss was only 0.2 tons per acre. In other words, a cover crop such as alfalfa is 300 times as efficient as corn in preventing soil erosion. Umland also states that a cover of grass is about 200 times as capable of checking soil washing. These data indicate the value of a vegetative cover in keeping soil in place.

#### Watershed protection

A vegetative cover that retards soil erosion also tends to hold water in place and enables it to be absorbed

into the ground. Abandoning agricultural land and permitting vegetation to return to it therefore brings about the conservation of water resources. This use of former agricultural land is of special importance in arid parts of the continent where water conservation is essential to successful habitation of the region.

### Grazing

This extensive form of land utilization is frequently well adapted to land incapable of further crop production. Only light grazing pressures should be tolerated upon worn out land, for, improper management of grazing is nearly as conducive of soil deterioration as poorly adapted farming practices.

### Forestry

Abandoned agricultural land in cutover regions is usually adapted to growing forest trees. Large tracts of idle land in regions of this sort should be reforested in the interest of future lumber supplies.

### Recreation

Wild lands are generally well adapted to recreational activities. Thus, Michigan is at present attempting to acquire and manage large tracts of abandoned agricultural land in the northern part of the Lower Peninsula

for this purpose.

### Wildlife management

Using former agricultural land for this purpose is definitely justified since the same vegetative cover that reduces soil erosion and conserves water supplies also produces a suitable habitat for a variety of species of wildlife.

## V. Basic Principles of Wildlife Management

### 1. A Form of Land Utilization

As implied above, wildlife management for the production of game crops and other recreational activities is becoming to be recognized as a desirable type of land use and one which is capable of being integrated with other possible forms of land utilization.

### 2. Growth and Trend of Wildlife Management

According to Leopold (1936: 4, 5) the evolution of ideas concerning game management have progressed through five rather definite stages in both the Old and the New Worlds as follows:

1. Attempts to increase game supplies by restricting or controlling hunting.
2. Predator control intended to eliminate agencies

taking an inordinate portion of the game crop.

3. Reservation of areas on which game could breed unmolested.
4. Artificial replenishment of wild game supplies through restocking activities.
5. Manipulation of environmental factors to provide a suitable habitat for game.

We have found by experience that the first four types of ideas are insufficient in themselves to accomplish the aims of wildlife management. At present attention is being directed toward the application of ideas in the last class so that wildlife will be produced more or less under natural conditions.

### 3. Importance of Vegetative Types in Wildlife Management

Reference to the provision of a favorable environment for wildlife involves principally the furnishing of food and cover of the proper kinds and in the proper proportions. Vegetation either directly or indirectly supplies the first essential, food. For all but fossorial animals, and certain other exceptions, it also furnishes the second requirement, cover. Depending upon the animal under consideration, vegetative cover is called upon to meet a variety of needs. Leopold (1936: 308) segregates



vegetation into the following types, each one of which has a specific function:

1. Winter cover, offering concealment from enemies and mechanical protection during periods of heavy snow.
2. Refuge cover, also termed escape cover, which provides a sanctuary from hunters and predatory animals.
3. Loafing cover, or places where game can rest and feel at ease.
4. Nesting cover.
5. Roosting cover.

The above discussion has attempted to point out that the basis of wildlife management is a knowledge of the life history of the species to be managed. With the habits and the food and cover requirements of an animal known, it is possible to so handle an environment that the elements which comprise a favorable habitat for that animal will be present in the correct proportions. This scientific application of certain fundamental principles, in a broad sense, constitutes what we call wildlife management.

#### VI. Value of Knowledge of Succession to Wildlife Management

Ecological succession operates continually to modify

biotic communities in the direction of a more or less stable environment. Succession may thus take place to such an extent that a game range will no longer be suitable for wildlife. Because of this fact wildlife managers are greatly concerned with the influence of environmental modifications upon the wildlife species in which they are interested. On areas under an intensive form of management it is essential to maintain control of the environment if consistent yields of wildlife are to be realized.

The influence of succession on the use of an area by wildlife is demonstrated by the work of Lay (1940) on cutover woodland in eastern Texas. According to this worker the density of bobwhite quail on cutover land reaches a peak about the eighth year and begins to decline about the tenth year after cutting the timber. Vegetative changes were held to be largely responsible for the differences in carrying capacities of cutover lands of varying ages.

Stoddard (1931) discusses the importance of succession on quail cover in Georgia. This investigator advises the use of fire in controlling succession on areas that would otherwise revert to a broomsedge stage

which is devoid of valuable quail food plants and harbors a large population of destructive cotton rats.

Leopold (op. cit.: 305) lists "tools" used for hastening or setting back plant succession so that proper control of game cover can be maintained. Those used for accelerating the process are: Planting, fencing against stock, and protecting against fire. Methods of checking succession are: Plowing, burning, grazing, and cutting.

## VII. Work of Other Investigators

### 1. Relating to Abandoned Land

In the work of Clements (1904: 119) is the first mention of succession on abandoned agricultural land that came to the attention of the author. His classification of types of succession includes (secondary) "succession by cultivation" and presents a brief account of the revegetation of former crop land. Buttrick (1917) describes "Forest Growth on Abandoned Agricultural Land" in the eastern part of the United States. This writer considers birds and mammals as valuable disseminators of forest tree seed and presents descriptions of various "old field" types. The work of Larsen (1935) deals specifically with succession on eroded abandoned land

in southern Ohio, but it is primarily concerned with plant succession. Animals are mentioned as aiding in dispersing seeds of herbaceous and woody plants. The most detailed recent investigation of succession following abandonment is that of Smith (1940) conducted on abandoned eroded farm land in Oklahoma. It presents both plant and animal succession. This valuable work would have been improved had the time element been taken into consideration.

## 2. Relating Specifically to the Value of Abandoned Land to Wildlife

That abandoned fields are utilized by pheasants for nesting sites, flock areas or brooding sites, crowing areas, protective shelter, roosting sites, and for food supplies is pointed out by the work of Wight (unpublished) as the result of his studies made between 1928 and 1930 near Northville, Oakland County, Michigan. Dalke (1935) states that uncultivated and marginal land about Ann Arbor produces much food and also affords valuable cover for wildlife.

In his work on quail management near Salisbury, Maryland, Wilson (1938) traces the general course of succession for at least eight years on formerly cultivated

land. While this author doesn't definitely state the period in the development that is most favorable for quail, he does say that "the first and second growing season after plowing the (important quail) food plants listed make up 60-80 per cent of the vegetation; the third year, 30-50 per cent; the fourth to eighth years, 10 per cent or less" (op. cit.: 712).

Stoddard (op. cit.: 362) states that "fallow fields furnish excellent nesting, roosting, and feeding grounds for quail for the first three or four years after cultivation."

#### VIII. Statement of the Problem

For the purpose of emphasizing the purpose of this work it would be well to restate the objectives of the investigation at this point. In spite of the fact that it has gone into the abandoned land situation in a general way, this work is chiefly concerned with the study of ecological development of biotic communities upon agricultural land following its retirement from use, and the determination of how that process fits in with the fundamentals of wildlife management in southern Michigan. Differences in ecological succession as influenced by the type of crop last present upon the land were included in this project.

## IX. Field Work

### 1. Location of Study Areas

A total of 41 areas were chosen for intensive study by driving about Washtenaw County in a car and checking all likely looking places on a map. Areas varying in age from those in cultivation the summer of 1940 to those that had been idle for as long as 18 years were designated in this manner.

### 2. Histories

The value of land areas for this work was largely determined by the amount and exactness of the information that was obtainable regarding their histories. In many instances tracts of otherwise suitable land had to be eliminated because of unsatisfactory data. Questions were asked of the owners or of nearby landowners to determine the crop at time of abandonment, the date of abandonment, the reason for the land being idle, and the history of burning and grazing on the area.

### 3. General notes

In addition to the above data, general notes were taken regarding topography, character of the vegetation, and type of bordering vegetation. Each species of plant

found on the boundaries of an area was listed as to position, that is, on the north, east, south, or west side.

Records were kept on the birds and mammals observed and animal signs noticed upon each area. Track counts were made principally during the winter season when there was snow on the ground. The lack of good tracking snow greatly handicapped this phase of the investigation.

#### 4. Classification of Areas Studied

Study areas were placed into the following groups on the basis of cropping practices preceding their abandonment: (1) Areas last in corn, (2) areas last in small grain, and (3) areas last in hay. Nineteen pieces of land in class 1 were studied. Eight small grain areas in class 2, i.e. those last in oats, wheat, or rye, were studied. Thirteen areas comprised class 3, which includes those that had been either in red clover and timothy or alfalfa. One apple orchard approximately 28 years old was also investigated to obtain some idea of what takes place on agricultural land of this type following its abandonment.

Each area was further classified as to the number of years it had been out of cultivation. Classes used

for this purpose were the following: 0 years for land used in the summer of 1940, 1 to 2, 3 to 5, 6 to 10, 11 to 15, and 16 to 20 years after the time of last cultivation.

## 5. Soil Type

The areas chosen for intensive investigation were limited chiefly to uplands. They were classified first according to the soil types recognized by Veatch et al (1934). Field observations on the character of the soil upon each study area later made it apparent that soils could be arranged into three broad groups: (1) Silt loam, including Miam loam and Miami silt loam; (2) sandy loam, incorporating such types as Fox sandy loam, Brady sandy loam, Berrien sandy loam, and Oshtemo loamy sand; and (3) Bellefontaine sandy loam, handles as a separate type because of certain unique peculiarities which create marked vegetative differences.

## 6. Determining Mouse Populations

Snap traps baited with a mixture of rolled oats and peanut butter were set out half a chain apart on a line across each field. Traps were left out for two nights, but they were inspected each morning. Results of the



census were calculated on the basis of 100 traps so that each trap line would be comparable. A total of 17 areas were censused in this manner during the months of October and November, 1940.

#### 7. Tree Age Determination

The age of woody plants found on the study areas was determined by methods in general use by foresters. Ring counts of older trees were made by cutting a cross-section or using an increment borer, while the age of seedlings was determined by counting the groups of winter bud scars.

#### 8. Growth Rate of Woody Shrubs

Weaver and Clements (1938: 324) state that "by means of rhizomes and root offshoots, plants may invade closed communities, such as grassland, where propagation by seeds or stolons would be difficult or impossible." The rate of invasion by root extensions of some common woody shrubs was studied in this investigation. In the case of sumacs the age of the parent plant was found to be accurately computed by counting the number of dead branches, or their remaining scars, beginning at the base of the shrub and progressing to the end of one of the branches. A stub

is left for every year of growth. Staghorn sumacs up to 16 years old were measured in this manner and found to check with ring counts made in the usual way. Ages of red osier and pannicled dogwood, meadow-sweet, hazelnut, and prickly ash were determined by making ring counts. Care had to be exercised for the dogwoods and hazelnut because it frequently happened that the oldest stem in the group was dead and other shoots had budded out from the base. The distance woody shrubs had covered was taken as the average radius of the area occupied by the plant, if it occurred away from the border of a field, or as the number of feet it had spread from its original location, such as the edge of a field, rock pile, ditch, or stump.

There was no accurate way of determining the age of the less woody shrubs, such as blackberry, raspberry, and wild rose, so that the number of years the land had been abandoned was taken as the length of time the plant had been spreading from its former limits.

#### 9. Measurement of the Vegetation

The method used was based upon an ocular estimate of the amount of area occupied by the crowns of each plant species found within a milacre quadrat. In this

way it was possible to obtain data that gave some indication of the density of the plants and also information that could be used to show the distribution of each plant species over the area.

The amount of area occupied by the various plants in each quadrat was estimated in per cent and designated by the following classes:

<u>Class</u>	<u>Per cent area occupied</u>
0	Less than 1 %
1	1 to 20
2	21 to 40
3	41 to 60
4	61 to 80
5	81 to 100

In actual practice class "0" was not used in the field, each species being placed in one of the other classes. Data obtained from measuring vegetation in this manner were handled by summing the coverage class indices estimated for each species on each quadrat and dividing by the number of quadrats which had been laid down. If the final value came to 0.5 or less, the species was rated as occurring in class "0" and arbitrarily was said to occupy less than 1 per cent of the whole area. If the average value for a species was from 0.6 to 1.5, inclusive, the species was in class "1" and accordingly covered from 1 to 20 per cent of the area. Other

averages were treated in a similar manner for the remaining coverage classes.

Originally Raunkiaer's method of indicating the composition of vegetation was done by means of a quadrat one-tenth of a square meter in area. In this investigation estimates of the per cent of area covered were supplemented by frequency indices based on milacre plats to show the distribution of each herbaceous species over the land as a whole. Indices for frequency of occurrence were segregated into the following classes:

<u>Class</u>	<u>Frequency of Occurrence</u>
1	0 to 10 %
2	11 to 20
3	21 to 30
4	31 to 40
5	41 to 50
6	51 to 60
7	61 to 70
8	71 to 80
9	81 to 90
10	91 to 100

The manner of laying out the milacre quadrats was to run a transect through the middle of each area and put down a plot at intervals of one-half a chain or one chain, the interval used depending upon the uniformity of the cover. In vegetation that appeared fairly uniform, plots were further apart than in vegetation that consisted of a mixture of species.

Herbaceous species of plants encountered were grouped

into those that were annual or biennial, or both, and those that were perennial. The ocular estimates were limited to these two types of plants. Woody shrubs and trees were merely indicated by the number of stems of each species found in a quadrat.

Measurement of the vegetation took place chiefly during the late winter after the snow had melted and before any new growth had taken place. Because of this fact several plant species may have been missed, however it is improbable that such an omission would result in a serious error. Species that have disappeared by the winter period in all probability exert little influence upon the animal life present during this period and can quite safely be regarded as being of slight consequence.

#### X. Presentation of Data

General trends in the composition of herbaceous vegetation upon abandoned agricultural land are demonstrated by Charts I to III. These indicate changes that take place in the numbers of annual, biennial, and perennial plants in each chronological stage of succession. They are based upon Tables VIII to XIII, included in the appendix, which list the species <sup>observed on each study area in the field.</sup> to which reference has <sup>In these tables,</sup> just been made, the left hand figure in each column represents the average coverage index, while the one on the

Chart I. Numbers of Herbaceous Plant  
Species on Corn Lands

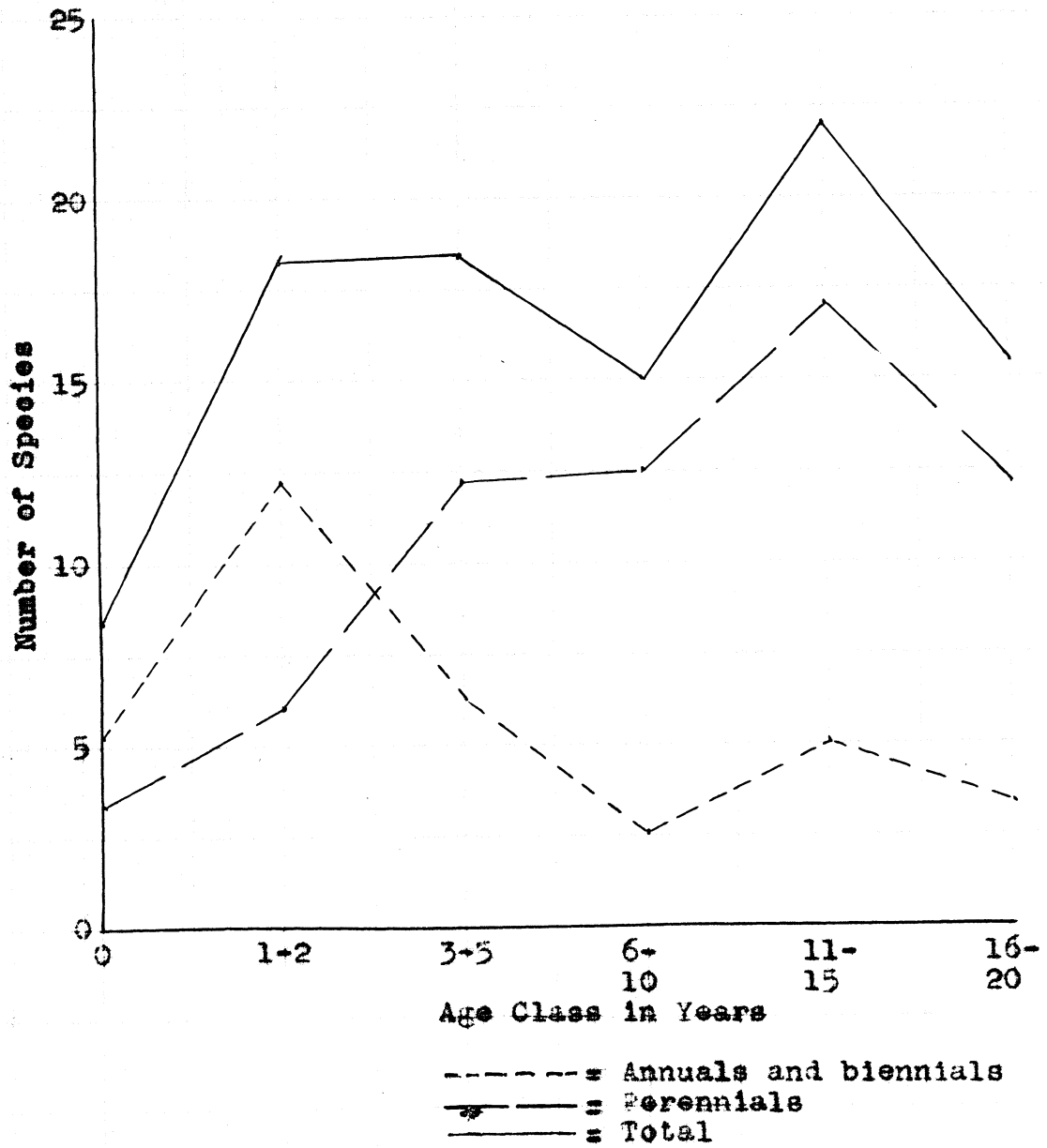


Chart II. Numbers of Herbaceous Plant  
Species on Small Grain Lands

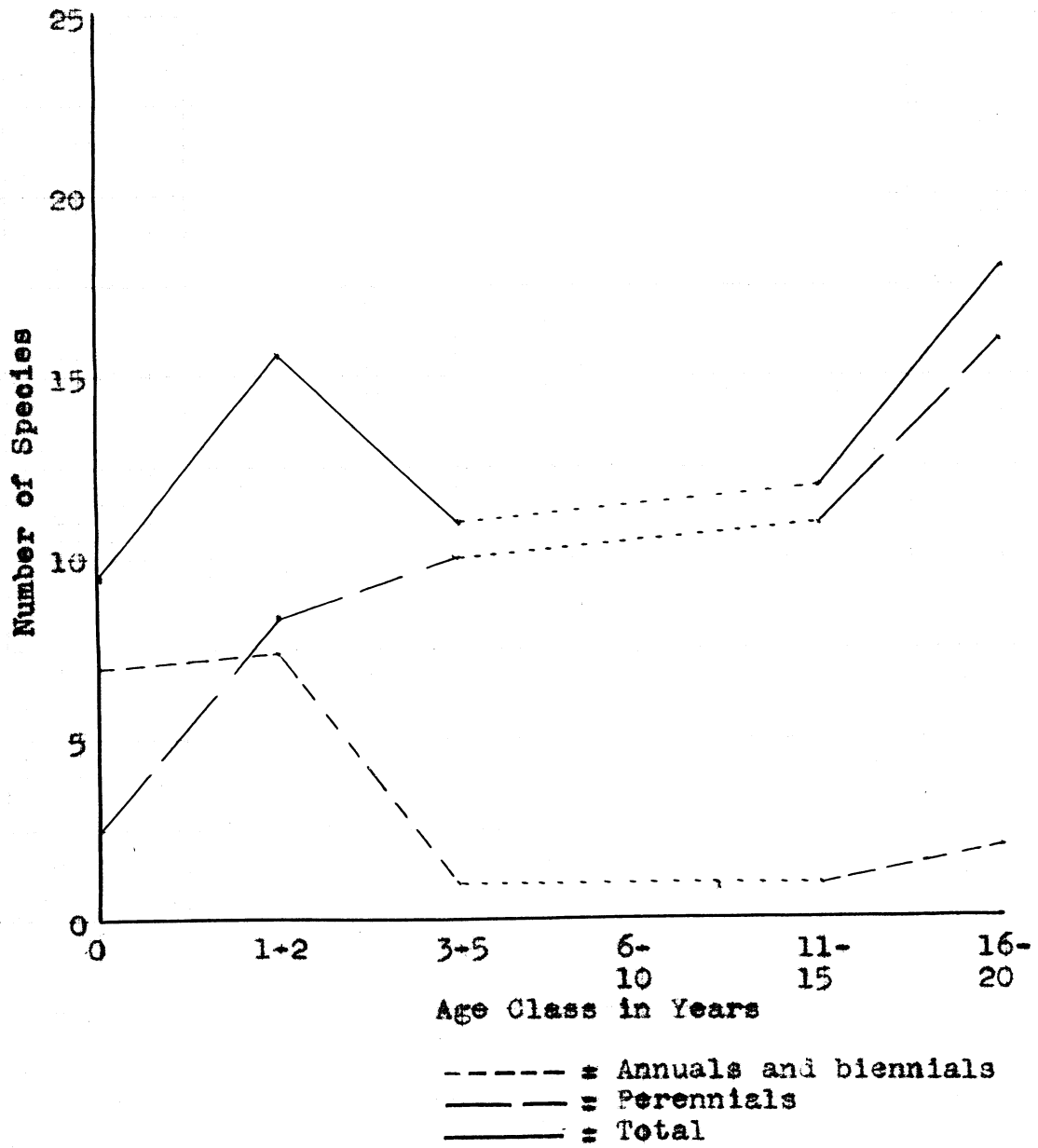
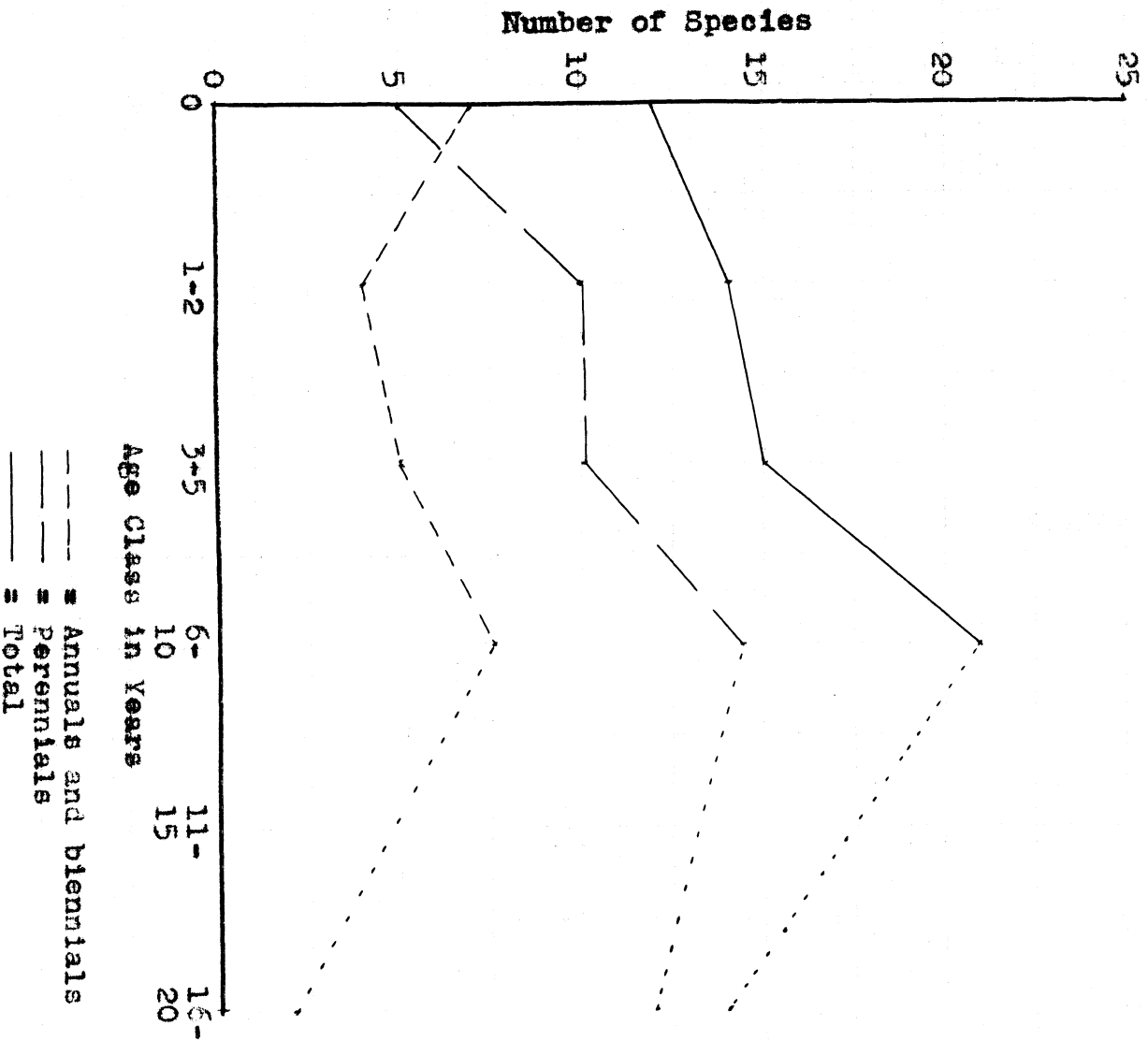


Chart III. Numbers of Herbaceous Plant  
Species on Hayfields





right is the frequency of occurrence index.

Tables I to III, also based on the above tables, comprise a summary of the herbaceous plant species found on abandoned land. Only those species were included that were thought to be significant as determined partly by the coverage and frequency of occurrence indices, and also by the writer's knowledge of their value to animal life, principally as sources of food. A symbol of "X" indicates that the species is of major importance from these two points of view, while an "O" means that the plant is of minor importance.

Species of trees and woody shrubs observed upon each area under investigation are presented in Tables XIV to XVI likewise found in the appendix. It will be observed that the varieties of woody plants found upon abandoned land increased with the length of time since the land was abandoned.

Tables IV and V present information secured upon the number of years after abandonment of each agricultural land type that tree species and woody shrubs become established in the ensuing successional development. A dot represents one observation, and "x" equals 10 observations, and a "-" represents 20 of them. In the case of shrubs, the age of which could not be

Table I: Summary of Herbaceous Plant  
Species on Corn Land

Age Class in Yrs.	0	1-2	3-5	6-10	11-15	16-20
No. Areas Included	4	5	4	2	1	3
<u>Ann's and/or Bienn's</u>						
Crab grass						
Old witch grass	0	X				
Foxtail grass	X	X	0			
Black bindweed		X				
Lambs-quarters	0	X				
Peppergrass		0				
False flax		0				
Wild carrot				0	X	
Common mullein			X			
Horseweed		0	X			
Ragweed	X	X	0			
Prickly lettuce		X	0			
<u>Perennials</u>						
Timothy						
Bluegrass		0	X	X	X	X
Quack grass					0	0
Sheep sorrel			X			
Strawberry			0	0	0	
Silvery cinquefoil			X			
Cinquefoil		0	0			
Red clover						
Alfalfa						
St. Johnswort				0		0
Heal-all				0	0	0
Broad l'd plantain			0	0	0	
Narrow l'd plantain	0	0				
Goldenrod			X	X	X	X
Aster				X	X	
Yarrow				X	0	0
Canada thistle		0	0	0	0	

Table II. Summary of Herbaceous Plant  
Species on Small Grain Land

Age Class in Yrs.	0	1-2	3-5	6-10	11-15	16-20
No. Areas Included	2	3	1	0	1	1
<u>Ann's and/or Bienn's</u>						
Crab grass	X	0				
Old witch grass	X	0				
Foxtail grass	X	X				
Black bindweed		0				
Lambs-quarters	0					
Peppergrass	0	0				
False flax		0				
Wild carrot		X	X		0	
Common mullein					0	0
<u>Horseweed</u>						
Ragweed	X	X				
Prickly lettuce		0				
<u>Perennials</u>						
Timothy					0	0
Bluegrass		0	X		X	X
Quack grass		X			0	0
Sheep sorrel	0	0				
Strawberry			0			X
Silvery cinquefoil	0	0				
Cinquefoil		0	0			0
Red clover	X	X				
Alfalfa		0	0			
St. Johnswort					0	0
Heal-all						
Broad l'd plantain						
Narrow l'd plantain	0	0				
Goldenrod			X		X	X
Aster			X		X	
Yarrow			0		0	
Canada thistle					0	

Table III. Summary of Herbaceous Plant  
Species on Hayfields

Age Class in Yrs.	0	1-2	3-5	6-10	11-15	16-20
No. Areas Included	1	1	6	3	0	2
<u>Ann's and/or Bienn's</u>						
Crab grass	X	X	X			
Oldwitch grass	X	0	0			
Foxtail grass	X	X	X	0		
Black bindweed						
Lambs-quarters	0					
Peppergrass	0					
False flax						
Wild carrot		0	0	X		X
Common mullein			0	0		
Horseweed			0	0		
Ragweed	X		0	0		
Prickly lettuce				0		
<u>Perennials</u>						
Timothy			X	X		0
Bluegrass		0	X	X		X
Quack grass		0				
Sheep sorrel	0		0	0		
Strawberry						
Silvery cinquefoil	X	X	0			
Cinquefoil			X			
Red clover	X	X	X	X		X
Alfalfa	X	X	X	0		
St. Johnswort				0		0
Heal-all						0
Broad l'd plantain		0	0	0		
Narrow l'd plantain	0	0	X	0		
Goldenrod			X	0		X
Aster						
Yarrow						
Canada thistle		0	0	0		0

Table IV. Observations Showing Establishment  
of Tree Species

Species	Crop Type	No. Areas Incl.	No. Records	Years After Abandonment																	
				0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Quaking aspen	Corn	1	1																		
	Grain	1	10				x				.										
	Hay	1	1			.															
Large-toothed aspen	Corn	1	5						;;												
	Grain	1	2		.	.															
	Hay	1	1			.															
Black walnut	Corn	2	5					..	.	..											
	Hay	3	5			..					.			.	.						
Shagbark hickory	Corn	1	2				..														
	Grain	2	14	..	..	..															
	Hay	1	11						.		..										
White oak	Corn	1	1								.										
	Grain	2	6		..	.	.				.						.				
Red and Black oaks	Corn	1	7				.		..	.	.		.								
	Grain	1	11	.	.		..	..		.	.		.	..	.						
	Hay	1	1				.														
Slippery elm	Corn	1	2								..										
	Grain	1	1		.																
	Hay	2	3						..	..											
American elm	Corn	11	81	-	..	.	.	..	..		..	..	..		..						
	Grain	4	122	..	x	.	..	..	..		..	..	.		..						
	Hay	3	47	..	..	.	.	..	..	..	.										
Sassafras	Grain	1	1			.															
	Hay	1	1								.										
Hawthorn	Corn	4	28	..	..	..	.	..	..	..	..	..	.	.		.	.				
	Grain	3	22	..	..	..	.	..	..	..	..	..	.	.		.	.	..			
	Hay	5	20			..	..	..	..	..	..		.	.		.	.				
Black cherry	Corn	6	47	..	x	..	..	..	..	..	..	..	.	.		.	.				
	Grain	3	45	x	x	..	..	..	..	..	..	..	.	.	..	.	.			..	
	Hay	6	20		..	..	..	..	..	..	..	..		.	.		.			..	
White ash	Corn	1	1			.					.	.	.								
	Hay	1	9		..	..	..														
Basswood	Grain	2	11	.	..	.	..	..													
	Hay	1	2								.	.									
Box elder	Corn	5	6				.		..	.		..									
Sugar maple	Corn	1	15		x	..															
	Grain	1	2											..							
	Hay	1	1			.															

Explanation of symbols:

- . = 1 observation
- x = 10 observations
- = 20 observations

Table V. Observations Showing Establishment  
of Woody Shrubs

Species	Crop Type	No. Areas Incl.	No. Rec-ords	Years After Abandonment																	
				0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Hazelnut	Grain	2	6				..	..	.	.											
Meadow-sweet	Corn	1	1																		
	Hay	2	3						.			.	.								
Prickly ash	Hay	2	2								.		.								
Raspberry	Corn	3	12						..				...								
	Grain	2	8						...				...								
	Hay	1	2										..								
Blackberry	Corn	5	7				.														..
	Grain	3	9				.			.											...
	Hay	2	8					..													..
Wild rose	Corn	1	1																		.
	Grain	1	1				.														
	Hay	1	1										.								
Staghorn sumac	Corn	3	25		.	..	..	..	x:..	:		.									
	Grain	2	3					..	..												
	Hay	3	7		.							..								..	
Smooth sumac	Corn	2	6						..	..	.	.									
	Grain	1	4				..														
Poison ivy	Hay	1	1										.								
New Jersey tea	Grain	1	6																...		
Grape	Corn	5	5	.						.											
	Grain	1	3																		..
	Hay	2	2									.									.
Virginia creeper	Corn	2	2										.								.
	Hay	1	1										.								
Panicled dogwood	Corn	3	3									.		.	.						
	Grain	2	12				.	..				.	.	.							
	Hay	2	8		..	..		..			.										
Red osier dogwood	Corn	2	3					.	.			.									
	Grain	1	1						.												
	Hay	1	6						.	...											
Cranberry	Grain	1	1																.		
Elderberry	Corn	3	3		.				.				.								
	Grain	1	1																		.
	Hay	2	2				.												.		

Explanation of symbols:  
 . = 1 observation  
 x = 10 observations

exactly determined by ring counts, they were simply indicated in the table as occurring on land of a certain age. Thus, raspberry was observed 9 times on corn land that had been abandoned for 10 years. Other species in this category are blackberry, wild rose, poison ivy, New Jersey tea, grape, Virginia creeper, and in some cases, elderberry.

Results obtained from data on the rate of invasion of new territory by woody shrubs are contained in Table VI. This table indicates that smooth sumac spreads more rapidly than staghorn sumac, and that the rate for each of these species is greater on the sandy and somewhat gravelly Bellefontaine sandy loam than for the other soil types. Red osier dogwood spreads at such a slow rate, at least early in its life, chiefly because of its habit of sending out innumerable shoots from the base of the original stem. As growth of these shoots progresses their own weight or an accumulation of snow in their branches causes them to bend over to the ground and take root at the point of contact. It is apparent from field observations that shoots take root primarily under moist conditions such as occur upon low ground or beneath a mulch of herbaceous vegetation, usually bluegrass if the shrubs are growing on an upland site.

Table VI. Rate of Invasion of Some  
Common Shrubs

Species	Soil Type	No. of Records	Spread in Ft. per Yr.
Hazelnut	Bellefontaine sandy loam	3	0.2
Raspberry	Silt loam	3	1.4
	Bellefontaine sandy loam	1	5.0
	Carlisle muck	1	3.0
Blackberry	Silt loam	3	1.9
	Sandy loam	3	1.4
Wild rose	Silt loam	2	0.7
Staghorn sumac	Silt loam	23	1.7
	Bellefontaine sandy loam	8	2.7
Smooth sumac	Silt loam	9	2.9
	Sandy loam	2	2.4
	Bellefontaine sandy loam	5	5.3
Poison ivy	Silt loam	1	1.6
Panicled dogwood	Silt loam	4	1.6
	Bellefontaine sandy loam	4	1.1
Red osier dogwood	Bellefontaine sandy loam	5	0.05
Hawthorn	Silt loam	1	1.6
Bittersweet	Bellefontaine sandy loam	1	1.7



Succession in species of small mammals upon abandoned agricultural land is indicated by results of the trapping technique which are summarized in Table VII. It will be noted that there is considerable variation in the species caught upon any group of crop-type lands in the same age class. When these variations are correlated with local vegetative differences they tend to show habitat preferences for these small mammals.

The general discussion which follows regarding ecological succession of biotic communities on each type of crop land is based largely upon field notes taken during this investigation. In addition, the writer's familiarity with food and cover requirements for the various animal species, obtained from the literature, will supplement original information on this important phase of the investigation.

## XI. Analysis and Discussion

### 1. Frequency of Crop-Type Abandonment

As was stated elsewhere, 19, or approximately one-half, of the study areas were found to have been last cultivated in corn. It was only after making many inquiries that a moderate number of small grain or hay lands were secured. This fact seems to support Kohlmeier (1940: 6) who reports that in Martin County, Indiana

Table VII. Results of Trapping Experiment:

Number of Specimens Caught on the  
Basis of 100 Traps

Crop Type	Corn				Hay							Grain			
	0	1-2	3-5	16-20	0	1-2	3-5				1-2	3-5	11-15	16-20	
Area Number	25	24	22	12b	27	41	4	18a	18b	26	42	29	30	28	12a
Prairie dee-mouse ( <u>Peromyscus maniculatus bairdii</u> )	14	32	12		10	48		10	10	21	50	35	18		
White-footed mouse ( <u>Peromyscus leucopus noveboracensis</u> )		6	6	5			4		20	5	22	10	5	10	45
Meadow vole ( <u>Microtus p. pennsylvanicus</u> )		12					24	25	10	10		5	22	20	
House mouse ( <u>Mus m. musculus</u> )	5					9	4	5				20	5		5
Short-tailed shrew ( <u>Blarina brevicauda talpoides</u> )				9			4	10		10		10	9		10
Meadow jumping mouse ( <u>Zapus h. hudsonius</u> )											6				
<u>Totals</u>	19	53	18	14	10	57	36	50	40	46	78	80	59	30	60
Actual Number of Traps Set Out	21	17	17	21	19	21	25	20	10	19	18	20	22	20	20

"corn is the last cultivated crop grown before fields are abandoned for cropping purposes." The preponderance of idle corn land over other types may be partially explained by the farmer's desire to obtain one last cash crop before abandoning a piece of land.

Fifteen of the 19 corn areas have been idle for more than 1 year. Sixty per cent of these fall in the classes including the years 1 to 5 inclusive. Hill (1939: 888) states that in 1935 Michigan had the largest acreage in corn since the year 1922, or 1,667,000 acres. Following 1935 a reduction in acreage took place until in 1939 the total had fallen to 1,590,000 acres. Possibly there is some correlation between this five-year drop in corn acreage and the large number of areas abandoned from 1 to 5 years. This year, 1941, 4 of these areas were cultivated and planted indicating an expected improvement in farm prices.

Eight study areas, or 20 per cent of the total, were abandoned small grain fields. Of the 6 fields not cultivated for a period of 1 year or over, two-thirds of them had been abandoned from 1 to 5 years. Hill (loc. cit.) indicates a general drop in acreage in small grains comparable to that of the corn acreage. Few areas may have been abandoned in this type because of the common practice of seeding in clover and timothy or alfalfa with a

small grain crop and using the land for pasture.

Thirty per cent of the study areas were last in hay. All but one of these had been abandoned for one or more years, and of these approximately 60 per cent had been idle for as long as 5 years. As a general rule it is apparent that abandoned hayfields are chiefly those upon which the established crop is rather thin and of poor quality. Although much of this type of land has been withdrawn from cultivation, it is nevertheless used for permanent pasture. In this investigation an attempt was made to study only fields that had not been pastured.

## 2. Ecological Succession on Corn Land

The large number of cornfields studied makes it possible for the account of succession to be most complete for this type.

### Condition the Year of Last Use

Data collected during the course of this investigation indicate that in the fall of the year in which the last crop is harvested, land which has been in corn is occupied by a scant cover of vegetation. Ragweed generally is distributed throughout the area and covers from 1 to 20 per cent of the land. Foxtail grass is also generally distributed but it occupies a comparatively smaller portion of the area. As might be expected,

lambs-quarters is another important species. Other annual plants frequently encountered are old witch grass, crab grass, snake grass, and black bindweed. Perennial species comprise a minor portion of the vegetative cover. Silvery cinquefoil and narrow-leaved plantain are evidently the most characteristic perennials to be found during the last year that cornfields are cultivated.

Twenty per cent of all American elms found on corn land was found to have germinated with the crop. Black cherry may also appear upon such areas at this time. One case is on record of grape occurring in this stage of succession.

Animal life upon corn land the year of its last use is greatly diversified. The prairie deer-mouse (Peromyscus maniculatus bairdii) was found to be the most abundant mouse on such a location, and house mice (Mus musculus) are also known to tolerate such conditions. Cottontail rabbits (Sylvilagus floridanus mearnsii) may occasionally venture out into an exposed area of this sort. The most characteristic winter bird under such open conditions is the horned lark (Otocoris alpestris), which was frequently observed feeding upon seeds of ragweed and lambs-quarters. Other songbirds, notably juncos (Junco hyemalis) and tree sparrows (Spizella arborea),

were also seen to utilize these areas.

Dalke (unpublished) reports that corn stubble fields are attractive to pheasants (Phasianus colchicus torquatus) in southern Michigan, especially during the fall and winter seasons. His data indicate that corn comprises 33 per cent of the total year's food of an adult pheasant. Most of this grain is eaten during the winter months, with large portions of it taken in fall and spring, and is obtained from waste corn scattered about the fields while harvesting and planting. Ragweed on such fields is also heavily utilized by pheasants. It is taken principally from October to March but receives its heaviest use in the month of November.

The writer's own records indicate that morning doves (Zenaidura macroura carolinensis) also feed in corn stubble fields. Fox squirrels (Sciurus niger rufiventer), red squirrels (Tamiasciurus hudsonicus), and chipmunks (Tamias striatus lysteri) obtain food from such areas.

The New York weasel (Mustela frenata noveboracensis) is reported by Quick (unpublished) to spend approximately 50 per cent of its time upon agricultural land when out of its den, while 28 per cent is spent upon plowed land. Although no specific mention is made of the type of crop

land, this investigator recorded several observations in which weasels hunted upon corn land where the corn had been left in shocks over the winter. The weasels were apparently searching for mice.

#### One to Two Years After Last Cultivation

Herbaceous vegetation on corn land which has been lying idle for from 1 to 2 years consists chiefly of ragweed. During this period it occupies approximately 21 to 40 per cent of the area. There is also a large amount of prickly lettuce and lambs-quarters, and an understory composed principally of foxtail grass and black bindweed. Several of the crucifers, such as mustard, false flax,<sup>and</sup> peppergrass, old witch grass, and knotweed are quite common, and horseweed is likely to be present. Although the number of perennial plant species has increased, only blue grass and cinquefoil seem to occur with any degree of regularity, but these two species are relatively insignificant in terms of area covered and frequency of occurrence.

Approximately 30 per cent of the American elm and half of the black cherry on corn land was found to come in in this stage of development. In one instance, where the area under consideration was surrounded by Carlisle muck, sugar maple was observed to have germinated profusely

on the moist locations. Staghorn sumac also appears in well drained sites on 1 to 2 year old corn land.

Data collected reveal the fact that corn land in this age class is much more heavily used by animal life than in the previous period. The most common rodent encountered is still the prairie deer-mouse, which was found to occur more abundantly than in the previous stage. Meadow voles (Microtus p. pennsylvanicus), house mice, and a few white-footed mice (Peromyscus leucopus noveboracensis) also use such areas. Thirteen lined ground squirrels (Citellus t. tridecemlineatus) have invaded the margins of these fields. Signs of cottontail rabbits were rather frequently observed. A red fox (Vulpes fulva) and a mink (Mustela vison mink) were also observed to have traversed such areas. Observations of songbirds, especially tree sparrows, indicate that these small birds make heavy use of the vegetation on this type of land where they feed on ragweed, lambs-quarters and knotweed. Bobwhite quail (Colinus virginianus) were flushed, while numerous pheasant tracks and several old pheasant roosts were observed. Dalke has shown that pheasants take considerable quantities of ragweed and other seeds from annual plant species on areas of this nature. Birds of prey, such as red-tailed hawks (Buteo



borealis), red-shouldered hawks (B. lineatus), broad-winged hawks (B. platypterus) and marsh hawks (Circus hudsonius) are known to feed over such areas.

#### Three to Five Years After Last Cultivation

Annual and biennial plant species in this stage are quite noticeably reduced in numbers and prominence. Ragweed continues to persist but its importance is relatively insignificant. The same is true of prickly lettuce, but foxtail grass may be locally evident. Common mullein and horseweed are commonly seen, but their influence is definitely limited.

A marked increase in perennial herba is apparent. Bluegrass is perhaps the most prominent species and may occupy as much as 80 to 100 per cent of the land, however where it occurs less abundantly such species as cinquefoil, sheep sorrel, and to some extent pussy toes and common moss are found to make up a large portion of the ground cover. The latter usually seems to be the case on Bellefontaine sandy loam. Broad-leaved plantain, dandelion, and strawberry also frequently occur regardless of soil type. The principal broad-leaved herb in this stage of development seems to be goldenrod, with

some cinquefoil and red clover.

Woody plants which come in during this period are somewhat diversified and depend largely upon the availability of seed. Five ring counts of black walnut, or all of the observations for this species on corn land, indicate that black walnut makes its first appearance in from 3 to 5 years. The two records for shagbark hickory on corn land point to a similar condition for this species. Data also indicate that red and black oaks and a considerable number of hawthorns germinate at this time. Black cherry and American elm continue to come in on favorable locations. Seventy-five per cent of the staghorn sumac and a portion of the smooth sumac was also found to have appeared at this stage. Two out of three ring counts on red osier dogwood show that this species comes in here, while blackberry and some raspberry also seem to have become established by this time.

This investigation showed that the mouse population on 3 to 5 year old corn land is composed of smaller numbers of deer mice, and an occasional white-footed mouse. Since only one area in this age class was trapped, this evidence can hardly be conclusive. It is expected that the moderately heavy bluegrass cover would be suitable

for meadow voles and also the insectivore, the short-tailed shrew (Blarina brevicauda talpoides). Signs of rabbit were rather infrequent, but their presence was indicated by their numerous droppings. Tracks indicated that a red fox had hunted over one study area in this class, while house cats made frequent visits to such fields. Other mouse predators also make use of these areas. Their use by pheasants is evidently limited to occasional roosting, and it is also probable that pheasants use them as nesting sites and flock areas where sufficient stable cover exists. Such locations were also attractive to meadowlarks (Sturnella magna). In places where ragweed and certain crucifers remained in sufficient abundance bobwhite quail and pheasants were observed feeding on the seeds of these plants.

#### Six to Ten Years After Last Cultivation

By this time practically all annual and biennial plant species have passed out of the picture, the only one remaining at all consistently being wild carrot. Foxtail grass and common mullein may also persist, however. Perennial species consist principally of bluegrass and goldenrod, which generally form a dense cover over the entire area. Aster and yarrow are also prominent,

while quack grass has become established. Other species such as St. Johnswort, horse mint, dogbane, and butter-and-eggs occur at this time but in limited numbers.

Corn stubble was found to be distinguishable for as long as ten years in spite of the fact that where it had been knocked over it, it was usually completely covered by vegetation.

Vegetation of a woody nature has become much more prominent and consists of a variety of species. American elm and black cherry germinate sparingly on the more or less open places where seeds are able to reach the mineral soil. The establishment of hawthorn was particularly significant, 75 per cent of it taking place at this time. Records for red and black oaks indicate that these species continue to make their appearance. Other tree species for which some records are available are quaking aspen, large-toothed aspen, white oak, slippery elm, white ash, and box elder.

The principal new woody shrub which was found to have germinated from 6 to 10 years after the time of last cultivation is panicled dogwood. The three records for this species on corn land indicate that it had germinated in the 7-, 9-, and 10 year classes respectively. On the

more moist situations meadow-sweet may occur. Virginia creeper may have come in on the well drained locations by this time. Staghorn and smooth sumac, raspberry and blackberry, and some red osier dogwood continue to make their appearance.

The animal population in this association has undergone marked changes. Prairie deer-mice have definitely been eliminated. The comparatively dense and uniformly distributed cover of bluegrass now supports a large population of meadow voles as evidenced by their gnawing on sumac, hawthorn, black cherry, American elm, and box elder, numerous winter nests, and mice actually observed darting through the grass in their runways. Short-tailed shrews should also occur under such conditions since it is known that they frequent runways of the meadow vole. The edges of a field where sumacs, raspberry, or blackberry have invaded the grassland provide a suitable habitat for white-footed mice.

Numerous signs of cottontail rabbits indicate heavy use of such areas by these animals. It was frequently observed that they had girdled or cut stems of staghorn sumac, smooth sumac, and raspberry among several other woody species. Tracks observed in the snow, several forms, numerous droppings, an occasional rabbit seen,

and a "dummy" nest indicate an abundant rabbit population.

The abundant meadow vole population makes it apparent that predatory animals feeding largely on this rodent frequent areas in this stage of development. McAtee (1935) states that such birds of prey as the red-tailed hawk, the broad-winged hawk, and the sparrow hawk (Falco sparverius) take large numbers of meadow voles, and Dearborn (1932) reports that New York weasels, minks, red foxes, and badgers (Taxidea t. taxus), in fact all predaceous mammals that are found in Washtenaw County, commonly include voles in their bills of fare. Foods of the skunk (Mephitis nigra) listed by Dearborn (op. cit.) also indicate that these animals probably venture into areas of this sort in search of insects and the fruits of dogwoods, raspberry, and blackberry.

That pheasants utilize such areas is indicated by the numerous roosts that were noted. Undoubtedly these birds use this type to some extent as nesting sites. A cock pheasant was observed to have taken up a crowing area in a corner of a former corn field that had become grown over with sumac, berry bushes, and grape. Other birds observed upon these grassy areas were meadowlarks, bobolinks (Dolichonyx oryzivorus), field sparrows (Spizella pusilla), an occasional song sparrow (Melospiza melodia),

and goldfinches (Spinus t. tristis).

#### Eleven to Fifteen Years After Last Cultivation

In this stage the only biennial of any significance that remains is wild carrot, but slight amounts of ragweed and foxtail grass may continue to occur where they have not yet been choked by the bluegrass. Perennial vegetation comprises the much more important portion of the plant cover as in the previous period, and for the most part its composition remains unchanged.

Woody plants show little if any increase in numbers, however, hawthorn, American elm, and black cherry apparently continue to become established sporadically wherever conditions are favorable for germination. Shrubs which occupy new territory primarily by sprouting from underground root extensions by this time occupy a much larger portion of the area.

#### Sixteen to Twenty Years After Last Cultivation

During this period annual and biennial plant species assume an exceedingly limited role in the composition of the vegetation. Ragweed, prickly lettuce, and common mullein are found only where the grass cover is sparse or on places where the ground has been disturbed, as by the workings of a mole, the dusting activities of a

pheasant, or some similar activity. Perennial herbaceous vegetation generally remains about the same, consisting principally of a ground cover of bluegrass with an interrupted overstory of goldenrod, yarrow, and St. Johnswort.

The woody plants upon 16- to 20-year-old corn land are especially prominent, but no new species seem to have been added to those already mentioned. Black cherry trees are now found up to 8 or 10 inches in diameter at 6 inches above the ground; American elm, white ash, and black walnut up to 3 inches; red oak up to 5 inches, in one case up to 10 inches; and hawthorns 3 to 4 inches in diameter at ground level. Shrubby plants have likewise increased in prominence and area occupied. Information secured during the investigation indicated that at the end of 20 years after the date of last cultivation each staghorn sumac, smooth sumac, or panicled dogwood can be expected to have grown to the following extent:

<u>Species</u>	<u>Soil Type</u>	<u>Avg.No.Yrs After culti- vation When Established</u>	<u>Rate of Invasion ft.per yr.</u>	<u>Total Feet Grown from origin</u>
Staghorn sumac	Silt loam	5	1.7	25
Staghorn sumac	Bellefontaine	5	2.7	40
Smooth sumac	Silt loam	6	2.9	40
Smooth sumac	Sandy loam	6	2.4	34
Smooth sumac	Bellefontaine	6	5.3	74
panicled dogwood	Silt loam	8	1.6	19
panicled dogwood	Bellefontaine	8	1.1	13



The population of small mammals upon cornfields from 16 to 20 years after their abandonment consists largely of short-tailed shrews and white-footed mice. Although no meadow voles were caught during the trapping experiment, their presence in grassy places was indicated by runways, feces, and other signs. Fox and red squirrels extend their trips away from their preferred tree habitat to a greater distance upon an area such as this which affords some refuge to these arboreal creatures.

The greatest number of cottontail rabbits were seen upon areas in this developmental stage. Other observations, such as the abundance of tracks upon snow beneath woody growth, cutting of sumac, droppings, and forms further indicate the presence of many rabbits.

Literature upon the common carnivores found in this region indicates that these mammals frequently utilize such brushy locations for feeding areas and denning sites. Signs observed indicated that a skunk had fed upon the fallen fruits of staghorn sumac upon such an area.

The workings of a woodchuck (Marmota monax rufescens) were found upon one of the study areas in this age group. Trippensee (unpublished), Haugen (unpublished), Gerstell (1939), and Hickie (1940) have pointed out the

value of holes made by this rodent as winter retreats for the cottontail rabbit. Haugen's work in particular demonstrates that the presence of woodchuck dens, or similarly constructed artificial dens, hold rabbits upon an area which otherwise would be incapable of supporting a rabbit population during the winter period. Skunks also make use of such holes for permanent dens or temporary winter refuges (Wight, oral interview).

Birds of prey continue to take a toll of the small mammals of the community. One observation of a red-shouldered hawk alighting in an elm sapling on a former corn field suggests the fact that tree growth of this sort assists hawks in their attempts to secure mice from such an area. Short-winged bird hawks, i. e. sharp-shinned (Accipiter velox) and Cooper's hawks (A. cooperi), which subsist upon large quantities of birds (McAtee, 1935), also occur under such a brushy habitat. The work of Errington, et al (1940) indicates that great horned owls (Bubo virginianus) take large numbers of cottontail rabbits, and therefore these birds could be predicted to make use of an area supporting such a heavy rabbit population. Other owls, notably the barred (Strix varia), screech (Otus asio), and barn owls (Tyto alba pratincola) would be expected to occur and feed upon the

nocturnal white-footed mouse.

Occasional roosts of pheasants noted upon the study areas reveal their continued use for roosting purposes by these birds. Song sparrows were seen in the dense cover about the margins. In addition, tree sparrows were observed to inhabit such localities during the winter period. Meadowlarks were likewise seen, both in the open grassy portions and perched in the more substantial shrubs and trees. Taller woody growth is apparently to the liking of robins (Turdus migratorius), Canada jays (Perisoreus canadensis), and numerous warblers (Dendroica sp.). Two nests, which may have been those of a yellow warbler (Dendroica a. aestiva), were located in hawthorns upon corn land in this stage. One woodcock (Philohela minor) was flushed from more or less dense, shrubby cover on this type.

### 3. Ecological Succession on Small Grain Land

The comparatively few abandoned small grain areas that were studied in this work makes it difficult to go into succession on this type of land in as much detail as possible in the case of corn lands, nevertheless some differences in the development are indicated by field data and mention of them will be made.

### Conditions the Year of Last Use

The significant difference in vegetation on corn and small grain stubble fields the fall of their last use seems to be that in the case of grain fields the vegetation consists of a greater number of important species, both annual and biennial, and perennial. Ragweed is the predominant annual and may occupy as much as 21 to 40 per cent of the area. Foxtail grass is also common, more so than on corn land. Other annuals found at this time are crab grass, old witch grass, lambs-quarters, and small amounts of peppergrass. Perennials are rather irregular in their occurrence and consist largely of red clover, sheep sorrel, silvery cinquefoil, and narrow-leaved plantain.

As in the case of corn fields, American elm and black cherry seed in abundance with the crop, percentages of the total records in each case being approximately 40 per cent and 25 per cent respectively. The next most common species to become established at this time is hawthorn. Other tree species found to have germinated during this period are shagbark hickory, swamp white oak, red or black oak, and basswood. Each species in this last group was found about the extreme edges of the fields.

Limited observations on woody shrubs seem to indicate that the establishment of these plants seldom takes place in this early stage in the development.

The rodent population on small grain stubble fields is similar to that found on cornfields the year of their last use, consisting largely of prairie deer-mice and house mice. That pheasants also utilize these fields is indicated by the amount of waste ~~small~~ grains consumed by pheasants (Dalke, unpublished), chiefly during the periods of heavy corn consumption mentioned previously. Horned larks, and occasional tree sparrows and juncos also make use of these lands.

#### One to Two Years After Last Cultivation

In this stage annual and biennial vegetation consists principally of ragweed with little or no prickly lettuce, and a cover of foxtail grass. Wild carrot appears for the first time, as do also black bindweed and false flax. The abundance of crab grass and old witch grass is apparently reduced. Red clover and quack grass are important perennials encountered. Sheep sorrel, silvery cinquefoil, narrow-leaved plantain, and peppergrass still occur. Besides quack grass, other perennials which become established at this time are bluegrass and cinquefoil.

Records for American elm and black cherry on small grain lands indicate that about 60 per cent of the elm and 30 per cent of the cherry reproduction takes place between 1 and 2 years after the date of last cultivation. In addition, 40 per cent of the observations for hawthorn on grain lands show that this species comes in largely at this time. Large-toothed aspen, shagbark hickory, white oak, sassafras, and basswood become established, while such woody shrubs as blackberry, wild rose, smooth sumac, and panicled dogwood also come in at this time.

Trapping records indicate that the vegetation on 1- to 2-year-old grain fields provides a suitable habitat for large numbers of deer-mice and house mice, and for a few meadow voles, short-tailed shrews, and white-footed mice. The predators of these small animals, as the various birds of prey and several carnivores, utilize such areas is suggested by their known food habits. The use of fields during this period by pheasants and quail is also to be anticipated from accounts previously described for corn lands. Original notes indicate that songbirds such as tree sparrows and juncos make use of these areas as in the case of the 1- and 2-year-old corn lands.

### Three to Five Years After Last Cultivation

The vegetation upon grainfields in this state of development differs markedly from that upon fields in the previous stage. Annual plant species have disappeared from grainfields by this time, but the biennial wild carrot persists in abundance. Dominant perennials are bluegrass, goldenrod, and aster. Others of lesser importance are strawberry, cinquefoil, alfalfa, and yarrow.

The establishment of black cherry is limited during this period while that of American elm is practically non-existent. Hawthorn may continue to seed in on suitable locations. Quaking aspen also apparently becomes established between 3 and 5 years after the date of last cultivation. Records indicate that shagbark hickory, red oak, basswood, staghorn sumac, and smooth sumac germinate on small grain lands during this period. Raspberry has also made its appearance by this time.

The most abundant rodent in this association is the meadow vole, but moderate numbers of deer-mice still endure the changed conditions. The presence of a few white-footed mice, house mice, and short-tailed shrews was confirmed. That cottontail rabbits are numerous was evidenced by their droppings, forms, cutting of red oak, basswood, and hawthorn, and by individuals seen. Two broad-winged hawks were observed to frequently hunt over this community.

Several roosts indicate the use of such an area by pheasants. Undoubtedly many other forms of wildlife obtain their livelihoods from grain land that has developed to this stage.

#### Six to Ten Years After Last Cultivation

Since the writer failed to secure any grainfields in this stage of development, it is impossible to make definite statements regarding the status of succession during this period. However, ring counts for red and black oaks, hawthorn, and black cherry upon older lands indicate that in a few instances these species had become established from 6 to 10 years after abandonment.

#### Eleven to Fifteen Years After Last Cultivation

As in the case of 3- to 5-year-old grainfields, herbaceous vegetation upon fields that have been abandoned for from 11 to 15 years is chiefly of the perennial habit, but nevertheless wild carrot occurs sparingly, while ragweed, prickly lettuce, and common mullein grow in places where the sod has been disturbed. Dominant perennial species present are bluegrass, goldenrod, and aster, but other species such as timothy, quack grass, St. Johnswort, and yarrow are also present in minimal amounts.

Tables IV and V show that few new woody plants



become established, however New Jersey tea comes in by this time. For the most part those species already present have attained a considerable diameter, and the extent of area which they cover has increased.

The small mammal population in this association consists of white-footed mice, which occur commonly throughout the entire area under the protection of stands of woody shrubs or trees, meadow voles which inhabit the grassy situations, and short-tailed shrews which are present in both types of habitats. Signs observed of cottontail rabbits indicate that these mammals make heavy use such a brushy area. Their forms, fecal pellets, and cutting of New Jersey tea, hawthorn, black cherry, and American elm were noted. One set of three red fox feces, containing principally the fur and bones of meadow voles, shows the use of such an area by this carnivore. A skunk den and tracks of a skunk and an opossum (Didelphis v. virginianus) indicate the presence of these mammals upon the study area in this age class.

Pheasants are present in such a community as evidenced by numerous tracks, roosts, droppings, and birds seen. Robins make use of such an area in searching for insects and feeding upon the fruits of several woody shrubs. That grain fields in this stage of development

are attractive to mourning doves as nesting sites was indicated by the finding of a nest of this bird in a hawthorn tree.

#### Sixteen to Twenty Years After Last Cultivation

Herbaceous vegetation upon grainfields in this developmental stage consists almost entirely of perennial plant species, however the biennial common mullein still occurs in places where the grass cover is not too dense. Bluegrass and goldenrod are the dominant perennials found. In addition, such species as timothy, quack grass, strawberry, St. Johnswort, and several others are present.

By 20 years after the date of last cultivation, grainfields support a rather evenly distributed stand of trees consisting chiefly of black cherry, American elm, and hawthorn with small amounts of red oak, white oak, shagbark hickory, and sassafras occurring about the margins.

Data collected during this investigation indicate that shrubs of staghorn sumac, smooth sumac, and panicle dogwood on grainfields abandoned for 20 years will have grown the following distances from their point of origin:

<u>Species</u>	<u>Soil Type</u>	<u>Avg.No.Yrs. After Culti- vation When Established</u>	<u>Rate of Invasion Ft.per Yr.</u>	<u>Total Feet Grown from Origin</u>
Staghorn sumac	Silt loam	4	1.7	27
Staghorn sumac	Bellefontaine	4	2.7	43
Smooth sumac	Silt loam	3	2.9	49
Smooth sumac	Sandy loam	3	2.4	41
Smooth sumac	Bellefontaine	3	5.3	90
Panicled dogwood	Silt loam	4	1.6	26
Panicled dogwood	Bellefontaine	4	1.1	18

The small mammal population on grainfields in this developmental stage consists chiefly of white-footed mice and short-tailed shrews with occasional house mice and meadow voles. Diurnal predators of these mammals, such as the various broad-winged hawks previously mentioned, would feed upon this population by day, while at night screech owls, barred owls, and others would feed upon it. Several carnivores would also be attracted to such a community.

Fleshy fruits of the shrubs upon such an area would provide food for pheasants and other fruit-eating birds and also for skunks, which include a large amount of fruits in their diet.

That rabbits made heavy use of the one grainfield in this age group that was studied was indicated by numerous animals observed and abundant signs.

Besides pheasants on this area, other birds noted were robins, Canada jays, and song sparrows. A woodcock

was jumped from a particularly shrubby portion of the area, and such cover also proved to be suitable for a red-eyed towhee (Pipilo Erythrophthalmus).

#### 4. Ecological Succession on Hay Fields

The greatest variation between study areas in any one age class occurred for land which was in hay, i. e. clover and timothy, or alfalfa. In part this was due to a poor stand on some of the areas, and in part to the fact that some of the areas had been mown each year while others had simply been left idle.

##### Conditions the Year of Last Use

There seems to be no marked difference in the herbaceous vegetation on fall grainfields and fall hayfields except for the presence of alfalfa in the case of hay. Such a condition is to be expected since oat fields are frequently sown to hay while the grain crop is still on the ground. Data from Tables IV for the periods of establishment of trees indicate that no germination of either American elm or black cherry occurs at this time. Animal life on hay fields in this early state of development is apparently similar to that on cornfields and grainfields.

### One to Two Years After Last Cultivation

The conspicuous difference between the vegetation on 1- to 2-year-old hayfields and that upon cornfields and grainfields of the same age is the unimportance or absence of such annuals as ragweed, an important seed-producer, prickly lettuce, peppergrass, and false flax. Cinquefoil is also scarce. On the other hand, silver cinquefoil is apparently abundant, whereas it is relatively unimportant on small grain lands and lacking upon cornfields. Broad-leaved plantain occurs but it is not present upon the other two crop-type lands. Canada thistle also occurs in this stage.

From Table IV it is evident that two-thirds of the American elms and approximately one-third of the black cherries on hayfields become established during this period. Records for black walnut show that this species may appear on 1- to 2-year-old lands. All of the ring counts for white ash found on this type land evidence to the fact that the establishment of ash occurs chiefly at this time. Table V indicates that panicked dogwood is apparently the only woody shrub to become established.

Mice inhabiting hayfields in this developmental stage are apparently the same as on other crop lands. Their predators that have been previously mentioned, both

birds and mammals, should also occur at one time or another.

In regions where woodchucks abound, their preference for clover and alfalfa fields is well known (Anthony, 1928; Silver, 1928). Here they throw up large mounds of dirt and thereby tend to break up the sod and dense vegetation and produce sites where other plants may become established. This statement is supported by the work of Bird (1935: 384) who finds that mounds of earth thrown up by badgers play an important role in hastening successional development in the Aspen Parkland of south-central Canada.

Hayfields in late fall and winter that have been cut the previous summer seem to be far less adapted to wildlife than grain or cornlands. This is due principally to the lack of suitable protective cover and of seed-producing plants. In the spring and early summer, however, Randall (1940) reports that hayfields are chosen as nesting sites by the ringneck pheasant. Wight (unpublished) finds these areas especially attractive to pheasants during summer and early fall. Thirty-three per cent of 223 observations on pheasant broods made during this period occurred in hayfields, one of seven cover types which, according to this worker, make up a pheasant's range. Trippensee (unpublished) and many other investigators report that hayfields are preferred nesting and

rearing grounds for cottontail rabbits.

Three to Five Years After Last Cultivation

The distinguishing characteristic of vegetation on 3- to 5-year-old hayfields is the presence of timothy, which forms a moderately heavy stand, and narrow-leaved plantain is abundant. In other respects, except for the continued predominance of red clover and alfalfa, plant life is quite similar to that on the previously discussed crop lands.

Tree growth which has become established on hayfields during this period consists of moderate amounts of American elm, about one-half of the black cherry, and approximately 70 per cent of the hawthorn. Slippery elm may also germinate at this time, and blackberry and elderberry may be present.

Small mammals in this community are comparable to those found on small grain lands, but meadow voles are evidently more abundant. Predators of these animals normally occur on such areas. Three sets of red fox scats were found which were composed of large quantities of meadow vole remains. A skunk was observed to have wandered over one area in this age class.

The winter population of cottontail rabbits upon

uncut fields is apparently large as indicated by droppings, forms, damage to woody plants, and individuals seen. Pheasants and bobwhite quail also frequent such locations. Other birds noted were meadowlarks, field sparrows, and song sparrows.

#### Six to Ten Years After Last Cultivation

Vegetation on hayfields from 6 to 10 years after being planted differs from that on corn land (no small grain areas in this age class were investigated) in consisting of a relatively large variety of annual and biennial plant species. A condition of this sort is difficult to explain from original data, but it is possible that it is caused by animals which disturb the soil surface and thus lessen root competition and enable intolerant species to maintain a foothold. Some annuals and biennials that occur at this time are foxtail grass, wild carrot, common mullein, moth mullein, horseweed, ragweed and prickly lettuce. Perennial vegetation differs in including timothy, red clover, and alfalfa, and lacking species such as aster and yarrow, which are abundant on corn land in this stage of development. The decreased prominence of alfalfa and goldenrod was noted. The latter evidently is not entirely eliminated for it was found on land in an older age class.



Shagbark hickory, as shown by only one study area, appears chiefly at this time. Reproduction of black walnut, white, oak, American elm, sassafras, black cherry, and basswood also takes place in this period. Woody shrubs making their first appearance here are staghorn sumac, panicled dogwood, meadow-sweet, and prickly ash. Raspberry, wild rose, grape, poison ivy, and Virginia creeper also have become established.

The animal population upon hayfields in this developmental period apparently closely approximates that observed on corn lands. Runways, winter nests, and damage to various shrubs disclose the presence of a large number of meadow voles. Shrews also occur, and white-footed mice occasionally wander out upon such an area under the shelter of sumac or prickly berry bushes. Pheasants frequent such localities, as evidenced by their roosts and droppings, while signs observed point to a moderately large rabbit population. The den of a skunk, possibly in a former woodchuck burrow, was noted. Field sparrows, song sparrows, meadowlarks, and bobolinks were observed during the spring of 1941. Two broad-winged hawks and a marsh hawk were occasionally seen hunting over the study areas.

#### Eleven to Fifteen Years After Last Cultivation

Since no areas in this age class were studied,

concrete statements pertaining to succession in this stage of development cannot be made. Some concept of how it should appear can be obtained by interpolating between the previous stage and the following one to be discussed.

#### Sixteen to Twenty Years After Last Cultivation

Annual plant species on hayfields in this stage of development are definitely out of the picture, and the only biennial remaining is wild carrot, which was found to be uniformly distributed over both tracts of land in this age class and to occupy approximately 30 to 50 per cent of the total area. Perennial herbaceous vegetation consists chiefly of a cover of bluegrass, goldenrod, and red clover. Other perennials of minor importance are timothy, heal-all, pussy-toes, dandelion, and Canada thistle. It is significant to note that alfalfa has been eliminated by this time, but red clover continues to occur.

Tree growth upon 16- to 20-year-old hayfields is similar in appearance to that upon the other crop types, consisting primarily of a dispersed stand of American elm, black cherry, and hawthorn. Several other species such as black walnut, slippery elm, white ash, and basswood may also occur depending principally upon the

availability of seed. One of the areas studied in particular suggests that black cherry trees are not so abundant as on corn or small grain lands in spite of the presence of an adequate source of cherry seed in all surrounding fence rows.

Shrubby growth upon these areas closely resembles that found upon cornfields and grainfields cultivated approximately 20 years ago. A sufficient number of records were collected for staghorn sumac and panicled dogwood upon hayfields to predict that these two shrubs would extend from their points of origin as follows:

<u>Species</u>	<u>Soil Type</u>	<u>Avg.No.Yrs. After Culti- vation When Established</u>	<u>Rate of Invasion Ft.per Yr.</u>	<u>Total Feet Grown from Origin</u>
Staghorn sumac	Silt loam	7	1.7	22
Staghorn sumac	Bellefontaine	7	2.7	35
Panicled dogwood	Silt loam	2	1.6	29
Panicled dogwood	Bellefontaine	2	1.1	20

As a general rule it can be said that animal life in such an association as this closely corresponds to that found in the final stages of the previously discussed crop-type lands. Small mammals present are chiefly white-footed mice, and short-tailed shrews, and a considerable number of meadow voles are also found where the ground cover is composed of large amounts of bluegrass. Mammalian and avian predators of these animals which have been

referred to previously are expected to exert their influence upon such a population. A brushy habitat of this sort would also be attractive to the short-winged Cooper's and sharp-shinned hawks.

Evidences of numerous cottontail rabbits were recorded in this community. Several bobwhite quail were flushed, and two hen pheasants were seen as well as abundant pheasant signs. Other birds observed here were song sparrows, field sparrows, Canada jays, robins, and several goldfinches and warblers.

##### 5. Conditions on a Twenty-Eight-Year-Old Apple Orchard

The area included in this description is an apple orchard about 7 acres in extent planted approximately 28 years ago. According to its former owners, it was abandoned about 20 years<sup>ago</sup>. Vegetation upon it is made up of only one biennial plant species, wild carrot, which is thinly distributed over most of the area. Perennial herbaceous plant species are dominant along with both smooth sumac, staghorn sumac, and panicled dogwood. Perennial herbs occurring are principally bluegrass, pussy-toes, and strawberry which form a ground cover, and goldenrod, aster, yarrow, horsemint as an overstory. New Jersey tea and blackberry are locally abundant. Wild

trees present are American elm, black cherry, quaking aspen, and hawthorn.

Panicled dogwood was especially evident in the form of a stand 8 to 11 feet in diameter about the base of each apple tree. If such a stand of dogwood was noted without a tree in the middle of it, a stump indicated where one had formerly existed. Birds undoubtedly brought about the presence of dogwood in such locations by defecating seeds along with other excrement from perches in the trees. Dogwood is apparently more tolerant than smooth sumac, for in one instance several dead sumac stems were seen in a stand of panicled dogwood.

A ring count of a smooth sumac which apparently had died about 2 years ago gave an age of 22 years. This species, therefore, became established about 4 years after the orchard was planted. No counts were made for other woody plants on the area.

Mice caught upon this area were principally white-footed mice and meadow voles, which were present in about equal numbers. A few house mice and short-tailed shrews were also present.

Cottontail rabbits evidently were abundant as indicated by the usual signs. Tracks in the snow showed where these animals had fed heavily upon fallen apples beneath the

trees. Fox squirrels were observed to have exhibited a similar behavior. Raccoons (Procyon l. lotor), skunks, and opossums should also be found under such conditions.

This piece of land was especially attractive to pheasants. Four cock birds were flushed from it at one time on October 3, 1940, and the same day a covey of about 20 quail were put up. Two flickers (Colaptes auratus) and one downy woodpecker (Dryobates pubescens) were observed in the apple trees. Several Canada jays and robins were also noted.

The presence of such a large number of animals, which constitute the prey of numerous predatory creatures, would serve to indicate the use of this area by such <sup>predators.</sup> ~~ani-~~ ~~mals.~~ Those that would frequent the locality are weasels, red foxes, red-tailed hawks, red-shouldered hawks, Cooper's hawks, sharp-shinned hawks, great horned owls, barred owls, screech owls, and barn owls.

## XII. Conclusions

### 1. Effect of Farming Practices Upon Wildlife

In regions where wildlife is raised upon land devoted chiefly to agriculture, farming operations affect wildlife in a variety of ways. Their effect is noticeable in disturbing wild animals to the extent of causing them

to seek other places less frequented by man. However, the most obvious results of such practices are changing food and cover conditions and directly causing mortality among many species of wild animals.

The important farming operations to be considered in this connection are burning fields and fence rows, plowing, cultivating, pasturing livestock, haying and harvesting grain. Haying is the most harmful practice due to the fact that many species of farm game prefer hayfields as nesting and rearing grounds. Wight (1930, 1933), Randall (1940), and English (unpublished) report that pheasants frequently nest in such locations, however, all of these workers state that a large portion of the nests are destroyed by mowing machines. In working with the Hungarian partridge in southern Michigan, Yeatter (1934) observed that 34 per cent of the nests that were found occurred in hayfields, and that of the nests that failed because of farming operations, approximately 70 per cent of them were destroyed by haying activities. Hickie (1940) reports that mowing hay is especially destructive to the nests of cottontail rabbits. Each of the other practices mentioned above also causes mortality to wildlife during the nesting season.

As stated previously, farming practices influence

environmental conditions in such a manner as to leave agricultural lands unsuitable to wildlife over the winter period. During this critical season farm land is stripped of most of its protective cover and wild animals are forced to go elsewhere for protection. Areas providing this protection include coniferous plantations, ungrazed woodlots, kettle holes, marshes, and unused or abandoned lands. Although these locations are utilized throughout the entire year, their heaviest use comes from late fall to spring when agricultural lands fail to provide proper cover.

## 2. Value of Abandoned Lands as Sources of Food

Agricultural land that has been permitted to remain idle for any length of time provides food for a variety of wild animals depending upon the type of crop preceding abandonment and to the stage of ecological succession to which it has developed. In the fall of the year, land that has been in corn, small grain, or a grain crop seeded to hay is a valuable source of waste grain for such wildlife species as pheasants, bobwhite quail, Hungarian partridges, mourning doves, rabbits, and squirrels. Natural seeds, chiefly from ragweed, foxtail grass, and lambsquarters, are also utilized by many game birds and numerous songbirds.



During the first and second growing seasons after cultivation annual plants such as ragweed, lambs-quarters, foxtail grass, black bindweed, knotweed, and several crucifers, comprise the dominant vegetation upon cornfields and grainfields. The seeds of these plants are readily taken by all of the important game birds as well as by many common songbirds. This source of food is totally lacking upon hayfields since clover and alfalfa effectively crowd out these intolerant annuals. Leafy parts of many annual, biennial, and perennial herbs on all three crop-type lands are extensively utilized by cottontail rabbits and mice, which in turn form an important link in the food chains of numerous predatory birds and mammals.

As a general rule, hayfields and grainfields support few annual food-bearing plants for as long as 3 to 5 years after abandonment, <sup>but cornfields supply these plants up to 4 or 5 years after abandonment.</sup> The intensity of use of such areas by the various seed-eating birds previously mentioned is therefore reduced considerably. Mice and cottontail rabbits utilize crop lands that have been abandoned from 3 to 5 years to a greater extent as indicated by the presence of large numbers of these mammals. Many woody plants that have become established by this time also are used

for food by cottontails during the winter season. Bird and mammal predators likewise feed over these areas.

During the sixth to the twentieth year after abandonment, cornfields, grainfields, and hayfields yield food supplies which are relatively stable in composition but which vary to some extent with time in regard to the quantity of the different constituents present. Herbaceous seed-producing plants for the most part have been entirely eliminated; however, woody plants become increasingly important in this respect. Species occurring during this period which produce seeds or fruits of value to wildlife species are blackberry, raspberry, staghorn sumac, smooth sumac, grape, panicked dogwood, red osier dogwood, and black cherry. This food source is utilized by pheasants, opossums, skunks, and red foxes. Cottontail rabbits also obtain much food from these woody plants and others which are present upon crop lands in the later stages of development.

### 3. Value of Abandoned Lands in Providing Cover

It has been shown that by the end of the farming season, agricultural land is generally barren of cover, and also that, in the case of cornfields and grainfields, wild plant species quickly assume dominance on such land

if it is left idle during the following growing seasons. In the case of hayfields, clover, timothy, and alfalfa retard the establishment of natural vegetation for a number of years.

Cornfields and grainfields which have been abandoned for agricultural purposes are occupied for as long as 2 years by annual plants furnishing the type of cover that may be over 2 feet in height but which forms an inefficient ground cover. Such cover as this provides nesting sites for numerous wild animals as well as spring, summer, and fall pheasant roosting sites. It is poorly adapted to the protection of wildlife against severe winter conditions. In the event that hayfields are permitted to remain uncut the first 2 years after being planted, these lands furnish substantial cover that affords moderate winter protection to bobwhite quail, Hungarian partridges, cottontail rabbits and other species of animals. In the spring and early summer hayfields which have been cut the previous year, as well as those that were uncut, provide suitable nesting and brood areas for many game birds and for cottontail rabbits.

Herbaceous vegetation upon cornfields and grainfields that have been idle for longer than 3 or 4 years becomes of a perennial nature and consists of large amounts of

bluegrass and broad-leaved herbs. This cover type is especially attractive to wild animals for nesting sites, brood areas, and roosting sites. Cottontail rabbits also utilize it for resting cover, as evidenced by the numerous rabbit forms observed in this type. Abandoned hayfields are likewise used by wildlife in the above manner.

Beginning approximately 10 years after the time of abandonment, the vegetation upon idle lands plays an important role in furnishing winter cover to cottontail rabbits and escape or refuge cover for rabbits, pheasants, and bobwhite quail, and crowing areas for pheasants. At this time vegetation functioning as winter cover or escape cover consists of clumps of woody shrubs scattered over the area or stands of woody plants that have invaded the area from such places as fencerows, ditches, rock piles, or stumps. Shrubs that furnish this shelter are chiefly blackberry, raspberry, panicled dogwood, and prickly ash. Staghorn sumac and smooth sumac alone are inferior in this respect, but they have some value in supporting vines such as grape and bittersweet, which are capable of forming excellent winter cover or <sup>winter</sup> escape cover under such conditions.

As stated earlier in this report, in regions where woodchucks are abundant, abandoned lands are frequently

inhabited by these large rodents. Holes made by these animals were also stated as valuable winter retreats for cottontail rabbits which are later taken over by skunks for denning purposes. Because of the fact that woodchucks living upon uncultivated lands seldom interfere with farming operations, they are rarely persecuted in such locations. Consequently, protection afforded to wild animals by woodchuck holes is another type of cover which is sometimes associated with abandoned lands.

#### 4. Use of Abandoned Lands by Wildlife

##### Hungarian Partridge

Consideration of the Hungarian partridge has for the most part been omitted from this investigation because of the relative scarcity of this bird throughout Washtenaw County. However, since this bird is unique in its food and cover requirements, brief mention of it will be made at this time.

According to Yeatter (1934), the Hungarian partridge is capable of existing in a habitat composed almost exclusively of cornfields, grainfields, and hayfields, but brushy areas are used to some extent for cover in the early spring while crop lands are being planted. Grassy

areas may be occasionally selected as nesting sites when such areas are adjacent to agricultural lands.

Abandoned cornfields and grainfields would be attractive as feeding areas for this bird for about 2 years after cultivation. Idle lands which have reached the bluegrass stage, i.e. after 5 or more years after abandonment, would be used to some extent for nesting as indicated above. Brushy margins of fields abandoned for as long as 10 years would also be occasionally utilized for protective cover.

#### Pheasant

That pheasants use tracts of abandoned land for feeding areas, nesting sites, brood areas, crowing areas, and roosting sites is evident from previous discussion concerning the general trends of succession. During the first 2 years following abandonment, cornfields and grainfields are extensively utilized for feeding areas and to some extent for roosting sites. By 5 years after abandonment, earlier in the case of hayfields, idle crop-lands provide excellent nesting sites, roosting sites, and brood areas. Approximately 10 years after the date of cultivation these lands support a sufficient amount of shrubby cover to make them attractive as crowing

areas and as sources of the fruits of many common woody plants. Such woody vegetation may also be utilized by these birds as escape cover.

This investigation has made it apparent that land which has been abandoned for 5 years or more are valuable to pheasants chiefly in providing nesting and roosting sites during the early spring, and roosting sites during the fall when suitable cover is lacking upon agricultural lands. Since pheasants are usually ready to nest in the spring before agricultural crops of the year are far enough advanced to provide proper cover, vegetative growth of the previous season upon abandoned lands fulfills an important function in this connection. The presence of ready nesting cover would result in larger pheasant broods, for it has been demonstrated that clutches of eggs laid early in the season are larger than those laid at a later date (Randall, 1940). In addition, nests situated upon uncultivated lands would not be subjected to any of the destructive farming practices previously mentioned. Therefore, such nests would also have a greater chance of being carried through to completion.

Except during the first few years of abandonment, uncultivated lands provide little food of value to

pheasants. For this reason the ideal situation for pheasants would be a tract of abandoned land surrounded by lands which are in a variety of crops. The crop lands would be used primarily as sources of food, while the area of abandoned land would provide comparatively safe nesting and rearing grounds.

### Bobwhite Quail

Abandoned agricultural lands are attractive to bobwhite quail during the entire course of succession that has been discussed. As in the case of pheasants and Hungarian partridges, cornfields and grainfields in the first 2 years of development are heavily utilized by these birds as feeding areas throughout the winter period. Annual seed-producing plants found sporadically upon these crop lands in later stages of development are also utilized during this period. Adequate nesting cover for quail is provided by the vegetation upon all types of unused lands. In addition, woody shrubs occurring upon lands abandoned for approximately 10 years or more furnish excellent protection that is used by quail throughout the entire year and especially during the winter season.

From the foregoing discussion it is evident that



abandoned lands in this part of the country are valuable in furnishing bobwhite quail with safe nesting sites and protection during periods of inclement weather conditions. In general, they are not adapted as feeding areas for these birds except during the first 1 or 2 years after abandonment. Such lands should therefore be used in the management of the bobwhite quail in a manner similar to that described for pheasants.

#### Cottontail Rabbits

It has been shown that tracts of abandoned land are used extensively by cottontail rabbits. Since rabbits prefer to nest in herbaceous cover, such lands are valuable in providing nesting sites for this animal for as long as such cover persists. This investigation has made it evident that suitable rabbit nesting cover is present upon abandoned lands for at least 20 years after cultivation. Uncultivated lands also supply excellent feeding areas as well as suitable resting sites for cottontail rabbits. The shrubby vegetation upon lands which have been abandoned for approximately 10 years or more provides adequate winter cover and <sup>winter</sup> feeding areas for these animals.

In view of the above discussion, it is apparent

that cottontail rabbits find most of their requirements upon tracts of uncultivated land. For this reason large areas of abandoned land are much more adapted to management for cottontail rabbits than for Hungarian partridges, pheasants, or bobwhite quail. However, as in the case of pheasants, a tract of abandoned land situated adjacent to cultivated lands would "catch" many rabbit nests which might otherwise be destroyed by farming operations. Such an area of land in a farming district would therefore result in an increase in the number of cottontail rabbits.

#### Fur-Bearing Mammals

This investigation has pointed out the fact that fur-bearing mammals such as red foxes, weasels, and skunks use abandoned lands as feeding areas without discrimination as to their ecological development. During the later stages of succession these mammals frequently utilize such abandoned areas for denning purposes. Raccoons and opossums also utilize these areas when woody cover has become established.

#### Fox Squirrels

Lands which have been withdrawn from cultivation are evidently unattractive to fox squirrels until

sufficient woody vegetation becomes established to afford adequate protection. This means that squirrels are rarely observed upon a land area that has been abandoned for less than approximately 15 years.

### XIII. Summary

1. Withdrawing agricultural lands from cultivation occurs universally throughout the United States. Land abandonment may be permanent or temporary, depending largely upon economic conditions.
2. Abandoned agricultural lands are adapted to such uses as retarding soil erosion, conserving water supplies, grazing, forestry, recreation, and wildlife management.
3. A knowledge of the principles of ecological succession is important in providing wildlife habitats.
4. Seed-producing annuals, such as foxtail grass, ragweed, lambs-quarters, etc., are dominant on cornfields for as long as 4 or 5 years after abandonment. By 5 years after abandonment herbaceous perennials are dominant. Woody shrubs and trees become conspicuous about 10 years after the date of last cultivation.
5. Important seed-producing annuals are dominant on small grain land up to 3 years after abandonment, while

perennials dominate the vegetation thereafter. Woody vegetation is prominent upon such lands as early as 10 years after cultivation.

6. Seed-producing annuals are lacking upon hayfields, being effectively crowded out by the dominating red clover, timothy, or alfalfa. Approximately 10 to 15 years after the date of planting, woody shrubs and trees are conspicuous upon hayfields.
7. Prairie deer-mice are characteristically found on cornfields and grainfields for about 5 years after cultivation. Meadow voles occur by 1 to 2 years after abandonment, short-tailed shrews are present about 5 years after abandonment, and white-footed mice are commonly found on such locations by 10 years after abandonment. Bird and mammal predators of these small mammals feed over abandoned lands during the entire course of succession that has been discussed.
8. In regions where Hungarian partridges are found, grainfields and cornfields abandoned for about 2 years should be excellent feeding areas for these birds. Cornfields and grainfields abandoned for approximately 5 years, and idle hayfields should also provide suitable nesting cover for Hungarian partridges. In addition, brushy

patches on lands abandoned 10 years or ~~more~~ more would furnish protective cover while agricultural lands are being plowed.

9. Pheasants obtain food from cornfields and grainfields for the first 2 or 3 years after abandonment, and also approximately 10 years after abandonment when fruit-bearing shrubs are abundant. All types of abandoned agricultural uplands are extensively utilized by pheasants for nesting sites, brood areas, and spring, summer and fall roosting sites. Areas which have grown up to brushy vegetation are also attractive for crowing areas.
10. Bobwhite quail make heavy use of abandoned lands. Cornfields and grainfields idle for 2 to 3 years provide excellent winter feeding areas for these birds. Adequate nesting cover is present upon agricultural lands in all the various successional stages discussed. Woody shrubs occurring in the later stages also provide suitable winter cover for bobwhite quail.
11. Tracts of abandoned lands are especially attractive to cottontail rabbits in providing food, nesting cover, and resting places. Areas grown up to brushy cover are heavily utilized for winter cover and winter feeding areas by these animals.

12. In regions where wildlife management is to be practiced, providing areas which are left uncultivated would result in the production of more wildlife by supplying cover for those species that prefer to nest early in the season, and by lessening the loss of nests from farming activities.

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APPENDIX

Common and Scientific Names of Plant Species

Used in This Investigation

Annuals and/or Biennials

Crab grass	<i>Digitaria ischaemum</i>
Old witch grass	<i>Panicum capillare</i>
Foxtail grass	<i>Setaria lutescens</i>
Bur grass	<i>Cenchrus pauciflorus</i>
Prairie three-awn	<i>Aristida oligantha</i>
Snake grass	<i>Eragrostis cilianensis</i>
Downy chess	<i>Bromus tectorum</i>
Knotweed	<i>Polygonum aviculare</i>
Black bindweed	<i>Polygonum convolvulus</i>
Lambs-quarters	<i>Chenopodium album</i>
Pigweed	<i>Amaranthus retroflexus</i>
Sandwort	<i>Arenaria serpyllifolia</i>
Peppergrass	<i>Lepidium virginicum</i>
Peppergrass	<i>Lepidium campestre</i>
Shepherd's purse	<i>Capsella bursa-pastoris</i>
False flax	<i>Camelina microcarpa</i>
Mustard	<i>Brassica kaber</i>
Hedge mustard	<i>Sisymbrium officinale</i>
Sweet clover	<i>Melilotus alba</i>
Clover	<i>Trifolium sp.</i>
Snake root	<i>Polygala senega</i>
Evening primrose	<i>Oenothera biennis</i>
Wild carrot	<i>Daucus carota</i>
Common mullein	<i>Verbascum thapsus</i>
Moth mullein	<i>Verbascum blattaria</i>
Horseweed	<i>Erigeron canadensis</i>
Ragweed	<i>Ambrosia artemisiifolia</i>
Goats-beard	<i>Tragopogon pratensis</i>
Bull thistle	<i>Cirsium lanceolatum</i>
Prickly lettuce	<i>Lactuca scariola</i>
Prickly lettuce	<i>Lactuca canadensis</i>

Perennials---Herbs

Lichen	<i>Clavaria sp.</i>
Common moss	<i>Ceratodon sp.</i>
Pigeon moss	<i>Polytrichum commune</i>
Horsetail	<i>Equisetum sp.</i>
Timothy	<i>Phleum pratense</i>
Redtop	<i>Agrostis alba</i>
Bluegrass	<i>Poa pratensis</i>
Quack grass	<i>Agropyron repens</i>
Dock	<i>Rumex crispus</i>
Sheep sorrel	<i>Rumex acetosella</i>
Anemone	<i>Anemone cylindrica</i>
Winter cress	<i>Barbarea vulgaris</i>
Strawberry	<i>Fragaria virginiana</i>

Perennials---Herbs (cont.)

Silvery cinquefoil  
Cinquefoil  
Avens  
Red clover  
Alfalfa  
Tick trefoil  
Bush clover  
Spurge  
St. Johnswort  
Dogbane  
Milkweed  
Catnip  
Heal-all  
Horse mint  
Butter-and-eggs  
Broad leaved plantain  
Narrow leaved plantain  
Goldenrod  
Aster  
Pussy toes(1)  
Pussy toes (2)  
Pearly everlasting  
Sunflower  
Yarrow  
Canada thistle  
Chickory  
Dandelion

Potentilla argentea  
Potentilla canadensis  
Geum sp.  
Trifolium pratense  
Medicago sativa  
Desmodium sp.  
Lespedeza capitata  
Euphorbia corollata  
Hypericum sp.  
Apocynum sp.  
Asclepias syriaca  
Nepeta cataria  
Prunella vulgaris  
Monarda fistulosa  
Linaria sp.  
Plantago Rugelli  
Plantago lanceolata  
Solidago sp.  
Aster sp.  
Antennaria neglecta  
Antennaria sp.  
Anaphalis margaritacea  
Helianthus scaberrimus  
Achillea millefolium  
Cirsium arvense  
Cichorium intybus  
Taraxacum officinale

Perennials---Woody Shrubs

Hazelnut  
Meadow-sweet  
Prickly ash  
Raspberry  
Blackberry  
Wild rose  
Staghorn sumac  
Smooth sumac  
Poison ivy  
New Jersey tea  
Grape  
Virginia creeper  
Panicked dogweed  
Red osier dogwood  
Cranberry  
Elderberry  
Bittersweet

Corylus americana  
Spiraea salicifolia  
Zanthoxylum americanum  
Rubus occidentalis  
Rubus allegheniensis  
Rosa sp.  
Rhus typhina  
Rhus glabra  
Rhus toxicodendron  
Ceanothus americanus  
Vitis sp.  
Psedera quinquefolia  
Cornus paniculata  
Cornus stolonifera  
Viburnum lentago  
Sambucus canadensis  
Celastrus scandens

Perennials---Trees

Quaking aspen  
Large-toothed aspen

Populus tremuloides  
Populus grandidenta

Perennials---Trees (Cont.)

Black walnut	Juglans nigra
Shagbark hickory	Hicoria ovata
White oak	Quercus alba
Swamp white oak	Quercus bicolor
Black oak	Quercus velutinus
Red oak	Quercus rubra
Slippery elm	Ulmus fulva
American elm	Ulmus americana
Sassafras	Sassafras varifolium
Hawthorn	Crataegus sp.
Black cherry	Prunus serotina
White ash	Fraxinus americana
Basswood	Tilia glabra
Box elder	Acer negundo
Sugar maple	Acer saccharum

Table VIII Field Data on Annual and/or Biennial Plant

Species Found on Corn Lands

Age Class in Years	0				1-2					3-5				6-10		11-15		16-20		
	25	43	44	58	24	32	33	35	56	22	47	59	60	21	49	52	12b	31	46	
Area in Acres	10	2	6	4	3	5	1	5	8	9	8	4	5	17	2	4	10	15	7	
Number of Quadrats	6	8	9	9	9	10	8	6	11	9	11	9	9	10	7	11	21	13	6	
Soil Type	SaL	BSL	BSL	SiL	SaL	SiL	SiL	BSL	SiL	SiL	SaL	BSL	BSL	SiL	SiL	SiL	BSL	SiL	SaL	
Crab grass *		1 7	0 4		0 2															
Old witch grass	0 5	0 3		0 4	0 1	1 8	1 5				0 2									
Foxtail grass	0 4	1 9		1 9	2 10	2 10	2 8	0 7	1 7	1 8	1 8			0 1		0 1				0 2
Bur grass																				
Prairie three-awn																				
Snake grass	0 5		0 2		0 1															
Downy chess					0 2		0 2													
Knotweed					0 3	0 2		0 2												
Black bindweed		0 1	0 1		1 9	0 2	0 3	1 7	0 1											
Lambs-quarters	1 5	0 4	0 2		2 10		3 10	0 2	0 1											
Pigweed					0 1	0 1														
Sandwort								0 2												
Peppergrass (1)					0 3	0 4			0 2		0 3									
Peppergrass (2)																0 1				
Shepherd's purse			0 1		0 1															
False flax					0 5	0 1		1 9												
Mustard					0 4	0 1	0 2		0 1											
Hedge mustard					0 2											0 1				
Sweet clover																				
Clover						1 3		1 5		1 6			0 3							
Snake root											1 3									
Evening primrose											1 6									
Wild carrot						0 1			0 5					0 1	0 3	1 6		1 10		
Common mullein		0 2			0 1			0 1		0 1	1 6	0 1	1 6		0 1	0 2				0 1
Moth mullein										0 2				0 1						0 2
Horseweed					0 3	0 1	0 2		0 1	1 5	1 5	0 4								
Ragweed	1 10	0 2	1 9	1 10	2 10	3 10	1 7	2 10	2 8	1 7		0 5	0 5			0 1	0 1			0 2
Goats-beard																	0 3			
Bull thistle						0 2		0 1		0 1										
Prickly lettuce (1)					1 9	0 4	2 10	1 7	0 1	1 6	0 1	0 3	0 2				0 1			0 1
Prickly lettuce (2)																				
Tot. No. Species	5	7	6	3	18	14	9	11	9	8	8	5	4	3	2	5	4	1	5	
Av. For Ea. Class		5.2			12.2					6.2				2.5	5			3.3		
Soil Type:	SiL--Silt loam; SaL--Sandy loam; BSL--Bellefontaine sandy loam																			

\* Figure on the left in each column is the coverage class index; on the right is the Frequency of occurrence index.

Perennial  
Table IX. Field Data on Herbaceous Plant  
Species Found on Corn Lands

Age Class in Years	0				1-2					3-5				6-10		11-15		16-20						
Area Number	25	43	44	58	24	32	33	35	56	22	47	59	60	21	49	52	12b	31	46					
Area in Acres	10	2	6	4	3	5	1	5	8	9	8	4	5	17	2	4	10	15	7					
Number of Quadrats	6	8	9	9	9	10	8	6	11	9	11	9	9	10	7	11	21	13	6					
Soil Type	Sal	BSL	BSL	SIL	Sal	SIL	SIL	BSL	SIL	SIL	Sal	BSL	BSL	SIL	SIL	SIL	BSL	SIL	Sal					
Lichen *																								
Common moss						0	1						1	9	1	4								
Pigeon moss																0	2	0	1					
Horsetail																0	1	0	1					
Timothy										0	4			1	5			0	1					
Redtop						0	3		1	3		1	6		1	3								
Bluegrass		1	8			0	1	0	3	2	10	1	6	5	10	1	6	2	7	1	7			
Quack grass			0	1					0	1	1	8		0	1									
Doak		0	2				0	1							0	1	0	2						
Sheep sorrel	0	5			0	2			0	1		1	7	2	8	2	9	0	3					
Anemone																0	2							
Winter grass		2	10																					
Strawberry											0	1	0	2	0	2			0	1				
Silvery cinquefoil	1	7		0	2					0	1	1	6	1	6	2	8		0	1				
Cinquefoil			0	3	0	1			0	1	0	3		1	5	0	2	0	2	0	3	0	1	
Avens										0	1									0	1			
Red clover						0	3		1	7	2	10	1	9					0	3				
Alfalfa			0	4					1	5	0	2							0	3				
Tick trefoil																								
Bush clover																								
Spurge																					0	2		
St. Johnswort																0	2			0	2	0	2	
Dogbane														0	1			0	1			0	1	
Milkweed							0	2	0	2				1	5									
Catnip		0	2				0	3																
Heal-all									0	1				0	2					0	2	0	1	
Horse mint															0	1			1	4		0	2	
Butter-and-eggs					0	1								0	1			1	6					
Broad l'd plantain									1	8	0	3	0	1			0	1						
Narrow l'd plantain	0	2		1	3	0	1		1	8		0	1		0	2			0	1				
Goldenrod									0	1	0	2		0	3	1	6	2	9	1	8	1	6	
Aster														0	2	0	3	0	4			1	3	
Pussy toes (1)																						3	10	
Pussy toes (2)																						0	1	
Pearly everlasting											1	8		0	3	0	3	0	2			0	1	
Sunflower																							0	2
Yarrow														0	1	1	8	0	4	0	3	1	10	
Canada thistle				0	2		1	4		0	1	0	2	0	4		0	3				0	2	
Chickory																								
Dandelion		0	2						0	2	0	3		0	4	0	3					0	1	
Tot. No. Species	5	5	3	3	4	5	4	6	11	10	12	15	12	13	12	17	15	12	9					
Av. For Ea. Class		3.2									12.2				12.5	17		12.0						

Soil Type: SIL--Silt loam; Sal--Sandy loam; BSL--Bellefontaine sandy loam

\* Figure on the left in each column is the coverage class index; on the right is the frequency of occurrence index.



Table X. Field Data on Annual and/or Biennial  
Plant Species Found on Small Grain Lands

Age Class in Years	0		1-2		3-5	6-10	11-15	16-20
Area Number	57	45	29	38	48	30	28	12a
Area in Acres	20	6	6	9	7	13	6	10
Number of Quadrats	10	9	11	8	10	9	11	21
Soil Type	Sal	BSL	SiL	BSL	SiL	SiL	SiL	BSL
Crab grass *	0 3	0 5		2 9				
Old witch grass	0 4	0 1		1 8				
Foxtail grass	1 9	1 10	0 3	2 10	0 4			
Bur grass		0 7						
Prairie three-awn								
Snake grass				0 2				
Downy chess								
Knotweed								
Black bindweed			0 2					
Lambs-quarters	0 1	0 4		0 2				
Pigweed								
Sandwort								
Peppergrass (1)	0 1		0 1					
Peppergrass (2)			0 4					
Shepherd's purse								
False flax			0 4					
Mustard			0 1					
Hedge mustard								
Sweet clover		1 2			0 1			
Clover				1 10				
Snake root								
Evening primrose					0 1		0 2	
Wild carrot			0 2		1 8	1 7	0 4	
Common mullein							0 1	0 1
Moth mullein								
Horseweed	0 1		0 2					
Ragweed	2 10	1 10	1 10	2 10	0 2			
Goats-beard								
Bull thistle								
Prickly lettuce (1)			0 2				0 1	0 1
Prickly lettuce (2)								

Tot. No. Species	7	7	10	7	5	1	4	2
Av. For Ea. Class	7			<del>21.5</del> 7.3		1	1	2

Soil Type: SiL--Silt loam; SaL--Sandy loam;  
BSL--Bellefontaine sandy loam

\* Figure on the left in each column is the coverage class index; on the right is the frequency of occurrence index.

Table XI. Field Data on Herbaceous Perennial Plant

## Species Found on Small Grain Lands

Age Class in Years	0		1-2		3-5		6-10	11-15	16-20
Area Number	57	45	29	38	48	30		28	12a
Area in Acres	20	6	6	9	7	13		6	10
Number of Quadrats	10	9	11	8	10	9		11	21
Soil Type	SaL	BSL	SiL	BSL	SiL	SiL		SiL	BSL
Lichen *									1 6
Common moss						1 6			0 2
Pigeon moss									1 4
Horsetail									
Timothy								0 1	0 1
Redtop									
Bluegrass					3 10	2 9		5 10	3 10
Quack grass			4 10		0 2			0 1	0 1
Dock					0 1				
Sheep sorrel	1 7			1 8	0 1				0 2
Anemone									
Winter cress									
Strawberry					0 1	0 5			1 5
Silvery cinquefoil	1 8				1 5				
Cinquefoil			0 1		0 1	0 2			0 2
Avens									
Red clover	2 9		1 8		2 8				
Alfalfa				1 9	0 1	0 2			
Tick trefoil									
Bush clover									0 2
Spurge									0 4
St. Johnswort								0 1	0 3
Dogbane									
Milkweed									
Catnip									
Heal-all					0 1	0 2		0 1	
Horse mint								0 1	
Butter-and-eggs			0 1						0 1
Broad l'd plantain					1 8			0 1	
Narrow l'd plantain	1 9		1 6		0 2				
Goldenrod						2 10		1 6	1 7
Aster		0 1			0 1	0 9		1 4	
Fussy toes (1)						0 3			0 2
Fussy toes (2)									
Pearly everlasting					0 1				
Sunflower									0 1
Yarrow					0 1	0 2		0 1	
Canada thistle			0 1		0 1			0 2	
Chickory					0 2				
Dandelion									
Tot. No Species	4	1	6	2	17	10		11	16
Av. For Ea. Class	2.5			3.3		10		11	16

Soil Type: SiL--Silt loam; SaL--Sandy loam;  
BSL--Bellefontaine sandy loam.

\* Figure on the left in each column is the Coverage class index; on the right is the frequency of occurrence index.



Table XIII. Field Data on Herbaceous Perennial Plant

## Species Found on Hayfields

Age Class in Years	0	1-2	3-5						6-10			11-15	16-20	
Area Number	27	41	4	18a	18b	20	26	42	37	61	62		2	63
Area in Acres	15	6	20	15	15	20	10	13	8	4	10		13	8
Number of Quadrats	6	7	13	10	10	7	13	9	9	8	11		11	8
Soil Type	SaL	SiL	SiL	SiL	SiL	SiL	SaL	SiL	BSL	SiL	BSL		SiL	SiL
Lichen *														
Common moss		0 3						1 4			0 1		0 4	1 5
Pigeon moss														
Horsetail													0 1	
Timothy			0 3	2 9	1 3	2 10			0 2	0 3	2 10		0 1	0 5
Redtop											0 3			
Bluegrass		0 3	4 10	0 1	2 9		1 4	2 9	5 10	4 10	2 7		4 10	4 10
Quack grass				1 2	0 1					1 8				
Dock		0 2	0 1	0 1	0 1			0 2	0 2		1 6			
Sheep sorrel	0 4		0 2			0 1	2 8	0 3	0 4		1 6			
Anemone														
Winter cress														
Strawberry			0 4										0 1	
Silvery cinquefoil	1 10	1 8			0 1		1 10	1 9			0 3			
Cinquefoil			1 6	0 2	0 4			0 2			0 1		0 1	
Avens			0 2		0 1					0 1				
Red clover	2 10	1 9	0 4	3 9	1 5			0 3	0 4	0 3	2 10		1 10	2 10
Alfalfa	1 7	4 10	2 8	0 1	3 10	3 10	2 10	4 10	0 4					
Tick trefoil									0 2					
Bush clover														
Spurge														
St. Johnswort			0 1						0 3	0 2			0 1	
Dogbane														
Milkweed									0 2					
Catnip									0 2		0 1			
Heal-all					0 1								0 1	0 1
Horse mint									0 1	1 4				
Butter-and-eggs														
Bread l'd plantain		0 3	0 3	0 4	1 6	0 1			0 2	0 3	0 3		0 1	
Narrow l'd plantain	0 2	0 3			0 1		1 10	1 6		0 2	0 2			0 2
Goldenrod			2 9	0 2	0 2						0 1		2 8	0 3
Aster			0 3							0 2				
Pussy toes (1)										0 1	0 1		0 1	0 2
Pussy toes (2)														
Pearly everlasting			0 1		0 1				0 1	1 6				
Sunflower										0 4				
Yarrow			0 1										0 1	
Canada thistle		0 2	0 1	0 2	1 3		0 1		0 2		0 3			0 2
Chickory														
Dandelion		0 6						0 3			0 4		0 4	1 6
Tot. No. Species	5	10	16	10	15	4	6	10	14	13	16		14	10
Av. For Ea. Class	5	10			10.1					14.3				12.0

Soil Type: SiL--Silt loam; SaL--Sandy loam; BSL--Bellefontaine sandy loam

\* Figure on the left in each column is the coverage class index; on the right is the frequency of occurrence index.



Table XV. Occurrence of Woody Shrubs and  
Trees on Small Grain Lands

Age Class	0		1-2			3-5	6-10	11-15	16-20
Area Number	57	45	29	38	48	30		28	12a
<b>Woody Shrubs</b>									
Hazelnut								X	X
Meadow-sweet									
Prickly ash									
Raspberry						X		X	
Blackberry						X		X	X
Wild rose									X
Staghorn sumac								X	X
Smooth sumac					X			X	
Poison ivy									
Bittersweet									
New Jersey tea								X	
Grape									X
Virginia creeper									
Red osier dogwood									X
Panicled dogwood						X			X
Cranberry									
Elderberry									
<b>Trees</b>									
Quaking aspen						X			X
Large-toothed aspen									
Black walnut									
Shagbark hickory			X			X			
White oak						X			X
Swamp white oak			X						
Red and black oaks						X			X
Slippery elm								X	
American elm			X			X		X	X
Sassafras									X
Hawthorn						X		X	X
Black cherry						X		X	X
White ash									
Basswood			X			X			
Box elder									
Sugar maple								X	

Table XVI. Occurrence of Woody Shrubs and  
Trees on Hay Lands

Age Class in Years	0	1-2	3-5						6-10			11-15	16-20		
			27	41	4	18a	18b	20	26	42	37		61	62	2
<b>Woody Shrubs</b>															
Hazelnut											X	X			
Meadow-sweet											X	X			
Prickly ash															X
Raspberry			X								X				
Blackberry			X												X
Wild rose											X				
Staghorn sumac			X											X	X
Smooth sumac											X			X	
Poison ivy											X				
Bittersweet															
New Jersey tea															
Grape												X		X	
Virginia creeper												X			
Red osier dogwood											X				
Panicled dogwood			X								X				
Cranberry															
Elderberry				X										X	
<b>Trees</b>															
Quaking aspen			X												
Large-toothed aspen			X												
Black walnut			X											X	X
Shagbark hickory			X								X				
White oak															
Swamp white oak															
Red and black oaks															
Slippery elm											X				X
American elm			X	X							X				X
Sassafras											X				
Hawthorn			X						X	X				X	X
Black cherry			X		X				X	X	X				X
White ash			X												
Basswood															X
Box elder															
Sugar maple			X												

Table XVII. Data on Invasion Rate of

## Woody Shrubs

Species	Area No.	Soil Type	Years	Total Ft. Invaded	Rate of Invasion Ft. per Yr.
Hazelnut	12a	Bellfontaine	11	1	0.1
"	"	"	14	3	0.2
"	"	"	9+	3	0.3
				Average	0.2
Raspberry	21	Silt loam	10*	15	1.5
"	"	" "	10-	10	1.0
"	49	" "	10*	16	1.6
				Average	1.4
"	59	Bellefontaine	5	25	5.0
"	32	Carlisle muck	1	3	3.0
Blackberry	4	Silt loam	4	16	4.0
"	21	" "	10-	3	0.3
"	52	" "	12	16	1.3
				Average	1.9
"	46	Sandy loam	18*	36	2.0
"	"	" "	"	16	0.9
"	"	" "	"	23	1.3
				Average	1.4
Wild rose	29	Silt loam	2	2	1.0
" "	49	" "	10	4	0.4
				Average	0.7
Staghorn sumac	2	Silt loam	18	40	2.2
" "	21	" "	5	11	2.2
" "	"	" "	5	3	0.6
" "	"	" "	8	10	1.2
" "	"	" "	5	10	2.0
" "	"	" "	8	11	1.4
" "	"	" "	5	8	1.6
" "	"	" "	5	8	1.6
" "	"	" "	6	11	1.8
" "	"	" "	9	20	2.2
" "	"	" "	5	9	1.8
" "	"	" "	5	9	1.8
" "	"	" "	5	9	1.8
" "	"	" "	7	14	2.0
" "	"	" "	10	22	2.2
" "	"	" "	4	10	2.5
" "	"	" "	5	10	2.0
" "	"	" "	6	12	2.0



Table XVII. (Cont.)

Species	Area No.	Soil Type	Years	Total Ft. Invaded	Rate of Invasion Ft. per Yr.
Staghorn sumac	48	Silt loam	4	2.5	0.6
" "	49	" "	5	8	1.6
" "	61	" "	3	3	1.0
" "	"	" "	3	2.5	0.8
" "	28	" "	9	16	1.8
				Average	1.7
Smooth sumac	21	Silt loam	5	19	3.9
" "	"	" "	3	6	2.0
" "	30	" "	5	10	2.0
" "	49	" "	5	16	3.2
" "	52	" "	12	30	2.5
" "	61	" "	10	30	3.0
" "	"	" "	10	30	3.0
" "	52	" "	4	15	3.7
" "	28	" "	10	34	3.4
				Average	3.5
" "	46	Sandy loam	18±	43	2.4
" "	"	" "	18±	43	2.4
				Average	2.4
" "	35	Bellefontaine	2	16	8.0
" "	"	" "	2	10	5.0
" "	36	" "	11	40	4.5
" "	--	" "	7	35	5.0
" "	--	" "	8	32	4.0
				Average	5.3
Poison ivy	61	Silt loam	10	16	1.6
Panicled dogwood	28	Silt loam	12±	18	1.6
" "	"	" "	12±	20	1.7
" "	30	" "	5	12	2.4
" "	63	" "	18	15	0.8
				Average	1.6
" "	12a	Bellefontaine	18	23	1.3
" "	"	" "	9	13	1.4
" "	"	" "	8	8	1.0
" "	"	" "	5	4	0.8
				Average	1.1
Red osier dogwood	12a	Bellefontaine	11	0.3	0.03
" "	12b	" "	8	0.3	0.04
" "	"	" "	12	0.4	0.03
" "	--	" "	5	0.5	0.1
" "	--	" "	6	0.3	0.05
				Average	0.05
Hawthorn	30	Silt loam	5	16	3.2
Bittersweet	12b	" "	18	30	1.7

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