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The Effects of Oil Well Sites on Forest Species of Birds

Wendy J. Baker

THE EFFECTS OF OIL WELL SITES ON FOREST SPECIES OF BIRDS

by

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THE EFFECTS OF OIL WELL SITES ON FOREST SPECIES OF BIRDS

Wendy J. Baker, M.A.

Western Michigan University, 1987

Fifty censuses were taken in 9 transects adjacent to 8 oil well openings. It was found that 2 species, the red-eyed vireo (Vireo olivaceus), and the ovenbird (Seiurus aurocapilus) were significantly affected in spatial distribution. These forest species had significantly lower numbers near the oil well site than in the forest. Two other forest species suggested the same pattern. The effect of the oil well site reaches well into the forest.

Other possible effects of the oil well sites are competition with edge species and brood parasitism by the brown-headed cowbird. Noisier sites may also affect the bird community within the forest. The low number or absence of other forest species may indicate that there have been adverse effects prior to this study.

ACKNOWLEDGMENTS

I would like to express my sincere appreciation to all who helped with my study, Claudia Kohler, Patricia Fagg, Stuart Turnbull, and Rachel Simmons. I especially appreciate LuAnne Ashley and Chris Haviland for all the vegetation work they did. I would like to thank Dr. Richard Brewer, major advisor, for his help in field methods and manuscript preparation. Finally, my sincere appreciation to Dr. Richard Pippen and Dr. David Cowan, my committee members, for their help and encouragement.

Wendy J. Baker

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INTRODUCTION

Concern has grown about the loss of forest in the United States, particularly the Northeast. Areas that used to be large, continuous tracts of forest now contain only patches of forest, or forest islands. Forest fragmentation has been the focus of a number of studies (Blake 1983, Burgess & Sharpe 1981, Conner & Adkisson 1975, Howe 1984). Certain species tend to be lost from the smaller patches (Blake 1983, Galli, Leck, & Forman 1976, Whitcomb et al. 1981). Among birds, these area-sensitive species tend to share certain life history traits: (a) long distance migrants, (b) nest on or near the ground, (c) open nests, (d) usually raise one brood per year, and (e) relatively small clutch size (Robbins 1979).

Within the last two decades there has been a surge of oil exploration and extraction in the northwest lower Peninsula of Michigan. As a consequence, patches in the forest cover have been clearcut for pumping stations, access roads, pipelines and storage sites. It seemed possible that the oil well sites had an effect on the fauna of the surrounding forest. This study concentrated on the avifauna, especially the area-sensitive forest species of birds. Basic information on bird responses to oil well sites, specifically, and clearcut patches in the forest in general are presented here. The study has practical value for guiding land-use decisions in this area.

METHODS

The study sites were established in large blocks of northern hardwood forest. Pctential sites were chosen using Agricultural Stabilization and Conservation Service aerial photographs taken in August 1984. Sites were then examined on the ground and selected on the basis of (a) forest composition, which needed to be similar from one site to another, (b) undisturbed forest extending 1500 feet (457.14 meters) from at least one edge of the site to allow placement of a transect, and (c) absence of broad open areas, such as a road or pipeline, running through the transect area or within 100 feet (30.5 meters) of any side of the transect. Eight areas were selected.

Transects 210 feet (64 meters) wide and 1050 feet (320 meters) long were set up along one edge of each of the eight sites (Figure 1). The transects were sectioned into 5 one-acre squares 210 feet (64 meters) on a side. The squares were sequentially numbered with 1 next to the edge of the site and 5 farthest into the undisturbed forest (Figure 1).

Decibel meter readings were taken at seven of the sites. The first reading was taken on the oil well opening where the noise originated. If there was no noise caused by machinery on the site, the reading was taken in the center of the opening. The second reading was

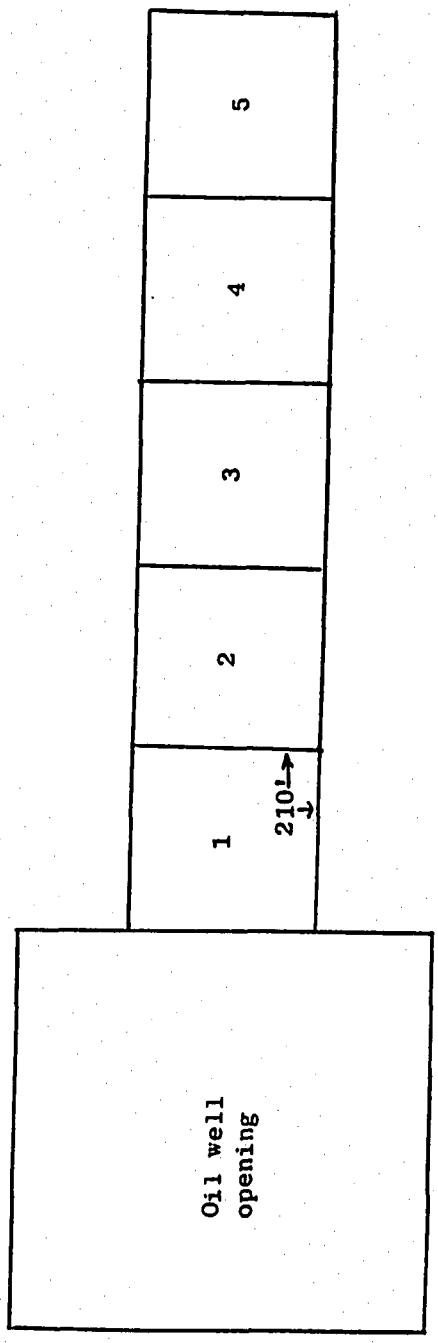

Figure 1. Diagram of a Transect Line

taken ten feet away from the first, toward the edge of the transect. The third was 20 feet from the first.

Location of Sites

All the sites, located in Blue Lake and Cold Springs townships in Kalkaska County, Michigan, are as follows:

Blue Lake Township

1. N1/2 of E1/2 Sec 8 T28N R5W
2. NE1/4 of NW1/4 of NW1/4 Sec 17 T28N R5W
3. NW1/4 of SW1/4 of SW1/4 Sec 16 T28N R5W
4. S1/2 of NW1/4 Sec 20 T28N R5W
5. N1/2 of NW1/4 Sec 33 T28N R5W

Cold Springs Township

6. SW1/4 of NW1/4 of SE1/4 Sec 13 T28N R6W
7-8. SW1/4 of NW1/4 of SE1/4 Sec 13 T28N R6W
9. NW1/4 of SW1/4 of SW1/4 Sec 24 T28N R6W

At 7-8 two transect lines were set up along two different edges of the one site.

Forest Composition

Large trees, 15cm diameter at breast height (DBH) or larger, were catalogued using the point-centered quarter method (Cottam & Curtis 1954). Small trees, less than 15cm DBH, were counted in circle plots of 100 meters square (Appendix A). Both the large and small tree samples were taken at two corners of each of the five sections in all 9 transects giving 10 samples of large trees and 10 samples

of small trees for each transect. Herbaceous species were noted in each quadrat of each transect.

The DBH of the large trees was recorded to get an idea of forest maturity. The DBH measurements were used to estimate basal areas and were added to calculations of relative frequency and relative dominance to determine the Importance Values of each species (Brewer & McCann 1982).

Species along the edge of the openings were recorded using the line intercept method. Each individual plant which came into contact with a straight line on three sides of each oil well opening was counted (Appendix B).

Censusing

Censusing was done during the peak of territorial advertisement, between 16 May 1985 and 11 June 1985. All birds seen or heard were plotted on daily maps (Figure 1). Seven minutes were spent in each acre and in the oil well site itself. Birds were recorded both in the quadrat being censused and the quadrat ahead of it. Each acre was thus censused a total of 14 minutes during one census period. Two sites were censused each morning between 7:30 and 10:00, alternating early and late censusing each time. Each census was begun at the oil well clearing and systematically continued along the transect until the last quadrat, number 5, was reached at the end of the census time. It took 49 minutes to complete a census. The fifth acre was always reached 42 minutes after the start of the cen-

sus period. Actual censusing of the 5th quadrat started 35 minutes after the beginning of the census period.

Each site was censused five times except #4 which was censused 10 times to assess the adequacy of sampling. The 10 censuses at site 4 were spread throughout the census dates ranging between 16 May and 8 June. Each site was also censused once on nine consecutive evenings between 9:30 and 10:30 pm. This was to record any night birds present. Totals were 50 day censuses and 9 evening censuses.

Study Areas

History

Logging in the late 1800s and early 1900s has left its mark on much of the forested land in Kalkaska County. White pine (Pinus strobus) was the primary species logged (Lewis 1973). Following the clearcutting of white pine, and some hardwood stands, fires spread throughout the area (Lewis 1973, Frederic Historical Society 1977).

Much of the region is now occupied by mixed hardwood forest, between 60 and 80 years old. The areas surrounding the oil well sites in this study have very few conifers on them.

Soils

The soils in Michigan were formed by glacial deposits

which cover the bedrock layer. Sandy glacial drift is the parent material for soils of the study region. They are considered Haplorthods, which are well drained spodosols, formed under coniferous and mixed hardwood cover (Sommers 1978). The soils in the areas studied are primarily what is known as Kalkaskan. The Kalkaska series is "somewhat excessively drained, rapidly permeable soils on outwash plains, moraines, and old beach ridges. The soils formed in sandy glacial drift" (USDA 1978, p. 34).

Geology

The geologic formation from which oil and gas are taken in Kalkaska County was formed in the Paliozoic era. It is middle Silurian rock of the Niagaran series. Niagaran reefs often contain oil and gas (Dorr & Eschman 1971). Silurian rock in the Michigan Basin contains large amounts of rock salt, or halite. Some estimates claim that the aggregate thickness of Silurian salt is 2000 feet. Brine is often brought up while drilling and has to be disposed of. The methods of disposal combined with porous soil may cause environmental problems by ground water contamination.

Study Sites

By far the most abundant tree species in the forest around each oil well site was sugar maple (*Acer saccharum*).

The Importance Values for this species ranged from 105.3 to 208.1 which were higher than any other species (Table 1). Sugar maple was also the most abundant understory species. The density of sugar maple was also high and most of the large trees measured were in the 15-22.9 cm DBH class. Small maples created thick understories especially near the edge of the sites. American Beech (Fagus grandifolia) and Basswood (Tilia americana) were also important canopy trees (Table 1).

I obtained copies of the applications for drilling permits for sites 3, 4, 6, 7/8, and 9. The dates on the permits ranged between 1977 and 1983. The sites at the time of the study were, therefore, approximately 2 to 8 years old.

Oil Drilling Activities

When oil drilling began in Kalkaska County, the ratio of success was 6 out of 10. This, however, has decreased rapidly until now only 1.5 out of 10 drillings are successful (Mason, Personal Communication).

About 35 different companies are involved in the process from the start of drilling for oil to the production. First, there is the leasor. When the land is leased the oil company can then come in. The oil company hires a driller who in turn hires service companies to set up and maintain equipment. These latter include a testing company, produc-

Table 1

Importance Values for Large Trees (>15 cm. DBH)

	Site Number									
Species	1	2	3	4	5	6	7	8	9	Mean
Sugar Maple	105.2	131.1	202.5	153.3	167.1	208.1	164.2	179.0	179.3	165.5
Basswood	48.0	48.0	85.6	17.9	53.6	0.0	78.6	98.8	69.4	55.5
Beech	34.1	81.2	11.9	46.1	49.3	0.0	20.5	13.5	23.0	31.1
Hop-Hornbean	31.7	0.0	0.0	9.6	0.0	0.0	8.3	0.0	10.8	6.7
Cherry	0.0	8.5	0.0	29.1	0.0	0.0	9.4	8.8	0.0	6.2
Red Maple	9.9	31.2	0.0	15.0	0.0	17.9	0.0	0.0	0.0	8.2
Aspen	71.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.9
Birch	0.0	0.0	0.0	29.1	0.0	24.9	10.5	0.0	0.0	7.2
Ash	0.0	0.0	0.0	0.0	0.0	0.0	8.7	0.0	0.0	1.0
Oak	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.9	2.0

tion company, operator, and finally, a transport company which transports the oil or gas from the site.

When a site is chosen, roads must be cleared for easy access and for large equipment. For the site, and area, usually between 40,000 and 250,000 square feet, is cleared. The size depends on the number of wells located on the site and the conditions of the lease. More than one well may be drilled on a site, depending upon the proximity of the wells to the property line. Maximum production, by law, is 300 barrels per day. If the well is too close to the property line then maximum production must be cut in half. In that case, another well may be drilled further from the property line allowing a maximum production of 450 barrels for the one site. Production of six barrels per day is the minimum at which the equipment can, mechanically, be kept running.

When drilling begins, it is not known whether they will get oil, gas, brine, water, a mixture of anything and it is usually a mixture. The mixture can change quickly, sometimes within 24 hours. A close watch is kept on what comes out of the well, especially at the beginning. The mixture usually comes out of the well in the beginning by its own pressure. This is known as a free-flowing well. The free flow could last from a few months to several years. It is not cost effective to keep a well running which needs to be mechanically pumped from the beginning.

A site which has no production facilities is connected to a pipeline through which the oil/gas is transported to a site with production facilities. At a production site there is an electrical or gas-powered generator. The gas generators are less costly and easier to install with the gas right at the site. They are, however, much noisier which creates a problem with many of the residents within several miles of a site.

The equipment at a production site consists mainly of the generator, storage tanks, compressor, scrubber, meter house, and a heater. The heater and compressor are used to keep the mixture under pressure. The mixture, called a condensate, is pressurized in order to control consistency. The scrubber removes unwanted chemicals and water. At those sites lacking a scrubber, the contaminated gas is burned off at the site. The meter house is where the gas and oil pressures are monitored. Once production is begun, and running smoothly, the main human activities on the site are transport of the oil and monitoring the pressure meters.

Size and Activity of each Study Site

The sites chosen for this study varied in size and the amount of activity and machinery on the site. Sites 1, 4, 5, 7-8, and 9 have no production facilities. These wells pump the mixture directly into a pipeline to a production site. Sites 2, 3, and 6 have production facilities

and consequently higher activity levels, as well as higher noise levels from the machinery. Sites 2 and 3 are notably larger (Table 2 and Figures 2-9) and louder (Table 3) than any of the other sites. The generators on these sites are gas powered and can be heard up to several miles away.

Table 2

Size of clearing for each site

	Site Number							
	1	2	3	4	5	6	7-8	9
Size								
Acres	1.81	3.44	4.66	1.83	2.07	1.17	1.85	1.43
Hectares	0.74	1.40	1.90	0.74	0.84	0.48	0.75	0.58

Diagrams of each site are shown in Figures 2-9.

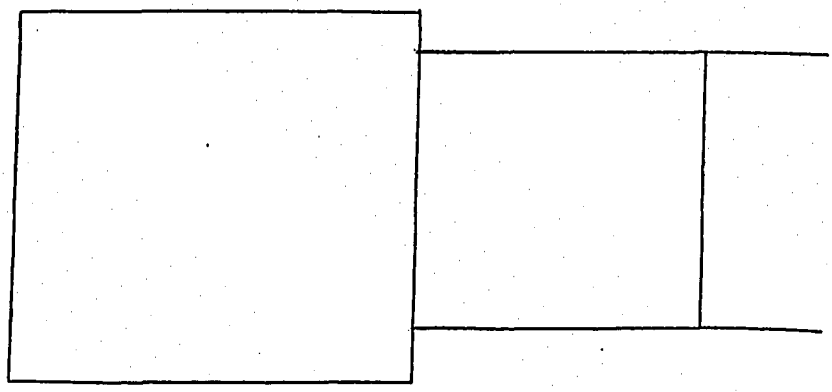

Figure 2. Diagram of Site 1 and Direction of the Transect.

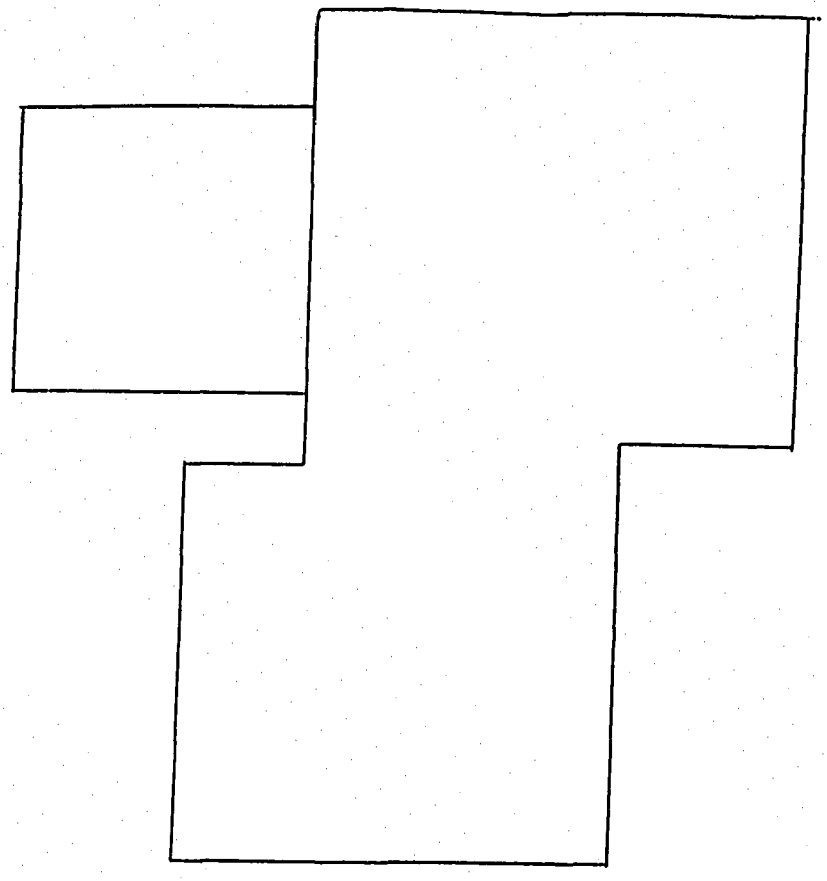

Figure 3. Diagram of Site 2 and Direction of the Transect.

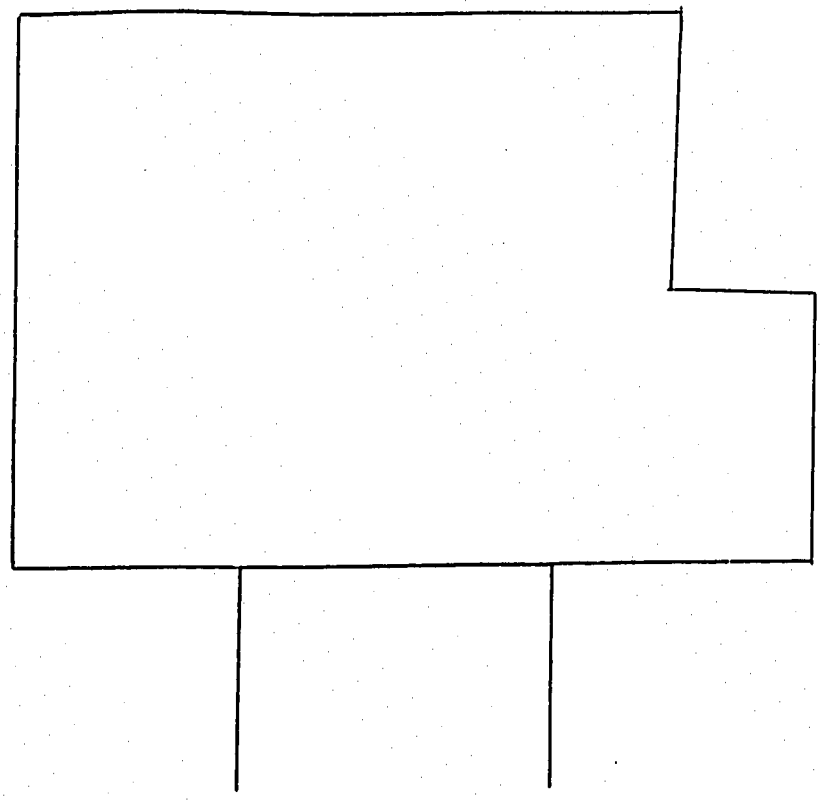

Figure 4. Diagram of Site 3 and Direction of the Transect.

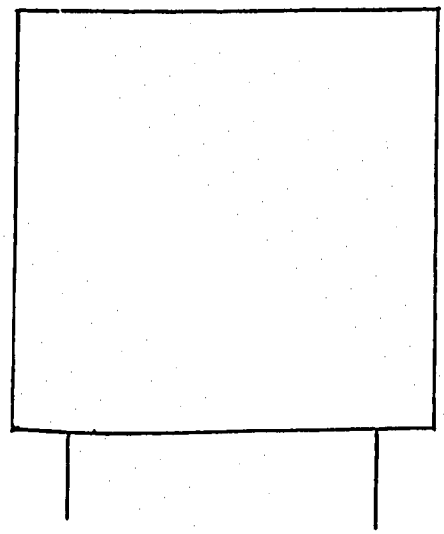

Figure 5. Diagram of Site 4 and Direction of the Transect.

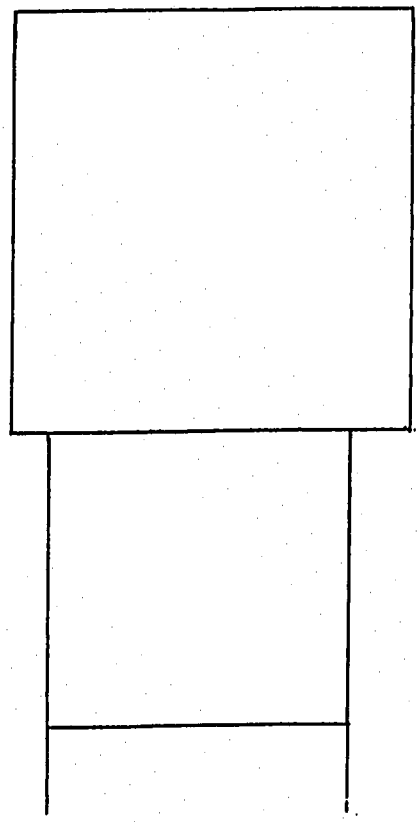

Figure 6. Diagram of Site 5 and Direction of the Transect.

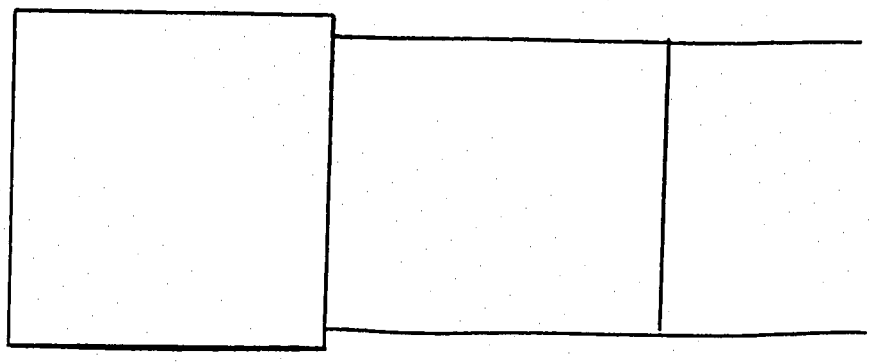

Figure 7. Diagram of Site 6 and Direction of the Transect.

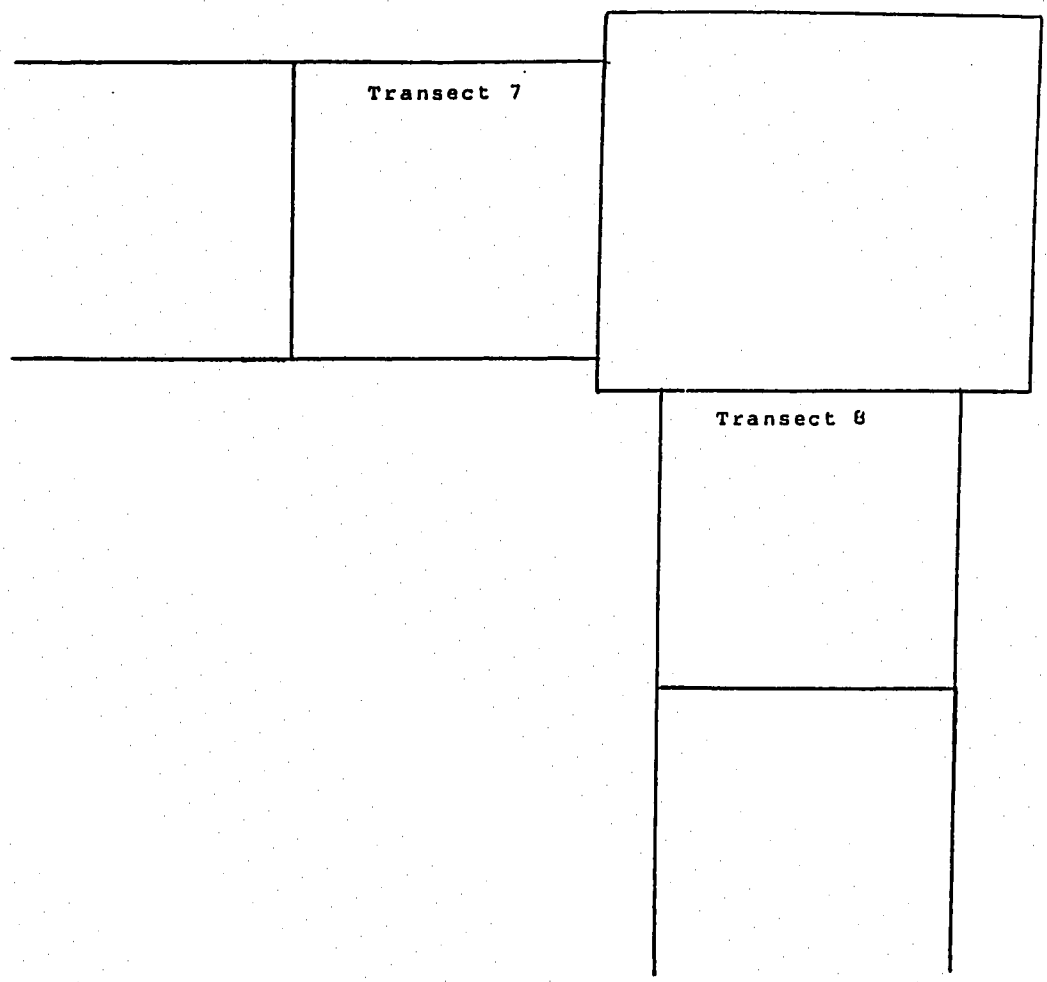

Figure 8. Diagram of Site 7/8 and Direction of the Transects.

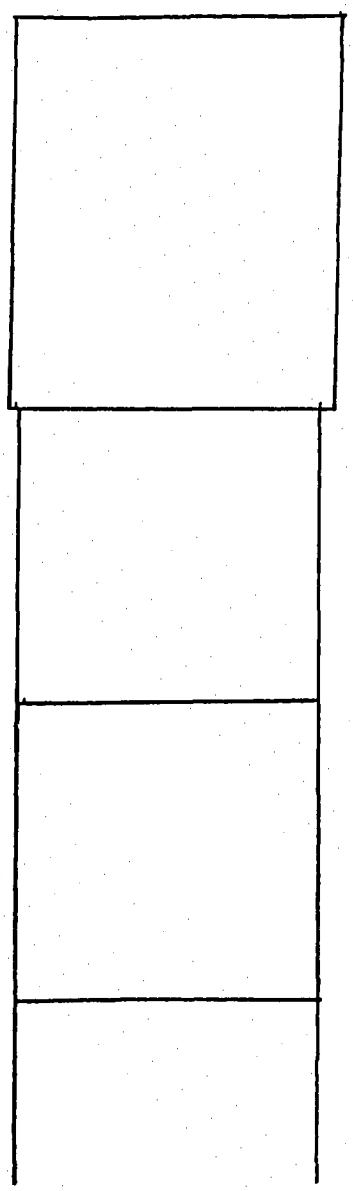

Figure 9. Diagram of Site 9 and Direction of the Transect.

Table 3

Decibel Meter Readings: On the Site, 10 Feet Away and 20 Feet Away and at the End of Each Quadrat Within the Transect. February 1986.

	Site Number							
Distance	1	2	3	4	6	7	8	9
Within	72	100	103	76	96	46	46	44
10 feet	62	97	94	69	84	46	46	44
20 feet	51	95	78	62	79	47	46	44
1	43	70	63	45	67	46	46	46
2	43	62	60	43	57	46	46	42
3	43	62	55	49	50	47	45	47
4	44	59	54	43	47	45	47	42
5	42	54	54	44	48	45	43	43

Note: Site 5 is not included because of inaccessibility due to snow cover in the winter when these readings were taken. There was no noticeable activity or noise on this site during the census period.

RESULTS

A total of 30 bird species occurred on the 50 censuses. Twenty-five of these were observed in, or on, the edge of the oil well opening. Of these, 8 species were found exclusively in the oil well opening or along the edge. Five species were recorded in all quadrats as well as the oil well opening. Four species were found exclusively within the transect and not in the oil well opening.

The 26 species in Table 4 are those seen or heard more than once. The oil well openings and each of the 5 quadrats are shown separately for comparison purposes. The species in Table 4 are separated into 2 categories: (1) species more common in the forest (species having a greater number within the transect than the oil well opening or edge), and (2) species more common in the opening (species having the same or a greater number in the opening or edge than the transect).

To help assess the adequacy of sampling, site 4 was censused twice as often as the others. The number of species was increased by doubling the sample size (Table 5); however, many of the added species were rare on the sites and were probably visitors to rather than residents of the sites. There were 4 species present only once in

Table 4

Species Observed Two or More Times on Censuses.

Species		Quadrat				
Birds more common in the forest	Opening/ Edge	1	2	3	4	5
Pileated woodpecker (*Dryocopus pileatus*)	-	4	1	-	1	1
Downy woodpecker (*Piocoides pubescens*)	1	-	2	-	2	-
Hairy woodpecker (*Piocoides villosus*)	-	2	5	2	-	1
Black-capped chickadee (*Parus atricapillus*)	19	8	15	17	34	9
White-breasted nuthatch (*Sitta carolinensis*)	-	-	2	4	2	3
Red-eyed vireo (*Vireo olivaceus*)	36	9	25	23	13	26
Black-throated green warbler (*Dencroica virens*)	-	2	1	5	8	11
Ovenbird (*Seiurus aurocapilus*)	5	6	15	15	24	10
Rose-breasted grosbeak (*Pheucticus ludovicianus*)	22	17	19	18	20	13
Scarlet tanager (*Piranga olivacea*)	7	4	2	-	3	5
Blue jay (*Cyanocitta cristata*)	6	3	1	-	2	3
Great crested flycatcher (*Myiarchus crinitus*)	7	-	7	4	2	1
Birds more common in the openings/edge						
Mourning dove (*Zenaida macroura*)	12	-	-	-	-	-

Table 4--continued

Species		Quadrat				
Tree swallow (*Iridoprocne bicolor*)	19	-	-	-	-	-
Chestnut-sided warbler (*Dencroica pensylvanica*)	8	-	-	-	-	-
Northern oriole (*Icterus galbula*)	2	2	-	-	-	-
Brown-headed cowbird (*Molothrus ater*)	22	3	1	3	3	2
Cedar waxwing (*Bombycilla cedrorum*)	16	5	-	2	3	-
Indigo bunting (*Passerina cyanea*)	29	-	-	-	-	-
Chipping sparrow (*Spizella passerina*)	9	1	1	1	3	-
Eastern wood pewee (*Contopus virens*)	8	2	1	1	-	1
Least flycatcher (*Empiconax minimus*)	5	2	1	-	-	-
American crow (*Corvus brachyrhynchos*)	1	-	-	1	-	1
American robin (*Turdus migratorius*)	23	4	-	3	1	2
Yellow-billed cuckoo (*Coccyzus americanus*)	4	-	1	-	3	-

Table 5

Total Number of Species, Mean, and Standard Error for the 10 Censuses in Transect 4 Compared With the Range, Mean, and Standard Error of 10 Sets of 5 Censuses Randomly Chosen From the 10 Censuses of Transect 4.

	10 Censuses	10 Sets of 5 Censuses		
Total Number of Species		Range	Mean	Standard Error
Oil Well Site	16.0	10-16	12.8	0.664
Quadrats 1-5	13.0	8-13	10.4	0.452
Total Number of Individuals				
Oil Well Site				
Mean	6.2	4.6-7.8	5.8	-
Standard Error	0.876			
Quadrats 1-5				
Mean	11.2	5.6-12.4	9.6	-
Standard Error	1.831			

the transect at site 4 during the census period: great crested flycatcher (Myiarchus crinitus), black-throated blue warbler (Dendroica caerulescens), American redstart (Setophaga ruticilla), and scarlet tanager. Five other species were present only twice during the census period. Eight species were, therefore, uncommon or incidental.

Five censuses seemed adequate for assessing overall abundance. Of 10 sets of 5 censuses randomly chosen, only 1 was more than 2 standard errors beyond the mean for the 10 censuses (Table 5).

Forest Species

This study focuses on the forest species of birds. Of the 12 species more common in the forest, 5 were seen or heard enough times that they could be compared statistically. The 5 most common forest species were black-capped chickadee, rose-breasted grosbeak, red-eyed vireo, black-throated green warbler, and ovenbird.

When abundance of forest species is plotted against distance from the oil well site, several patterns are evident (Figures 10-15). First, quadrat 1 nearly always has lower numbers than the other quadrats. Second, the numbers do not steadily increase from quadrat 1 to quadrat 5. The red-eyed vireo had 2 well defined peaks, in quadrats 2 and 5 (Figure 10). The rose-breasted grosbeak (Figure 11) showed little change over the transect except for a drop

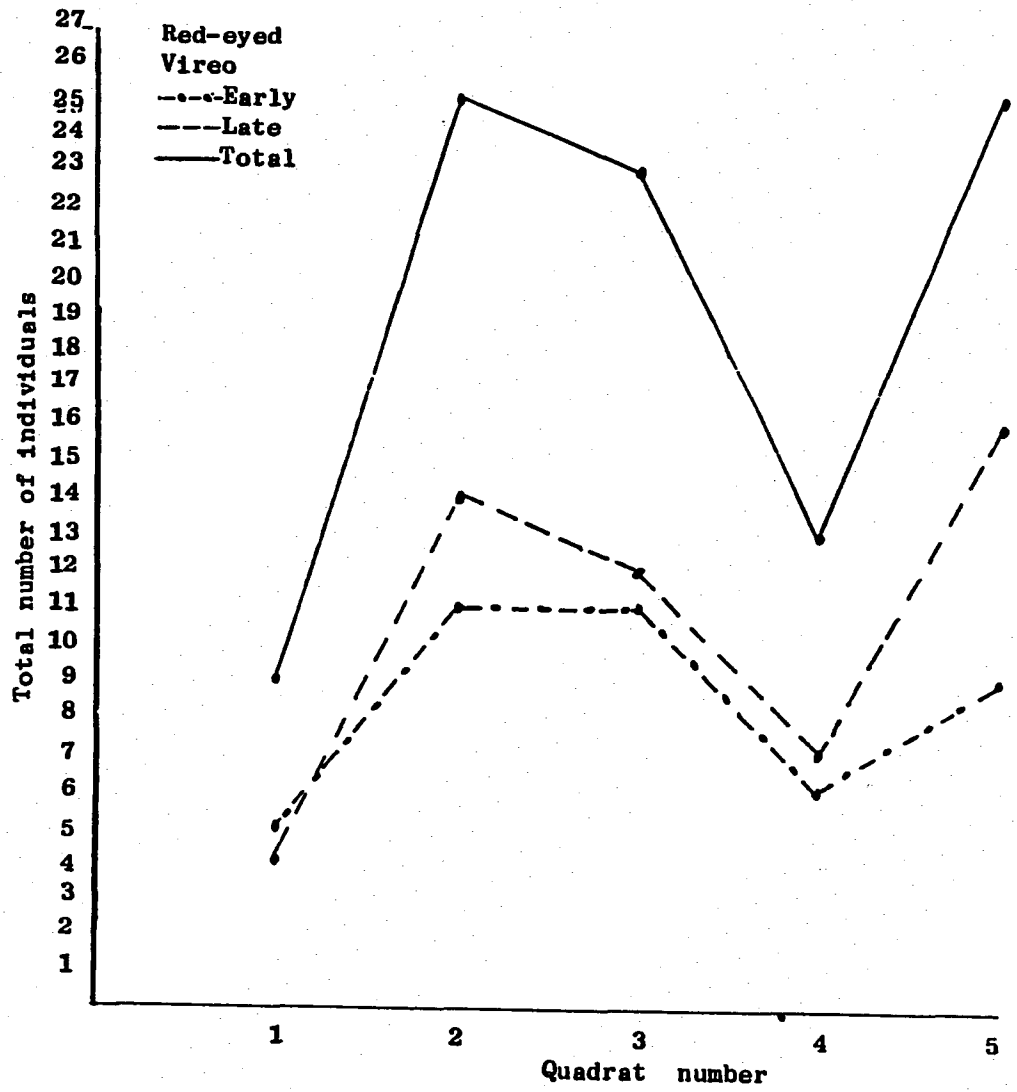

Figure 10. Number of Individuals/Quadrat.

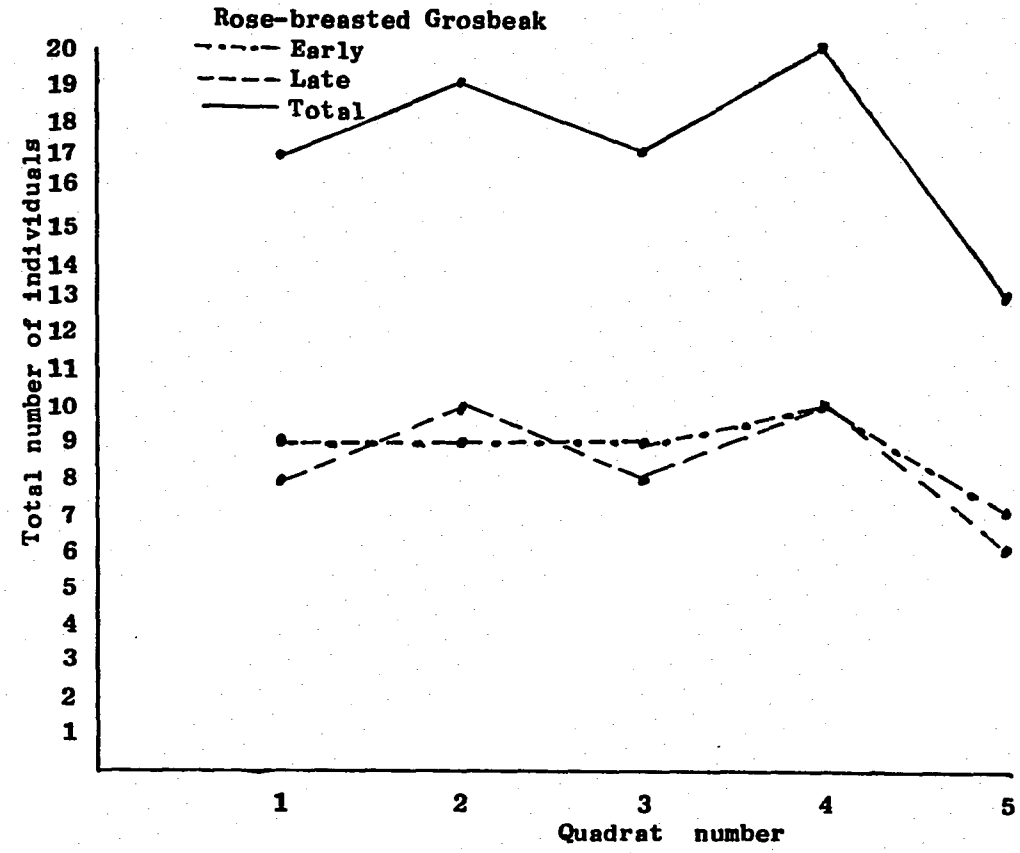

Figure 11. Number of Individuals/Quadrat.

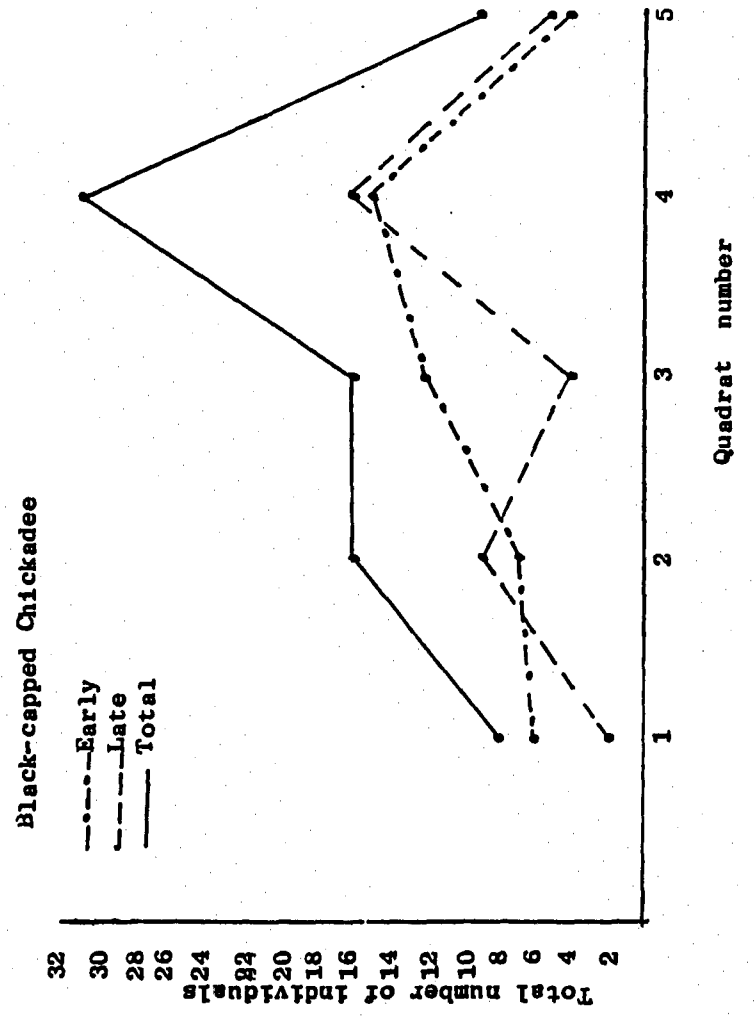

Figure 12. Number of Individuals/Quadrat.

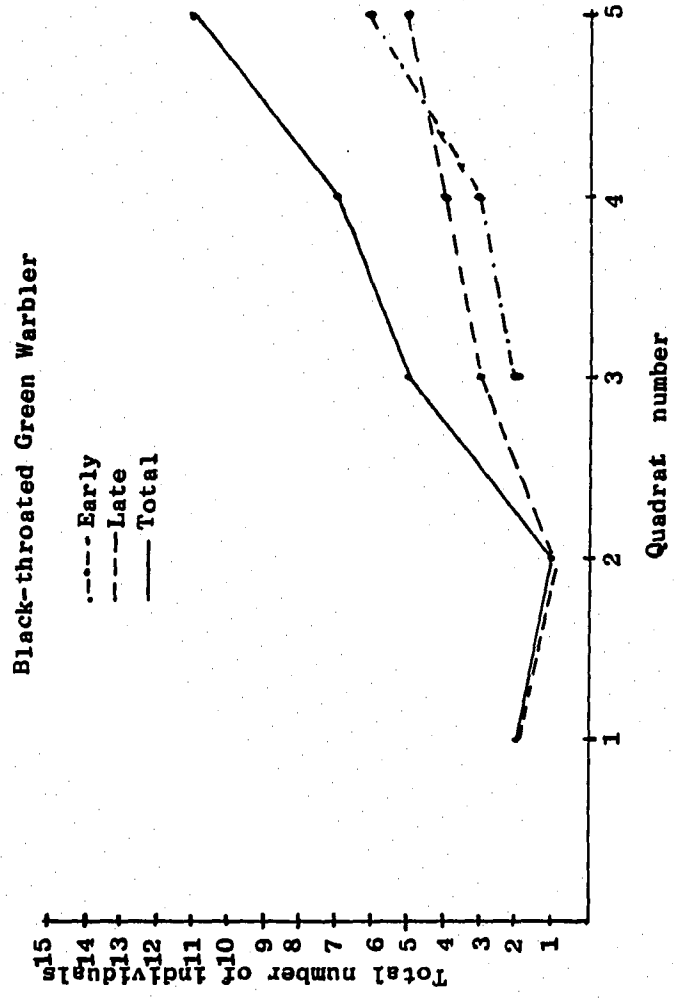

Figure 13. Number of Individuals/Quadrat.

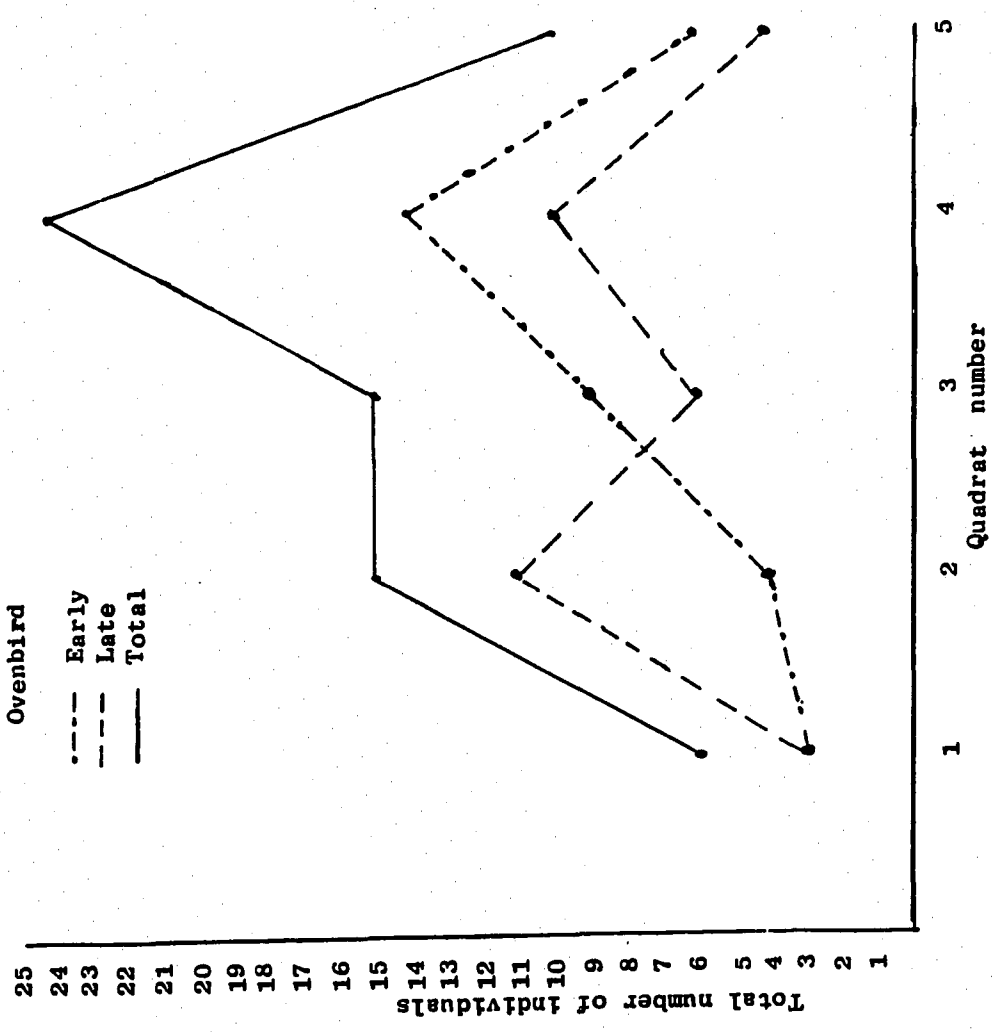

Figure 14. Number of Individuals/Quadrat.

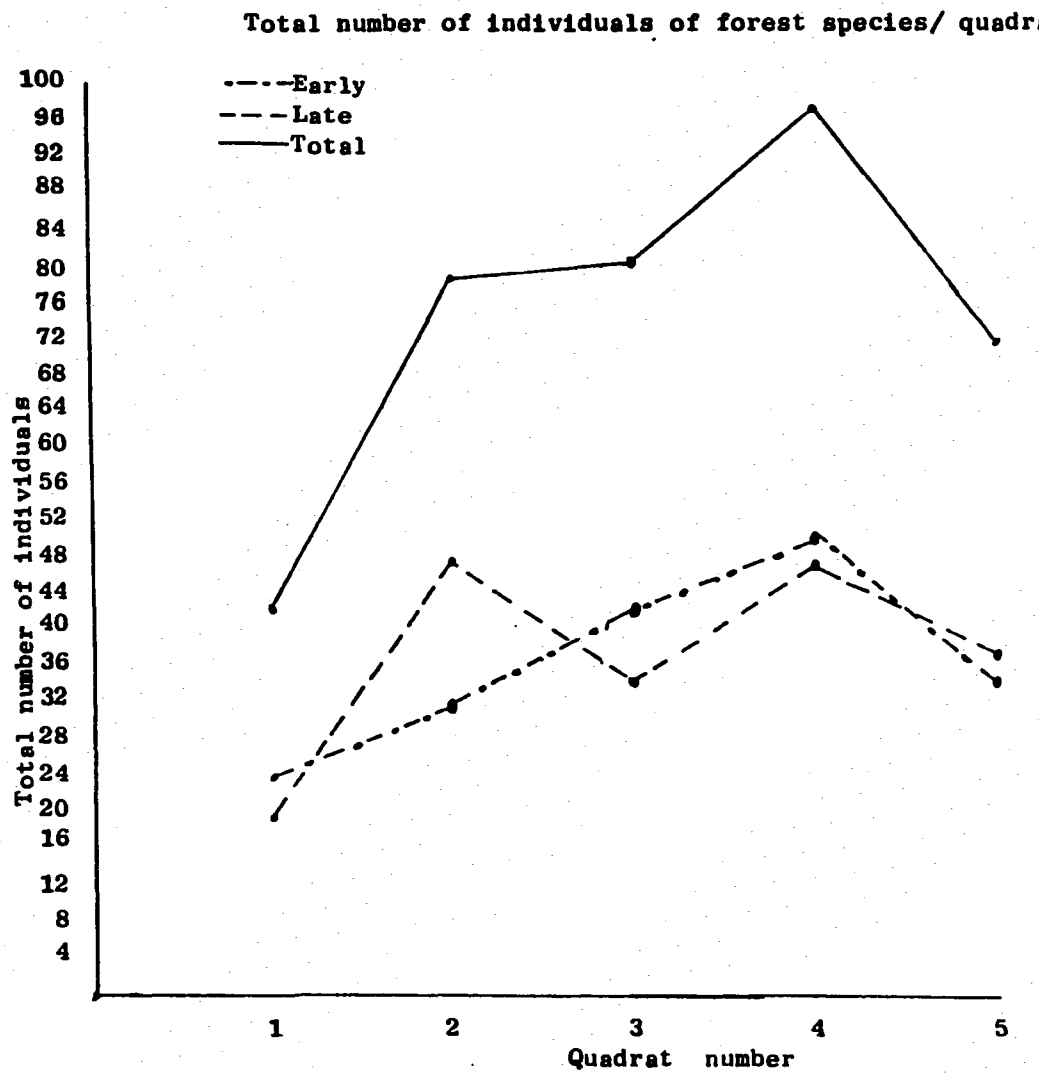

Figure 15. Total Number of Individuals of Forest Species/Quadrat.

in quadrat 5. Both the black-capped chickadee (Figure 12) and the ovenbird (Figure 14) showed a peak in quadrat 4. The black-throated green warbler (Figure 13) increased rather steadily away from the oil well site. For all 5 of these forest species together, the peak is in quadrat 4 and a drop in quadrat 5 (Figure 15).

All species except the grosbeak showed a significant deviation from the null hypothesis that the numbers in each quadrat were the same (Table 6).

Table 6

Chi-Squared Distribution Test for the Forest Species. Degrees of Freedom = 4

Species	Chi-Squared
Red-eyed vireo	12.30
Ovenbird	13.0
Black-capped chickadee	26.3
Rose-breasted grosbeak	2.35
Black-throated green warbler	12.81

A large part of the pattern just described is based on the lowered numbers of forest birds in the quadrat nearest the opening. A paired t-test was used to compare quadrat 1 against the 4 quadrats deeper in the forest.

In all species, abundance was lower in quadrat 1 than the mean of the rest of the quadrats (Table 7). In 2 species, red-eyed vireo and the ovenbird, the difference reached significance at the 5% level.

Table 7

Paired t-Test for each of the 5 Forest Species.
df = 8

Species	Average D	Standard Deviation	t-paired	Significant
Red-eyed vireo	-0.261	0.203	-3.88	Yes
Rose-breasted grosbeak	-0.333	0.368	-0.2715	No
Black-capped chickadee	-0.122	0.322	-1.1366	No
Black-throated green warbler	-0.094	0.196	-1.4456	No
Ovenbird	-0.183	0.228	-2.412	Yes

DISCUSSION

Forest Species

It is evident that forest species are affected by the opening (Figures 10-14). The usual trend was an increase to a peak somewhere within the transect followed by a drop. Kroodsma (1984) discussed a similar tendency of forest birds along power line corridors. He suggested that the peaks represent the "core areas of territories" and the low areas are "buffer areas between territories." The power line corridor was a natural border for the birds. The oil well openings appear to have the same effect as the power line corridors.

The territory sizes of the different species appear to have an effect on the location of the core areas and, thus, of the peaks. The red-eyed vireo territory peaks in quadrat 2. Its territory size is 2.72 acres (1.1 ha, Sherry & Holmes 1985). The red-eyed vireo occurs in high numbers within the oil well openings as well as the transect (Table 4). The red-eyed vireo is particularly noted for its broad tolerance range (Bond 1957, Kendeigh 1948), and utilization of both the woods edge and interior (Kroodsma 1982, Strelke 1980). The red-eyed vireo does,

however, show a preference for mature forests rather than selectively cut forests (Adams & Barrett 1976). The second peak for the red-eyed vireo is in quadrat 5.

The rose-breasted grosbeak appears to have a similar tolerance for the oil well opening as the red-eyed vireo although it has been reported as requiring a larger area of forest for nesting than the red-eyed vireo (Galli et al. 1976). The territory size for the rose-breasted grosbeak is 2-3 acres (0.81-1.21 ha, Stokes 1983).

The black-capped chickadee and the ovenbird both showed distinct peaks in quadrat 4 (Figures 12 and 14). Although both have relatively large territories, their territory sizes are quite different. The territory for the black-capped chickadee is 10 acres (4.05 ha, Stokes 1979), and the ovenbird is 4.69 acres (1.9 ha, Sherry and Holmes 1985). Their life histories are also quite different.

The black-capped chickadee is a resident species of this area. It nests in cavities generally around 100-200 cm from the ground (Brewer 1963), often near the edge of a forest. In summer it forages in the forest and on foliage insects. It tends to forage in family groups once the young have fledged. Most of the chickadees were found in groups. My census period was late enough that the numbers recorded were likely to have been the family groupings. This made it more difficult to determine the difference

between one territory and another. Although the chi-squared test showed that the number of chickadees varied significantly from one part of the transect to another (Table 6), the paired t-test showed that there was no significant difference between the area nearest the oil well opening and the areas deeper in the forest (Table 7). The peak in quadrat 4 may be the core area for the territories of the family groupings.

The ovenbird prefers deep forest habitat (Kroodsma 1984) and tends to be absent in small forest islands (Ambuel & Temple 1982, Forman et al. 1976, Galli et al. 1976). The paired t-test shows that this species is significantly lower near the oil well site (Table 7). It is likely that the peak in numbers well into the forest was not only because of a larger territory size than the rose-breasted grosbeak and red-eyed vireo, but also because the ovenbird does not utilize forest edges or openings.

The number of black-throated green warblers was highest in quadrat 5 (Figure 13). This may not be the peak inasmuch as no data were taken further away from the oil well site. The territory for this species is only about 0.5 acres larger than the ovenbird so the core territory may be at or near the fifth quadrat. The black-throated green warbler occurred in relatively low numbers and, although it has a broad range of habitats (Collins 1983), it prefers conifers and mixed hardwood stands (Bent 1963,

Kendeigh 1948). The paired t-test showed no significant difference in numbers near the opening and further away. Figure 13, however, shows a steady increase from the opening and this suggests the warbler's preference to be away from the opening.

For all forest species one obvious effect of oil well openings is a decrease in habitat by the removal of the forest. From the above description, it is also obvious that the effect extends beyond the opening. The opening creates a border from which each species has a preferred distance. Two of the species, the red-eyed vireo and the ovenbird, are significantly affected by the opening, and the chickadee and the black-throated green warbler both suggest the same pattern.

Related Studies

Studies on the effects of deforestation on non-game avifauna in North America are relatively recent. Deforestation for agriculture, urbanization, or other purposes has created what are known as forest fragments, forest patches, or forest islands.

Although an early study on the effects of forest size on bird populations was done by Bond (1957), other detailed studies are recent, (e.g., Ambuel & Temple 1983, Crawford Hopper, & Titterington 1981, Galli et al. 1976, Whitcomb et al. 1981). Studies show differences in species, spe-

cies richness and species diversity according to the size of the forest fragment, the successional stage of the forest, and the ratio of forest edge to area.

Bird species richness has been measured with respect to both increasing forest size and increasing forest edges. Galli et al. (1976) found no correlation between increasing species richness and internal heterogeneity of the forest. They concluded that "the increase in bird species richness can be due to the progressive encountering of minimum areas." (p. 362). That is, different species have different minimum forest size requirements. As forest size decreases species requiring larger forest areas decline and eventually disappear.

The vegetational gradient may have an effect on the spatial distribution of certain species of birds regardless of wood lot size. When Bond (1957) compared species frequency to the continuum indices of the forest he found a stronger correlation between species and vegetational gradient than when comparing forest sizes alone. The general trend was that species most common in large woods were those most common in mesic stands, while those species most common in smaller woods were mainly pioneer species, "For example, the Cerulean Warbler was most common in the most mesic continuum interval regardless of the size class of the woods under consideration. It appeared

in xeric stands...only if they were large or, conversely, in smaller stands only if they were mesic." (p. 373).

Tolerance to fragmentation differs from one species to another. Whitcomb et al. (1981) calculated tolerance levels by comparing the number of territories in small wood lots to those in large wood lots. The calculation was the mean number of "perceived" territories per survey point in 6 to 14 ha islands (14.8 to 34.6 acres) vs. 70 ha islands (173 acres). They found no significant change in species richness with forest size. The forest-edge species increased with decreasing forest size and forest interior species increased with increasing fragment size. They correlated two life history traits with the birds' ability to tolerate forest fragmentation: (1) neotropical migration, and (2) habitat preference. Neotropical migrants in Whitcomb et al. were restricted as breeders to forest interior, were rare on small (1 to 5 ha or 2.4 to 12.4 acre) forest islands, somewhat more common on fragments of intermediate (6 to 14 ha or 14.8 to 34.6 acre) size and were most abundant on large (70 ha or 173 acre) forested tracts. Nest placement also was correlated with intolerance to forest fragmentation. Open and ground nesting birds were less tolerant of fragmentation. Whitcomb et al. (1981) also found that isolation of a

forest island, as well as size, is important in determining the avifaunal composition.

Crawford et al. (1981) categorized a range of species along a continuum of forest types. They ranged from closed-canopy obligatory species to open-canopy obligatory species. This suggests that as large, mature forests are lost so also are certain species of forest-dwelling birds, while other species with a higher tolerance to areas with an open canopy are gained.

Once it became apparent that certain species were lost as forest area was lost and others species were gained, a next step was to determine the specific habitat requirements of these species. Ambuel and Temple (1983) studied wood lots in southern Wisconsin, which ranged from 3 to 500 ha. They found species richness to increase with the size of the forest. They attributed this to "an increase in the number of ecological specialists." (p. 1063). The forests they studied were less than or equal to 12 ha (29.652 acres), 13-50 ha (32.123-123.55 acres), and greater than 50 ha (123.55 acres). They separated the forest specialists into two categories, common and uncommon long-distance migrants. They concluded that common long-distance migrants are absent in small wood lots of less than 5 ha because of "area-dependent changes in habitat and biotic interactions." (p. 1066). The uncommon long-distance mi-

grants were absent "from all but the largest wood lots." (p. 1066).

Ambuel and Temple supported the conclusion of Whitcomb et al. (1981), and Galli et al. (1976). That is, in order to preserve and maintain forest bird communities, sufficiently large tracts of "hundreds or even thousands of hectares" must be left undisturbed (Whitcomb et al. 1981, p. 190).

The habitat which surrounds a forest patch has an influence on which species may utilize that patch and their distribution within the island. Those species able to utilize areas such as fields or open spaces around a forest patch, as well as the forest patch, are most likely to be present in that forest patch (Blake 1983). Blake correlated the trophic class of the avifauna with the size of forest patches. He also found that small forest patches consisted mainly of generalist forest-edge species.

Effects of Oil Well Sites

The studies described in the preceding section support my findings that the red-eyed vireo and the ovenbird are significantly affected by the oil well openings.

The red-eyed vireo is a neotropical migrant, wintering in South America (Peterson 1980), and is an insectivore in the spring and a frugivore in the fall (Blake & Hoppes 1986). The possibility of its numbers declining as forest sizes continue to decrease in northern Michigan is likely

(Blake 1983, Whitcomb et al. 1981). Robbins (1979) suggested that the minimum critical area or minimum forest seize for the red-eyed vireo is 250 acres (or 100 ha) in order to sustain a viable breeding population. Galli et al. (1976) lists the red-eyed vireo in the area-sensitive category.

The ovenbird is a familiar breeding bird in this area and its loud song is well known in the spring and summer. Although currently ubiquitous, it is a likely species to be affected by clearcutting large areas in the forest (Galli et al. 1976, Robbins 1979). The ovenbird is a long distance, forest-dwelling migrant. It nests and forages on the ground. Ambuel and Temple (1982) considered the ovenbird as a decreasing species in Illinois because of deforestation.

As the forests continue to decline in this area, we will likely see a dramatic decline in the red-eyed vireo and the ovenbird as well.

The low numbers of individuals and species found in the transects may be another indication that the oil well openings have alreeady affected the avian composition. Species which would otherwise have occupied these forested areas may have left. It is impossible, from this study, to tell whether other species were here before the time of this study and, if so, the cause of their absence. Some forest species with breeding ranges that include this

region but that were rare in or absent from the transects include: yellow-billed cuckoo (Coccyzus americanus), wood thrush (Hylocichla mustelina), black-and-white warbler (Mniotilta varia), whip-poor-will (Caprimulous vociferus), and American redstart (Setophaga ruticilla). The scarlet tanager was also noticeably low in numbers. These species appeared to be important in other forest fragmentation studies (Bond 1957, Forman, Galli, & Leck 1976, Galli et al. 1976). Robbins (1979) points out that some forest fragmentation studies do not have some critically area dependent forest species because the fragments are already too small. Kendeigh (1948) conducted a study in Emmet and Cheboygan Counties just north and east of Kalkaska County. He found all of the species listed above except the yellow-billed cuckoo in a survey of beech-maple-pine forests. His study indicates that these species may have been in this area once.

Further studies of the forests included in this study are necessary to understand whether the oil well sites are the cause of the low numbers or absence of some species.

Factors Affecting Forest Species

Specific causes of the decline of area-sensitive forest songbirds in the eastern United States have thus far been difficult to determine. Among possible factors

are absence of ultimate factors, failure of a fragment to elicit appropriate habitat selection behavior, predation, competition and brood parasitism.

Absence of Ultimate Factors

As Galli et al. (1976) suggest, smaller patches may lack certain species simply because those patches are not big enough to provide required resources, such as sufficient food, perches, nest sites, or suitable space for a territory.

Habitat Selection

It is possible that some species fail to occupy small forest patches or broken forest, not because the site is physically deficient for one or more territories, but because the birds respond positively only to large expanses of their preferred habitat. A requirement for social stimulation by the presence of conspecifics might act in the same way. Hilden (1965) gives apparent cases in which the habitat, though seemingly suitable, was unoccupied for these reasons.

Predation

The oil well openings, pipelines, and access roads may make it easier for predators to travel into what was

once a forested area. A predator could reach certain species of birds, such as ones that construct open nests on the ground, that are normally protected by large expanses of forests (Blake 1983). More detailed studies are required to determine whether predation is a factor at these sites.

Competition

Four of the ten species more common in the openings, listed on Table 4, were also found in the forest. Their actual numbers were low enough that strong competitive effects seem unlikely.

The most common of the oil well site species, the indigo bunting, was not recorded in the transects at all (Table 4). The American robin was second to the indigo bunting in total numbers recorded on the oil well sites. It occurred sporadically within the transects and conceivably could be involved in competitive interactions with some forest species.

Brood parasitism

Brittingham and Temple (1983) reported that the density of the brown-headed cowbird is inversely related to distance within the forest. This means that nests placed close to the edge of a forest are more likely to be para-

sitized by the cowbird than those further in the forest. The ovenbird is reported by Brittingham and Temple as being heavily parasitized especially within 99 meters (324.8 feet) of an opening. Other species important in this study have been reported as heavily parasitized by the cowbird, including black-throated green warbler, scarlet tanager and red-eyed vireo (Southern & Southern 1980).

In this study, the cowbird was recorded in all the oil well sites. There was no strong evidence that the opening was influencing its presence; there was, for example, no drop in numbers along the transects. One might surmise that any cowbirds attracted to the openings would choose nests of the edge species in preference to traveling far into the forest. The indigo bunting is heavily parasitized by the cowbird (Brittingham & Temple 1983, Southern & Southern 1980). The chestnut-sided warbler has been reported as an important host for the cowbird (Southern & Southern 1980). Many of the species reported by Southern and Southern as important hosts for the cowbird are species which utilize an opening or edge as part of their territory.

Noise

Another possible factor affecting birds around oil well openings was the noise level of each site (Table 3).

Although the mean number of species in transects at the noisy sties (sites 2, 3, and 6) was lower than at the quiet sites (sites 1, 4, 5, 7, 8, and 9) the difference was not significant. Means were 9.0 (SD = 1.0) and 12.12 (SD = 2.32), respectively ($t = 0.77$, $P > 0.05$).

CONCLUSIONS

The red-eyed vireo, rose-breasted grosbeak, ovenbird, black-capped chickadee, and the black-throated green warbler were the forest species analyzed in this study. The red-eyed vireo and ovenbird both showed significantly lower numbers near the oil well opening. Two other species, the black-capped chickadee, and the black-throated green warbler, suggested the same tendency, having distinct peaks in numbers well into the forest. The ovenbird is the most likely species to show a significant decline if the forests continue to be clearcut the way they have been. Its life history traits fit the description of affected species in forest fragmentation studies (Robbins 1979).

Although surrounding noise may be a problem when considering forest fragmentation effects, the louder sites were not significantly lower in number of species overall than the other sites.

One obvious effect of the clearings is decrease in available habitat. It is unclear whether factors such as predation, brood parasitism and competition are increased by the clearings.

I suggest that because the ovenbird and the red-eyed vireo show a significant aversion to the clearings, other forest species with similar life history traits will begin

to decline also. Some forest species may have already left the area surrounding the oil well opening. The low number of forest species may be an indication that some factor has affected the population of birds in the forest.

APPENDICES

APPENDIX A

Small Trees on Transects 1-9 (Trees/acre)

	Transect								
Species	1	2	3	4	5	6	7	8	9
Sugar Maple	607.0	348.0	323.8	489.7	283.3	420.8	424.9	424.9	105.2
Beech	16.2	76.9	16.2	4.0	-	8.1	8.0	-	4.0
Hop-Hornbeam	28.3	60.7	97.1	-	-	-	16.1	-	85.0
Basswood	-	-	4.0	-	4.0	4.0	-	-	4.0
Red Maple	-	-	-	-	-	12.1	-	-	-
Yellow Birch	-	-	-	-	-	-	-	4.0	-
Oak	-	-	-	-	-	-	-	-	44.5

Appendix B

Edge Species of Plants
on Sites 1-9

Site	Species	Number of Plants
1	Mullein Verbascum thapsus	2
	Pin Cherry Prunus pensylvanica	13
	Raspberry Rubuis sp.	16
	White Campion Lychnis alba	1
	Climbing False Buckwheat Polygonum scandens	67
	Daisy Fleabane Erigeron annuus	5
	Wild Strawberry Fragaria virginiana	20
	Hoary Alyssum Berteroa incana	3
	Bladder Campion L. cucubalus	1
	Maple Acer sp.	16
	Common Ragweed Ambrosia artemisiifolia	3
	Smooth Sumac Rhus glabra	2
	Goldenrod Solidaga sp.	4
	Oxeye Daisy Chrysanthemum leucanthemum	1

Site	Species	Number of Plants
2	Mullein	1
	Pin Cherry	1
	Raspberry	6
	Common Ragweed	9
	Bracken Fern *Pteridium aquilinum*	19
	Common Milkweed *Asclepias syriaca*	8
	White Sweet Clover *Melilotus alba*	37
	Spotter Knapweed *Centaurea maculosa*	2
	Maple	32
	Wild Strawberry	22
	Yarrow *Achillea millefolium*	2
	Mullein	1
3	Spotted Knapweed	12
	Winged Pigweed *Cycloloma atriplicifolium*	3
	Common Ragweed	34
	Bladder Campion	4
	Raspberry	18
	St. Johns Wort *Hypericum perforatum*	5
	White Sweet Clover	2

Site	Species	Number of Plants
3	Leafy Spurge *Euphorbia esula*	16
	Wild Strawberry	8
	Common Milkweed	13
	Hedge Bindweed *Polygonum scandens*	4
	Canada Mayflower *Mayanthimum canadensis*	2
	Hawkweed *Hieracium sp.*	40
	Wild Lettuce *Lactuca pulchella*	1
	Service Berry *Amelanchier sp.*	2
	Club Moss	
	Lycopodium luciculum	1
	L. complematum	1
	L. obscurum	1
4	Common Milkweed	2
	Bladder Campion	2
	Spotted Knapweed	29
	White Sweet Clover	7
	Climbing False Buckwheat	5
	Common Ragweed	1
	Daisy Fleabane	3
	Hoary Alysum	13

Site	Species	Number of Plants
4	Goldenrod	2
	Yellow Goatsbeard *Tragopogon pratensis*	1
	Wild Strawberry	9
	Maple	53
	Hawkweed	9
	Raspberry	33
	Fleabane	3
	Sheep Sorel *Rumex thapsus*	11
	Mullein	1
	Pearly Everlasting *Anaphalis margaritacea*	1
	Sandwort *Arenaria sp.*	1
	Alfalfa *Medicago sativa*	1
	Black Alfalfa *M. lupulinus*	1
5	Common Milkweed	2
	Herb Robert *Geranium robertianum*	2
	Wild Strawberry	51
	Climbing False Buckwheat	3
	Raspberry	84
	White Sweet Clover	2

Site	Species	Number of Plants
5	Hawkweed	2
	Black Medic *Medicago lupulines*	3
	White Clover	8
	Black Cherry *Prunus serotina*	2
	Canada Thistle *Cirsium arvense*	4
	Maple	12
	Mullein	1
	St. Johns Wort	3
6	Climbing False Buckwheat	9
	Maple	56
	White Sweet Clover	1
	Spotted Knapweed	1
	Raspberry	13
	Club Moss *L. obscurum*	1
	Service Berry	1
	Woodshield Fern *Dryopterous austriaca*	2
	Canada Mayflower	4
	True Solomons Seal *Polygonatum biflorum*	1
	St. Johns Wort	1
	Hawkweed	2

Site	Species	Number of Plants
7/8	Violet *Viola sp.*	1
	Maple	25
	Raspberry	15
	Climbing False Buckwheat	5
	White Clover	3
	Smooth Sumac	2
	Woodshield Fern	1
	Hoary Alysum	1
9	Raspberry	125
	Wild Strawberry	9
	Hoary Alysum	3
	Common Milkweed	4
	Yellow Sweat Clover	5
	White Sweat Clover	28
	Common Mullein	10
	St. Johns Wort	10
	Spotted Knapweed	28
	Spreading Dogbane *Apocynum androsaemifolium*	2
	Staghorn Sumac *Rhus typhina*	45
	Sarsasparilla *Aralia racemosa*	1
	Smooth Sumac	3
	Thistle *Cirsium sp.*	1

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