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BIRD POPULATIONS IN AN IRRIGATED WOODLOT, 1963-1967[1]

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Changes in bird populations caused by man's alteration of the environment usually occur under circumstances that fail to permit monitoring of the details. Indeed, most such changes result from drastic alterations of the habitat rather than modest changes in the climate. An opportunity arose to monitor bird populations for several years in a woodlot, part of which is being irrigated with sewage effluent. The addition of nutrients and water might enrich the habitat without change in area. Thus even territorial species such as birds might increase in number.

This paper describes the bird populations and gross changes in the vegetation following irrigation with treated effluent from the sewage plant of The Pennsylvania State University in Centre County, Pennsylvania. Observations on bird populations were systematically conducted from 1963 through 1967. The history of the project and the changes in vegetation as well as the characteristics of the irrigated effluent will be discussed briefly. More details are available (Parizek, *et al.*, 1967) but lamentably no measures of biomass were made.

The area (Figure 1) consists of approximately 160 acres of relatively flat land. The northern section has a gently sloping valley and the flat western part of the area has two temporary ponds. Formerly, the ponds became almost dry each year during August and supported a growth of button bush, sedges and other wetland plants. Several types of vegetation occupy the study area. The northern side consists of deciduous oak vegetation (Figure 2) that has never been cleared but has been selectively cut since early 1900. Approximately two-thirds of the area consists of impoverished farm land that was abandoned about 1935 and was planted with various conifers between 1938 and 1940, the most numerous being red pine (*Pinus resinosa*) (Figure 3).

The land was chosen for an experiment in the use of treated sewage effluent to enrich the soil. Efficient waste treatment plants produce effluents low in biochemical oxygen demand (B.O.D.) but such effluents are usually rich in the nutrients needed by biological systems. Slow infiltration of the effluent in the soil mass provides an

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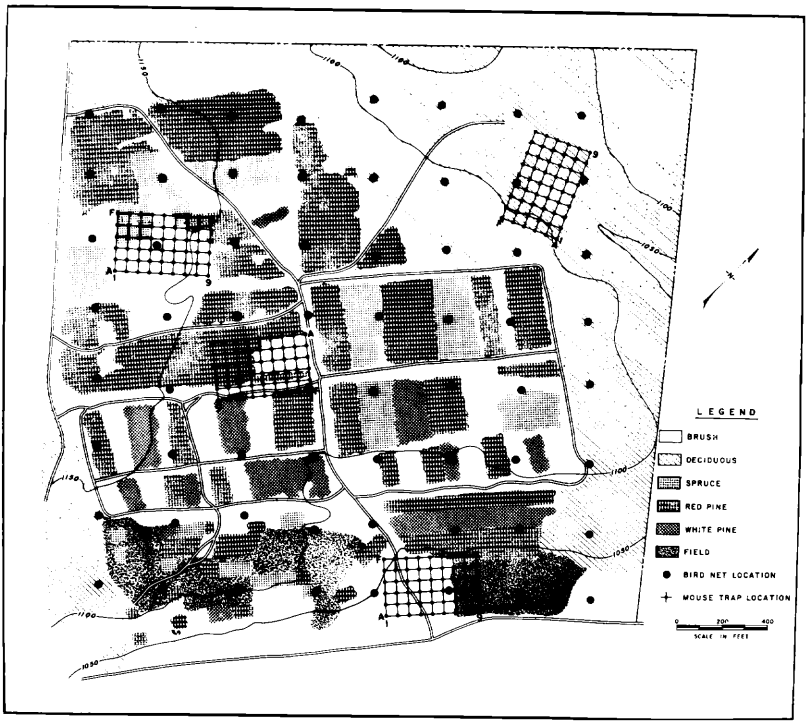

Figure 1. Map of study area. The nets, indicated by dots, were placed in a square grid. The parts irrigated (upper left corner) include approximately the upper five nets in the three vertical rows of nets on the left. The vegetation varied from young spruce plantations to 30-year old pines.

opportunity for retention of large amounts of the mineral nutrients by absorption through the root systems of plants and by chemical fixation by soil colloids (aluminosilicates, sesquioxides, and humus). Temporary retention of the surfactants (detergents) in the biologically active horizons may result in transformation of the surfactants to an innocuous form through utilization as an energy source for the soil microbes. Details of the treatment (see Parizek, *et al.*, 1967) are not relevant to this report except to note that irrigation brought about great changes in the vegetation in the area irrigated.

The area affected by irrigation was the west corner of the study area. The first year (1963) only about one acre was irrigated. In 1964 and subsequent years about 40 acres in a somewhat irregular square (see Figure 1) were irrigated. This part of the tract can be considered "experimental" and the rest "reference." Comparisons can thus be made between captures of birds in the two parts. Further analysis is possible by searching for long-term trends of population in the whole tract that might result from changes in population in the irrigated part.

Figure 2. Oak-hardwood stand that covered one-fourth of the tract.

Figure 3. Plantation of red pine about 30 years old that showed no change in undergrowth after 2 years of irrigation.

TABLE 1. AVERAGE COMPOSITION OF APPLIED SEWAGE EFFLUENT IN THE 2-INCH PER WEEK TREATMENT AND POUNDS OF MATERIAL APPLIED PER ACRE DURING 1964. (FROM PARIZEK ET AL 1967 TABLES 8 AND 24)

Constituent	Concentration ppm	Amount Applied lb./acre
MBAS apparent	1.75	27
Phosphorus	7.84	116
Nitrate-Nitrogen	13.6	202
Organic-Nitrogen	3.6	54
Potassium	15.7	234
Calcium	30.2	449
Magnesium	16.3	242
Sodium	35.4	527
Chloride	39.6	590
Boron	0.38	6
pH	7.4	—

Two levels of irrigation (23 or 46 inches of effluent) were started on June 18, 1963 and terminated on December 5 that year. Application in 1964 started on April 8 and terminated on November 18, also at two levels (33 or 66 inches). In subsequent years the dates were: 1965, April 12-November 23; 1966, April 4-November 21; 1967, April 17-November 15. The average composition shows that the applied effluent (Table 1) had high phosphorous levels. The dates were somewhat arbitrary, being chosen in part for mechanical convenience.

Nutrient content of the effluent applied to each acre at a level of two inches per week was equivalent to 250 pounds each of N, P, and K, a quantity more than adequate for most agricultural pursuits.

Responses of vegetation have been determined by various growth measurements of the forest species and chemical analyses of hardwood leaves, red pine needles, and old-field vegetation. Irrigation with the effluent had no significant effect on annual diameter growth of the hardwoods or red pine until the second year. However, irrigation did result in a significantly greater increase in height growth of the red pine and white spruce and in length of the red pine needles (Sopper, *et al.*, 1966). Dry matter production of herbaceous vegetation on the old-field area was increased (Figures 4 and 5) by a factor of 2 to 6 in various years (Sopper, 1968). Nutrient concentration in the hardwood leaves, red pine needles, and herbaceous vegetation from the irrigated areas was generally higher than in similar tissue from the unirrigated areas (Parizek, *et al.*, 1967: 58).

The bird populations were examined systematically beginning in 1963. At that time only a few small plots of land were being irrigated and no changes in numbers were expected to result from irrigation. In July of 1964 the expansion of the irrigation plots was made after the growing season. Thus, one would not expect much change in bird numbers until 1965, if then.

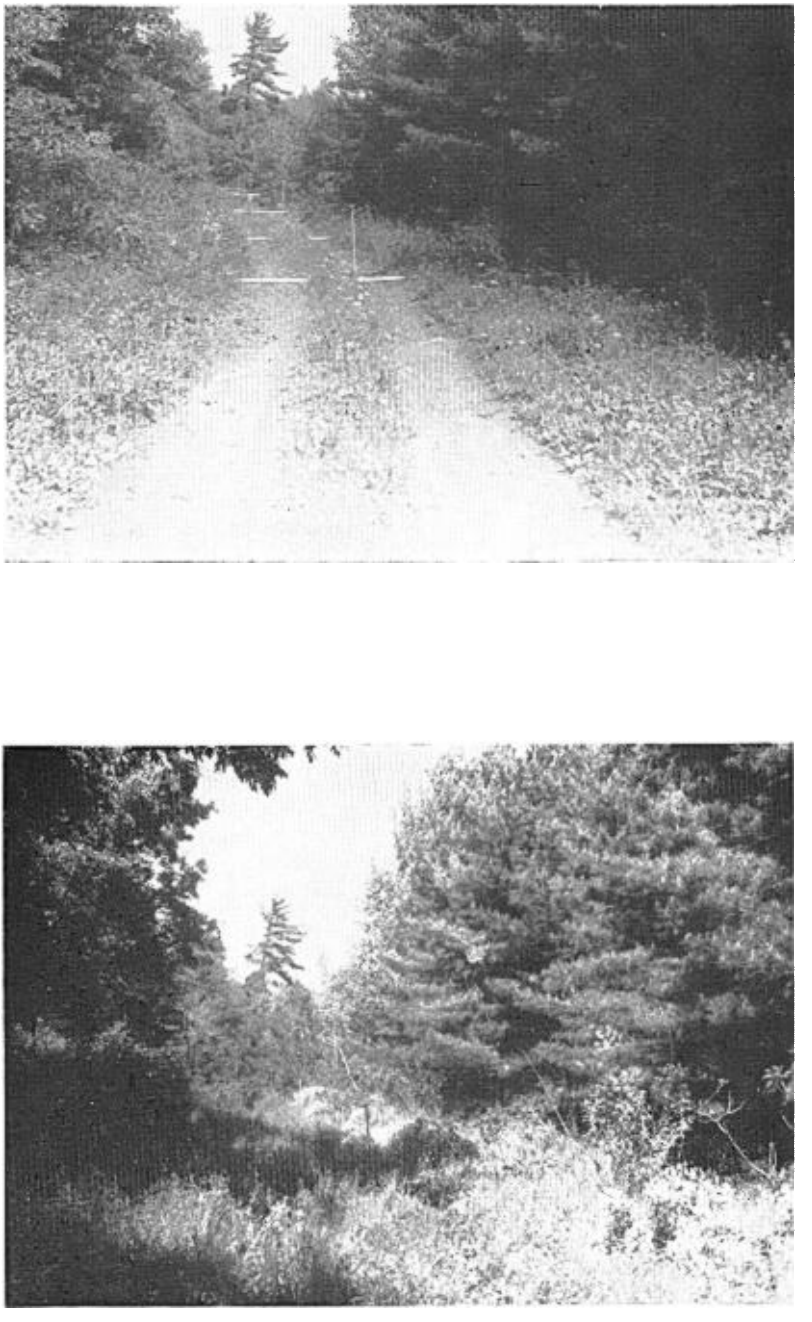

Figure 4. Comparison of same location in September 1964 when irrigation had been operated for a few weeks and in May 1966.

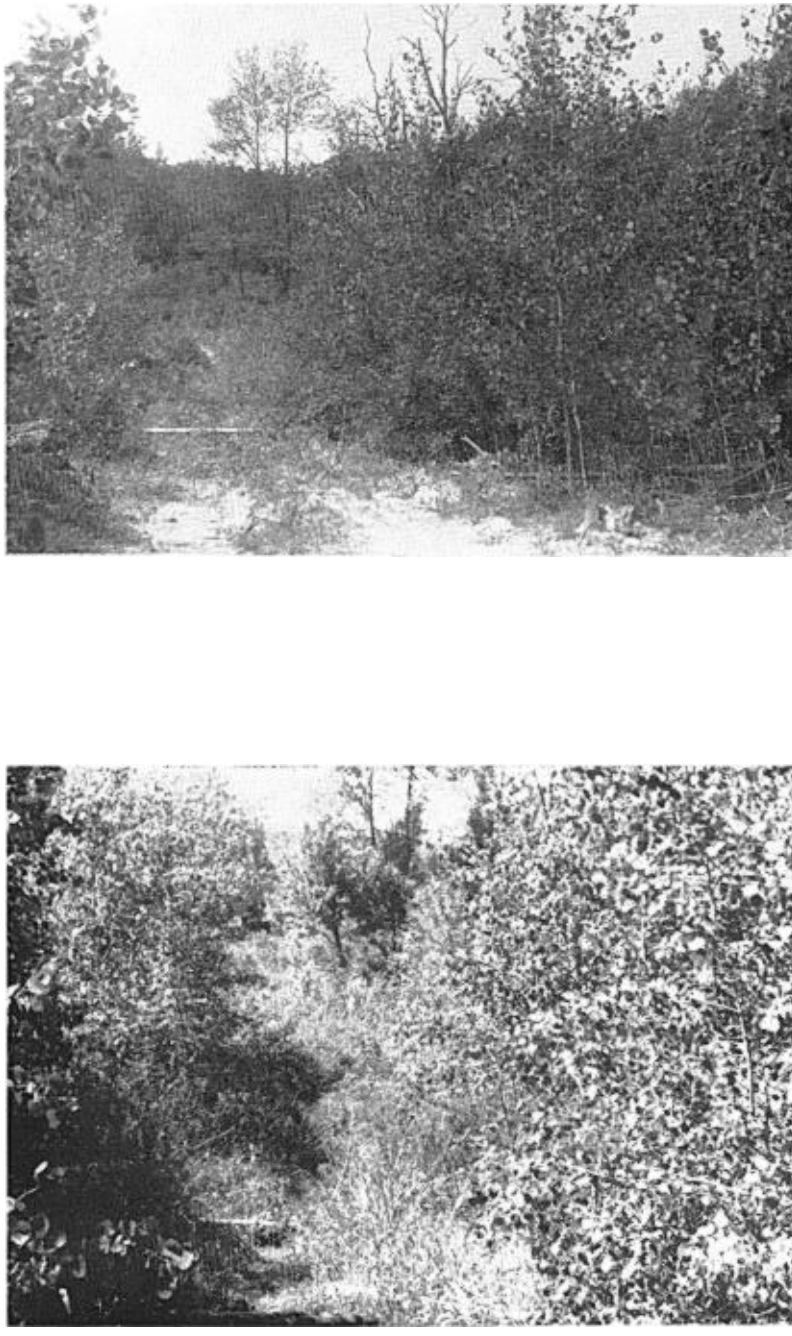

Figure 5. Growth of large-toothed Aspen during 2 years of irrigation.

TABLE 2. VEGETATION TYPES FOR 64 NETS. THE PERCENTAGE OF NETS IN EACH TYPE OF VEGETATION DOES NOT DIFFER (CHI-SQUARE) FROM THE PERCENTAGE OF THE TOTAL VEGETATION IN EACH TYPE

Type of vegetation	Percentage of Vegetation	Nets
Locust, dense understory	2.8	3.1
White pine (plantation)	6.1	4.6
Oak-Hardwood	27.2	23.4
Field and Scrub	10.6	12.5
Red Pine (plantation)	24.1	26.6
Aspen (brush)	4.0	4.6
Spruce (plantation)	5.8	6.3
Edge, Conifer-Scrub	7.2	9.4
Edge, Conifer-Hardwood	9.6	7.8
Edge, Conifer-Conifer	2.6	1.6

METHODS

The birds were captured in nylon mist nets placed 300 feet apart on an 8 x 8 grid (64 nets) (see Figure 1). The sites for nets were chosen by plotting the locations on a map before going to the field. Then the south corner of the grid was staked and all other nets were located by survey from this stake. Thus the actual site was systematically chosen but without bias. In fact the nets (Table 2) were located in approximate proportion to the extent of vegetation in the total area; analysis by planimeter of the total area showed excellent correlation ($r = 0.982$) of the area of habitat and the portion of nets in each habitat (Table 2). During the years 1963-1967 the type of vegetation did not change enough to warrant reclassification of site of net. (Growth, however, was great in irrigated areas.) A net was described as covering an "edge" situation if one-third or more of the net was in one type of vegetation and one-third or more in another type.

The nets measured 2 x 9 meters and were suspended between vertical poles permanently placed in the ground. The schedule for operation varied from year to year in the number of hours and time of day. Thus, totals can not be compared between years. The procedure generally was that one man opened 16 nets in two adjacent lines at dawn and followed the circuit around at intervals of an hour or more. About 11 a.m. he closed the nets on the last circuit. In another schedule all nets were opened at dawn and left open for three days. Four to six men followed the circuits at intervals continuously till the nets were closed at dusk of the last day. Although the number of hours differed in the two procedures, it is possible to compare ratios or percentages between the two methods because no bias is apparent.

For another study blood samples (0.2ml) were taken from a large number of the birds for serological and cytological examination.

Survival rate as determined by recapture data was not affected by this blood sampling (Franks, 1967).

RESULTS

To examine the history of the populations it is desirable to consider first, possible changes in the entire tract and second, possible changes in the irrigated part.

The total number of birds caught each year varied widely because of improvements in the netting schedule instituted during the first two years, and because of changes in availability of manpower. The actual number of birds caught per year (Tables 3, 4 and 5) is, therefore, a reflection of the amount and schedule of netting rather than an indication of the bird population during the study period. Each year the total captures (includes recaptures) of 24 common species (Table 4) and the captures in June of each year (Table 5) remain relatively constant (when compared by dividing by the total for the year). June was chosen to avoid the migration earlier in the year and at the same time to allow easy identification of any young that may have been fledged. Therefore, only adult birds, presumably the resident populations, are compared each year. A homogeneity test of the seven most common species of the June captures (first seven species in Table 5) indicates no change in their relative numbers in any year from 1963 to 1967 ($X^2 24 = 30.9$). However, estimates, based on capture throughout the summer, of the population levels of six common species (Table 6) indicate that robins increased significantly in number during the 1964-67 period.

TABLE 3. TOTAL BIRDS AND TOTAL SPECIES CAPTURED IN WOODLOT 1963-1967. (SINCE THE NUMBER OF "NET HOURS" VARIED AMONG YEARS, THESE FIGURES ARE USEFUL ONLY TO INDICATE MAGNITURE OF OPERATION)

Year	Net hours	Birds captured	Species
1963	31,408	1,070	68
1964	40,517	756	67
1965	76,149	2,012	81
1966	—	2,356	86
1967	—	1,495	70
Total	—	7,689	—

The possible effect of effluent can be examined now. The distribution of total captures fluctuated between habitats in various years of the study (Table 7) but no evidence was obtained that irrigation of effluent into part of the study area influenced the populations. The percent of total birds captured in 12 selected nets (Table 8) when irrigation was starting (1963 and 1964) and after it was established (1965, 1966, and 1967) are 27.15 and 24.91, respectively ($P > .05$). The significant increase of birds captured in aspen after irrigation may be a result of enrichment, but unfortunately adequate

TABLE 4. SPECIES COMPOSITION OF CAPTURES OF ADULT BIRDS BY YEAR (COMMON SPECIES ONLY)

Species	1963	1964	1965	1966	1967	Total
Yellow-shafted Flicker (*Colaptes auratus*)	16	11	20	27	22	98
Hairy Woodpecker (*Dendrocopos villosus*)	3	5	5	17	5	35
Downy Woodpecker (*Dendrocopos pubescens*)	18	10	33	13	12	91
Blue Jay (*Cyanocita cristata*)	22	16	23	33	15	114
Black-capped Chickadee (*Parus atricapillus*)	85	42	90	45	36	315
Tufted Titmouse (*Parus bicolor*)	13	37	40	40	25	169
Catbird (*Dumetella carolinensis*)	70	53	100	108	96	448
Brown Thrasher (*Toxostoma rufum*)	6	4	10	10	8	41
Robin (*Turdus migratorius*)	39	29	82	129	113	400
Wood Thrush (*Hylocichla mustelina*)	109	59	152	137	134	648
Red-eyed Vireo (*Vireo olivaceus*)	50	27	57	94	54	293
Ovenbird (*Seiurus noveboracensis*)	79	34	92	76	44	364
Yellowthroat (*Geothlypis trichas*)	9	9	23	21	12	77
Yellow-breasted Chat (*Icteria virens*)	5	8	30	14	10	69
Baltimore Oriole (*Icterus galbula*)	6	6	6	15	6	35
Brown-headed Cowbird (*Molothrus ater*)	37	12	13	20	31	116
Scarlet Tanager (*Piranga olivacea*)	26	9	50	35	35	165
Cardinal (*Richmondena cardinalis*)	11	11	18	19	22	92
Indigo Bunting (*Passerina cyanea*)	14	10	30	30	20	119
American Goldfinch (*Spinus tristis*)	37	12	13	20	45	136
Rufous-sided Towhee (*Pipilo erythropthalamus*)	41	31	75	48	49	265
Chipping Sparrow (*Spizella passerina*)	15	10	50	37	29	150
Field Sparrow (*Spizella pusilla*)	42	26	122	54	50	309
Song Sparrow (*Melospiza melodia*)	7	15	37	39	35	140
Total	760	484	1,169	1,081	908	4,691
Other Species	310	272	843	1,275	587	2,998
Grand Total	1,070	756	2,012	2,356	1,495	7,689

TABLE 5. SPECIES COMPOSITION OF CAPTURES BY YEAR FOR JUNE (COMMON SPECIES ONLY)

Species	1963	1964	1965	1966	1967	Total
Robin	15	8	27	52	40	142
Wood Thrush	29	15	40	49	48	181
Catbird	22	8	29	26	27	112
Ovenbird	24	6	25	20	15	90
Rufous-sided Towhee	11	7	16	16	15	65
Red-eyed Vireo	11	1	13	22	16	63
Scarlet Tanager	7	3	18	18	10	56
Field Sparrow	4	0	22	9	8	43
Chipping Sparrow	2	3	9	10	12	36
American Goldfinch	1	0	11	12	10	34
Brown-headed Cowbird	9	2	7	8	17	43
Indigo Bunting	2	3	9	8	6	28
Song Sparrow	2	1	9	8	11	31
Yellow-shafted Flicker	0	3	6	5	4	18
Total	139	71	230	263	239	942

$X^2 24 = 30.9$ (first 7 species)
$.1 > P > .2$

reference nets for this habitat were not available so that the effect of the effluent cannot be separated from the normal maturation of the aspens during the five years.

Another comparison can be made by examining the relative abundance of various species (Figure 6). While the percentage of the total varied for several species, only the ovenbird and possibly the blue jay changed consistently. Thus, this comparison yields no suggestion of consistent increases in numbers.

Another approach is to consider what species might profit from the luxurious vegetation. The catbird frequents brushy edges and low vegetation. The catbird percentage of total birds caught in the irrigated area was 30 in 1963 before irrigation had any effect, 23 in 1964 when a little effect was appearing, and 31, 61, 31 in the subsequent years. Also, there was no change in the proportion of total captures of catbirds in the edge habitat in either the irrigated or non-irrigated areas between 1963-1964 and 1965-1967.

DISCUSSION

From 1963 to 1967 the bird population in the non-irrigated part of the study area remained fairly constant in respect to both species composition and total number of resident birds. This constancy should have enabled us to detect any effect the irrigation of effluent may have had on the bird population in the irrigated sector. No

TABLE 6. POPULATION ESTIMATES FOR SIX COMMON SPECIES OF BIRDS IN THE STUDY AREA FOR THE YEARS 1963 TO 1967

	1963		1964		1965		1966		1967	
Species	N	95%[1]	N	95%	N	95%	N	95%	N	95%
Field Sparrow	64	28–124	—[2]	——	135	93–188	91	47–158	187	68–427
Ovenbird	67	40–105	—[2]	——	55	35–105	102	61–157	88	37–179
Catbird	134	70–231	114	31–335	94	57–145	92	61–132	89	62–122
Tufted Titmouse	18	7–38	58	45–113	46	27–75	34	19–57	27	11–67
Wood Thrush	86	38–118	106	51–192	114	80–141	147	103–189	101	70–123
Robin[3]	—[2]	—	36	12–93	74	50–105	145	96–209	138	94–192

[1]Ninety-five percent confidence interval (Chapman and Overton 1966).
[2]Not enough captures to make a reasonable estimate.
[3]Significant increase during study period.

TABLE 7. INTERACTION BETWEEN YEAR AND VEGETATION TYPE WITH REGARD TO BIRD CAPTURES. THE VALUES INDICATE THE NUMBER OF BIRDS CAPTURED IN EACH HAHITAT IN EACH YEAR. THE VALUES IN PARENTHESES INDICATE THE CONTRIBUTION OF THAT CELL TO THE INTERACTION X^2 AND THE DIRECTION OF THE DEVIATION FROM THE EXPECTED VALUE. CELLS CONTRIBUTING LESS THAN 2.0 ARE NOT GIVEN FOR CLARITY.

	1963		1964		1965		1966		1967		Total
Vegetation Type	Birds	Cell	Birds	Cell	Birds	Cell	Birds	Cell	Birds	Cell	Birds
Locust	52	(7.8−)	72	(6.0+)	136		159		130	(5.1+)	549
White Pine	35		30		79		90		62		296
Oak-Hardwood	165		155	(10.2+)	288	(3.1−)	385		228		1221
Field Scrub	210	(9.0−)	154	(4.4−)	568	(14.1+)	526	(3.2−)	397	(3.7+)	1855
Red Pine	209	(14.0+)	92	(4.3−)	258	(6.8−)	388	(3.0+)	213		1160
Aspen	93		55		146		191		110		595
Spruce	58		38		104		113		63		376
Edge Conifer Scrub	113		89		246	(2.3+)	255		151		854
Edge Conifer-Hardwood	118	(5.9+)	59		154	(3.1−)	221		126		678
Edge Conifer-Conifer	17		12		33		28		15		105
Total for Year	1070		756		2012		2356		1495		7689

Interaction $X^2_{36} = 122.8$ $P < .005$

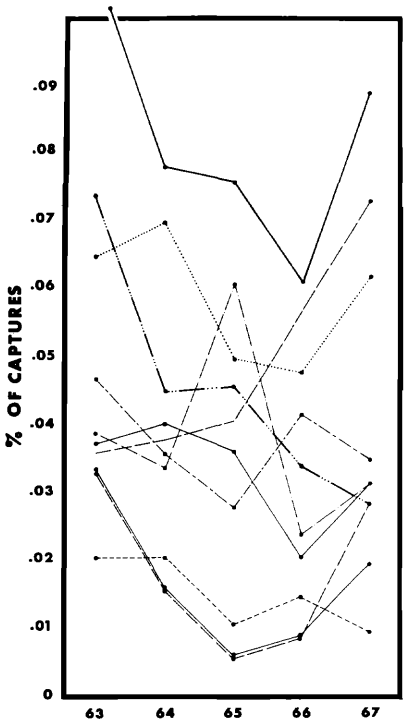

Figure 6. The percentage of total captures in each year total was comprised by the following species (from top to bottom) Wood Thrush, Ovenbird, Catbird, Red-eyed Vireo, Field Sparrow, Towhee, Robin, Cowbird, Goldfinch, and Blue Jay.

effects of effluent irrigation could be detected in the bird population. The robin population increased markedly during the study, but the increase probably started in 1963 before the application of effluent and occurred throughout the entire area. Over longer periods of time the more rapid growth of plants in the irrigated sector may produce differences due to increased rapidity of succession. Also, these results cannot be extrapolated to higher levels of treatment which, if extreme, might alter the plant community markedly. However, the levels of application in this experiment did not increase the total bird population and no adverse effects were noted.

Comparison of graphs (not shown here) of the captures in nets located in the irrigated part show no regular trend. The changes in vegetation were principally an increase in brush and forbs. Thus, nets on an edge were exposed to greater change than were nets, for example, inside a pine plantation. However, comparison of numbers of birds in irrigated edge with numbers in non-irrigated edge showed no consistent trend over time (Table 8).

TABLE 8. PERCENTAGE OF TOTAL BIRDS (FOR EACH YEAR) CAPTURED IN IRRIGATED OR NON IRRIGATED NET LOCATIONS

Net	Vegetation	1963	1964	1965	1966	1967	Paired t-test on mean percent 1963-64 vs 1965-67
				Irrigated (after 1964)			
1–3	Edge	1.40	0.53	1.04	1.36	0.87	
2–4	Edge	2.05	1.06	2.49	2.25	1.58	
3–4	Edge	2.70	2.51	1.39	2.17	3.01	P > .5
2–5	Aspens	2.88	3.83	4.03	4.58	4.24	P < .01
2–6	Aspens	1.87	2.51	2.54	3.82	2.94	
1–4	Red Pines	1.03	0.67	1.34	1.18	1.22	
1–8	Red Pines	2.80	1.45	0.79	1.15	1.12	
2–3	Red Pines	1.87	1.32	1.44	0.98	0.61	
2–8	Red Pines	0.84	1.19	0.35	0.89	0.29	P > .05
3–5	Red Pines	1.12	0.13	0.89	0.55	0.51	
3–6	Red Pines	0.93	1.98	0.79	0.59	0.87	
3–8	Red Pines	1.21	1.19	0.35	0.51	0.29	
				Not Irrigated			
2–2	Edge	1.95	1.45	1.49	1.79	1.20	
3–3	Edge	1.68	1.58	1.34	1.46	1.60	
6–6	Edge	1.58	1.35	1.49	1.87	1.41	
7–3	Edge	0.93	1.06	0.79	1.33	1.60	P > .5
7–4	Edge	1.77	1.98	2.04	1.50	0.82	
7–5	Edge	1.12	1.35	1.49	1.87	1.41	
1–5	Red Pines	1.95	0.32	0.40	2.17	0.82	
4–5	Red Pines	1.21	2.24	1.40	1.23	0.82	
4–6	Red Pines	1.40	0.48	0.64	0.59	0.94	
4–7	Red Pines	0.75	0.16	0.40	0.68	0.60	P > .5
5–6	Red Pines	1.21	0.32	0.74	0.55	0.34	
6–2	Red Pines	1.03	0	0.94	0.85	0.60	
6–4	Red Pines	0.84	0	0.94	0.51	0.60	
7–2	Red Pines	0.47	0.76	0.55	0.42	0.40	
Total Captures in 64 nets		1070	756	2012	2356	1495	

Possible explanations for failure to increase are that not enough time had elapsed for the population to respond, that territorial defense restricted increase, or that some factor decreased survival.

SUMMARY

The habitat occurring in part of a woodland was enriched by irrigation with treated sewage effluent. The bird populations were determined before and during this change (1963-67). The land was partly covered with deciduous hardwoods and partly with conifers planted about 1938. A total of 7,689 birds was captured in 64 hets placed 300 feet apart in a square grid.

The sewage effluent acting as a liquid fertilizer produced great increases in brush and weeds and some increases in growth of conifers and hardwoods. With the exception of an increase in robins, the bird population during the five years remained relatively constant, as was the proportion of captures of the 24 common species. Analysis of the captures of particular nets did not show changes attributable to the irrigation.

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