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Project Summary

Changes in Terrestrial Ecology Related to a Coal-Fired Power Plant: Wisconsin Power Plant Impact Study

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The full report summarizes the ecological effects on terrestrial plants and animals from a 1054-MW coal-fired power plant. Research was conducted from 1971 through 1977 at the site of the Columbia Generating Station, in the eastern flood-plain of the Wisconsin River in south central Wisconsin.

Initial studies were largely descriptive, involving development of species lists and documentation of habitats. Mapping of plant communities documented extensive changes, most notably heavy losses of sedge meadow habitats and increases in open water. These impacts on plant communities brought about concomitant changes in animal communities.

Bird populations were observed and analyzed in a sampling system consisting of five permanent transects, each having 17 or 18 stations and representing the entire range of plant communities. In mean analysis, a "t" test was applied to identify significant differences in the mean number of birds observed in each station during each year of study. The Shannon-Weaver function, which combines species richness and evenness components into a single index, was used as a measure of diversity. Polar ordination, a type of multivariate analysis based on a similarity coefficient to measure "distances" between stations, revealed many changes in the composition and structure of bird communities. Observations of a nesting colony of great blue herons showed that the nesting population decreased and foraging habits changed as a result of the impact of the cooling lake on the wetlands.

Drift fence-pitfall trapping is one source of information on presence and abundance of species, migration routes and seasonal use of different habitats, and occurrence of rare and endangered species. This report summarizes the effects of drift fence construction and orientation, trap dimensions, cycles in time, and weather variables on the results obtained by drift fence-pitfall trapping.

This Project Summary was developed by EPA's Environmental Research Laboratory, Duluth, MN, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

This report summarizes several studies on the effects of a 1054-MW coal-fired power plant on terrestrial plants and animals. The studies were conducted from 1971 through 1977 at the site of the Columbia Generating Station near Portage, Wisconsin, in the eastern floodplain of the Wisconsin River. Before construction began, the dominant vegetation of the area was sedge meadow and lowland forest. Building and operating the power plant had major consequences for the surrounding communities of plants and animals.

Approach

The initial studies were primarily descriptive. They involved developing

lists of species, evaluating habitats, and documenting elements in the natural history of important species. For population studies, field censuses were made on a regular basis, using visual and acoustical observations, traps, and nets to assess densities of animal populations. At the community level, plant communities and habitat types were mapped and analyzed by aerial photography, point-quarter, and transect methods. Finally, analytic studies were made to determine the physiological and behavioral responses to the impact of the power plant This variety of approaches to impact analysis provided a balance between long-term qualitative observations and short-term quantitative studies.

Studies of Plant Communities

Studies of plant communities are important both in their own right and in relation to animal studies, because impacts on animal populations must be understood in terms of any habitat changes. Eighteen natural plant communities were identified, described, and mapped Table 1 summarizes changes in the sizes of plant communities between 1971 and 1979. The net loss of 638 ha represents the area occupied by the generating station and its associated facilities Four plant communities disappeared completely, while heavy losses were sustained by the sedge meadow community [1]

Descriptive Animal Studies

Some 287 species of vertebrates use the Columbia Generating Station site This total is distributed as follows among the classes of vertebrates·

Fishes	22
Reptiles and amphibians	32
Birds	197
Mammals	36

Usage by some species (e.g., geese, warblers, walleyes) is seasonal, and some of the animals are rare (muskellunge, sandhill cranes, otter). Many species are seasonally very abundant (red-winged blackbirds, muskrats, chorus frogs, walleyes). The site contains a number of game species (ducks, white-tailed deer, northern pike)

Although changes were observed in many animal populations, determining the significance of these changes was difficult and identifying causal links was sometimes impossible. The difficulty in observing some animals, and the size of the site made complete coverage difficult. Long-term observations are needed to distinguish natural fluctuations from those induced by human activity. Finally, animals tend to move in response to their needs, so that some areas which seem but lightly used may in fact be temporary refuges necessary for survival.

Table 1. *Changes in Size of Plant Communities (ha) from 1971 to 1979*

Community type	Area 1971	Area 1979	Area lost 1971-1979	Area gained 1971-1979	Net change
Open water	236	274	47	74	+27
Emergent Aquatics	358	311	68	21	-47
Sedge Meadow	662	181	481	0	-481
Shrub Carr	34	13	28	7	-21
Alder Thickets	12	0	12	0	-12
Fen	6	0	6	0	-6
Prairie	7	4	3	0	-3
Southern Wet Forest	137	165	63	91	+28
Southern Wet Mesic Forest	270	270	0	0	0
Southern Mesic Forest	15	18	1	3	+2
Southern Dry Mesic Forest	93	88	18	13	-5
Southern Dry Forest	70	26	54	0	-54
Northern Wet Forest	2	0	2	0	-2
Northern Wet Mesic Forest	3	0	3	0	-3
Oak Barrens	19	7	12	0	-12
Sand Communities	23	30	4	11	+7
Cliff Face	18	18	0	0	0
Old Field	81	35	71	15	-56
Total	2046	1408			-638

Mammals

Mammals were studied by direct observation, winter tracks, box traps, drift fences, dropping boards, den counts, and records of trappers.

Estimates of deer populations show a reduction from 80 to 100 in 1971 to approximately 50 in 1977. Destruction of habitat coupled with increased access for hunters was probably the cause for this decline

Based on an average of five muskrats per den, populations of muskrats varied from approximately 1000 in 1972 to 250 in 1973. Few dens were observed in 1976. Muskrats do not exhibit regular population cycles common in some smaller microtines but are sensitive to changes in water level and other environmental factors. Because of environmental changes generally favorable for muskrats, it is expected that populations will increase.

Reptiles and Amphibians

Reptiles and amphibians were studied by seining, netting and trapping; and by direct observation (shed skins, road kills, chance encounters, resting places, and habitats).

All amphibian species seemed to be reduced in numbers. Results for reptiles were inconclusive due to sparsity of data. Three species of turtle occupy waters throughout the site and nest in several onsite areas. The six-lined race runner, an endangered species of lizard, may have been lost through habitat destruction. Sightings of several species of snakes (mostly road kills) were too infrequent for any conclusions about population trends. The garter snake remains in wet areas throughout the site.

Birds

Birds were studied during regular walks along a set of five transects, through observation of confined habitats such as the cooling lake, and by incidental observation

The total of 197 species observed from 1973 to 1977 includes permanent residents, seasonal residents, migratory visitors, and species utilizing temporary transitional habitats created by construction activities.

Effects of the cooling lake exceeded all other impacts on birds Numerous species dependent on the wetlands for nesting or foraging were displaced when the 200-ha lake was filled. Affected species included the red-winged blackbird, sora rail, Virginia rail, American bittern, harrier, and great blue heron Sandhill cranes, relatively intolerant of disturbance, deserted adjacent wetland areas.

The new cooling lake, however, attracted thousands of migratory birds. Twenty-two species of waterfowl were observed during the 1975 spring migration. These included the double-crested cormorant, an endangered species in Wisconsin. Only 17 migrant species used the cooling lake in 1976 Furthermore, although the coot population increased sharply, numbers of nearly all other species were reduced. The decrease in use of the cooling lake by migratory waterfowl may be due to changes in the temperature or quality of the water, or to the generally wet conditions which created ephemeral

ponds on nearby lands that may have attracted the birds. Additional studies of the lake's use by migrating waterfowl are recommended [2]

Population and Community Studies

Transect Counts and Analyses of Bird Populations

The sampling system consisted of five permanent transects, each having 17 or 18 observation stations 2500 m^2 in size. All major plant communities were sampled open water, emergent aquatic, sedge meadow, shrub carr, southern wet forest, southern wet mesic forest, southern dry forest/southern dry mesic forest, sand barrens, and old field. In addition, a number of stations represented community edge types.

To obtain a sample count, an observer walked for three minutes through a station on its center line, using visual and song cues to record all birds observed within the boundaries of the station. Each transect was sampled approximately every 10 days from April to October and every 20 days during the rest of the year, from 1973 through 1976 Data were analyzed by three methods: mean analysis, a diversity index, and polar ordination.

Mean Analysis

In mean analysis, a "t" test was applied to identify significant differences in the mean number of birds observed in each station during each year of the study. Mean analysis revealed many cases where a specific construction activity was followed by an immediate decrease in the sample mean In several cases, the activity resulted in total destruction of the habitat and the mean remained depressed. Where construction caused only partial or temporary destruction of a habitat, the mean tended to rebound. Stations inundated by the cooling lake showed a decrease in mean number of birds except when occasional rafts of waterfowl appeared

Diversity Index

Although there is no concensus on how to measure diversity, species diversity is generally thought to be associated with the stability of a habitat. This study employed the Shannon-Weaver function, H', which uses information theory for analysis of community organization, combining richness and evenness components into a single index of diversity. The equation is.

$$H' = -\sum_{i=1}^{N} \left(\frac{x_i}{T}\right) \ln \frac{x_i}{T},$$

where

N=total number of species
T=total number of individuals
x_i=number of individuals in the ith species.

Although the diversity index was lower for impacted stations in most habitats, the decrease was usually small. More significantly, diversity values tended to decrease with time at impacted stations, while diversity at nonimpacted stations did not show this trend. The decrease in H' was most marked in impacted sedge meadow habitats where, following a peak in H' during filling of the lake, values dropped sharply. A similar decrease occurred in impacted old field stations.

Values of H' are more closely related to changes in species richness than to changes in species abundance Thus, while values for the sample mean may bounce back following construction, values for diversity do not Construction activities therefore have a larger impact at the community level than is indicated by changes in species abundance alone.

Polar Ordination

Polar ordination, a type of multivariate analysis, was used to study changes in composition and structure of bird communities through detection of patterns in the data. This technique expresses variation by measuring the distance between each pair of stands with communities by means of a dissimilarity coefficient, equal to

$$1 - \frac{2w}{a + b},$$

where

a=sum of abundance values of all species in one stand
b=sum of abundance values of all species in another stand
w=sum of abundance values that the two stands have in common for each species.

These differences are then used to place stands on axes

For ordination studies, data were taken from observations during June and July (the breeding season) 1973 through 1976. The most common species (e.g., song sparrow, blue jays, red-winged blackbirds) were relatively unaffected by construction activities The dominance of these species is evident in the ordination plots, in which it overshadows the effects of construction on rarer species and thus decreases the separation of impacted vs. nonimpacted stations. Nevertheless, ordination studies revealed major changes in bird communities at stations affected by construction activities Many of these changes could be related to alterations in the water regime, with consequent effects on plant communities.

Clearly, construction of the Columbia Generating Station has had a major impact on local bird communities. Impacts range from immediate responses to specific construction activities, to changes in diversity and evenness in various habitats, to alteration in overall community composition One widespread result is the proliferation of common species at the expense of rarer ones. This can have serious implications for community productivity, stability, and succession

Effects on Great Blue Herons

A great blue heron nesting colony is located about 2 km west of the wetlands on the generating station site In 1974, the colony contained 113 active nests at a density of 94/ha. The herons foraged in groups of up to 12, in the diked area of the wetlands During the winter of 1974, the dikes were joined and the cooling lake was filled. Few herons were observed foraging on the site during the following summer, and the density of nests in the colony dropped to 69/ha. In 1976, herons again began foraging along the dikes, but the nest density dropped to 33/ha. The herons no longer foraged in groups, but rather, fed individually along the dikes at regularly maintained intervals of about 150 m By 1977, the number of nests had fallen to 16 (9/ha), even though the nesting site itself was unchanged from its preconstruction condition.

The response of great blue herons to construction of the Columbia Generating Station was clearly a response to impacts on the feeding grounds rather than on the nesting site Although the cooling lake contains abundant food, the distribution of food and its availability to great blue herons have changed With foraging possible only in limited areas along the lake shore, the herons changed from a pattern of feeding in groups to one of solitary feeding in individual territories. With food supplies curtailed, the nesting population dropped sharply.

Drift Fence-Pitfall Trapping for Data on Populations of Small Animals

Baseline studies of populations of small animals are often concerned with the presence and abundance of species, migration routes and seasonal use of

different habitats, and the occurrence of rare or endangered species Drift fence trapping can provide some of this information.

This report summarizes the effects of various factors on results obtained by drift fence-pitfall trapping. The factors include:

1. Construction of drift fences (sheet material vs screen),
2. Size and shape of traps,
3. Orientation of drift fences (parallel or perpendicular to habitat boundaries),
4. Cycles in time (daily and seasonal), and
5. Weather (e g., precipitation, cloud cover, temperature, wind).

Trapping took place between June 11 and October 31, 1976. Daily visits to traps insured sampling of populations without undue mortality. Altogether, 1227 individuals representing 28 species of small mammals, reptiles, and amphibians were captured (Table 2). The species composition of captured animals varied spatially and temporally, with some species captured throughout the study and others captured discontinuously. It would be desirable to collect data for an entire year, to provide information on seasonal changes in populations and their use of various habitats.

In general, more amphibians were caught on fences running parallel to land-water boundaries, while more mammals were caught on fences running perpendicular to these boundaries. This is because amphibians tend to travel toward or away from water, and mammals tend to travel parallel to water boundaries. With a longer period for collecting data, observations on relationships between animal captures and drift fence orientation could provide information on migration routes and changes in habitats with time

The study showed also that temperature and moisture are important in controlling movements of small animals, and that there is interaction among weather variables. The effect of weather on trapping results could be incorporated into a predictive model that would yield overall population estimates from actual numbers of animals captured under specific weather conditions

Conclusions

Plant Communities

The construction of the Columbia Generating Station resulted in the net loss of 638 ha of native plant communities on the 2046 ha site. The largest single loss was in sedge meadow (481 ha). Four minor communities (alder thicket, fen, northern wet forest, and northern wet mesic forest) were lost completely. Seepage and upwelling of cooling lake water under the dikes is dislodging peat mats which continues to affect the sedge meadow community west of the cooling lake.

Mammals

White-tailed deer populations on the site declined with the onset of construction due to increased hunting pressure. Habitat destruction and plant facilities, which tend to restrict deer movements along the Wisconsin River, have continued to keep deer populations depressed. Increases in the amount and depth of water in the sedge meadow should favor muskrats but may limit the range of voles and shrews.

Drift fence-pitfall trapping proved a suitable method for capturing a variety of small mammals, reptiles, and amphibians. Capture rates depend on trap size and shape, orientation, timing, and weather conditions. The method was useful for gathering baseline data.

Birds

Construction activities directly affected bird abundance; however, if the habitat destruction was modest, abundance levels in the affected areas returned to predisturbance levels with the completion of the construction activity. In the sedge meadow and old field communities, construction activities kept species abundance below preconstruction levels.

Species diversity indices generally decreased over time in those sampling stations impacted by construction activities. This suggests that construction activities had a larger community level impact than species abundance changes alone indicated.

The disturbances on the site seemed to favor the more common bird species over the rarer ones. Species which declined in number during the study period include harriers, sandhill cranes, and great blue herons. A great blue heron colony which used the Columbia sedge meadow for

Table 2. *Summary of Pitfall Trap Captures of Small Mammals, Reptiles, and Amphibians*

Mammals	*No.*	*Reptiles*	*No.*	*Amphibians*	*No.*
Sorex arcticus		*Ophisaurus attenautus*	3	*Bufo americanus*	124
Saddlebacked shrew		*Western glass lizard*		*American toad*	
	446				
S cinereus		*Storeria dekayi*	34	*Rana clamitans*	52
Cinereous shrew		*Dekay's snake*		*Green frog*	
Blarina brevicauda	12	*S occipitomaculata*	82	*R pipiens*	185
Short tailed shrew		*Red-bellied snake*		*Leopard frog*	
Microtus pennsylvanicus		*Thamnophis sirtalis*	54	*R. sylvatica*	2
Meadow vole		*Eastern garter snake*		*Wood frog*	
	79				
M. Ochrogaster		*Opheodrys vernalis*	25	*Pseudacris triseriata*	3
Prairie vole		*Smooth green snake*		*Chorus frog*	
Zapus hudsonius	44	*Heterodon platyrhinos*	6	*Hyla crucifer*	83
Hudsonian jumping mouse		*Eastern hognose snake*		*Spring peeper*	
Peromyscus bairdi		*Chrysemys picta*	20	*H. versicolor*	8
Prairie deer mouse		*Painted turtle*		*Grey tree frog*	
	9				
P gracilis		*Emydridea blandingi*	7	*Ambystoma laterale*	23
Woodland deer mouse		*Blanding's turtle*		*Blue-spotted salamander*	
Eutamias jacksoni	1	*Graptemys geographica*	2	*A tigrinum*	2
Wisconsin least chipmunk		*Map turtle*		*Tiger salamander*	
		Trionyx spiniferus	1		
		Spiny soft shell turtle			

feeding declined from 113 active nests in 1974 to 16 nests in 1977

Polar ordination was useful in considering how certain environmental parameters affect bird species distributions. The results suggest that polar ordination could be used to predict how changes in these parameters might affect species distribution and abundance.

Recommendations

The baseline data and, consequently, the results of this study would have been more useful had they been obtained before construction began. Unfortunately, the initial field sampling occurred after the start of construction.

Methods have recently been developed to provide before-and-after assessments in a shorter time frame and at less cost than the present study. Most notable of these is the U.S Fish and Wildlife Services Habitat Evaluation Procedures (HEP). However, such methods are not designed to consider impacts to rare species or unique habitats. In these cases, direct surveys and measurements must be used.

Drift fence-pitfall trapping and transect counts are two conventional methods that can be easily and cheaply used to gather baseline data. When conducted over sufficient time, such methods effectively monitor and document impacts to terrestrial communities.

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The complete report, entitled "Changes in Terrestrial Ecology Related to a Coal-Fired Power Plant: Wisconsin Power Plant Impact Study," (Order No. PB 84-171 701; Cost: $13.00, subject to change) will be available only from:

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