(about 80 percent of the flora) are genera and families of the nearby vegetation, and all are represented by pollen in the recent sediments. The similarity between the fossil and living flora is consistent with, and tends to support, a late Tertiary age for the microflora. With regard to the pollen production of genera revealed by the recent pollen rains, pine in inferred to have been less common locally in the Mio-Pliocene vegetation than oak and juniper-cypress; its affinities, based on pollen size-frequency studies, are with the xeric *Pinus cembroides* (pinyon) group rather than the better-watered montane ponderosa pine.

Chaparral plants (other than oak?) are largely missing from the microflora. Most of them, however, are entomophilous, and few have shed pollen that has settled into contemporary sediments (Table 1). The more moisture-loving ash, walnut, and hackberry presumably thrived along washes and canyon bottoms, like their modern counterparts, throughout central and southeastern Arizona; two species of *Ephedra* evidently ranged into the wooded uplands, as do *E. trifurca* and *E. viridis* near Prescott.

Alnus, Betula, and *Ulmus* occur sporadically in the microflora, though it is believed that vegetational facies of the Madro-Tertiary geoflora completely controlled the southern Great Basin in the Mio-Pliocene (*8*). A more comprehensive record of these and other plants of presumed Arcto-Tertiary derivation has been obtained, also, from Mio-Pliocene sediments from coastal southern California (*9*). In all probability, the source of the Prescott pollen was a montane (conifer-deciduous hardwood) forest characteristic of the Arcto-Tertiary geoflora and in particular its West American element, many of whose living equivalents are found in the Rocky Mountain forest and its southern extension into uplands of northern and central Arizona. Single grains of alder and birch pollen in the recent sediments presumably were windborne 60 to 200 miles from the nearest stands of these genera. Elms reach their natural limits in Texas (Pecos River), though they survived in the Far West till at least the late Pliocene (*10*). Elm pollen has been recovered recently from possible Nebraskan pluvial sediments of southeastern Arizona (*11*), which suggests that the genus became extinct in the West only during the Pleistocene. Three species are cultivated at Prescott.

The microflora undoubtedly presents an incomplete spectrum of the herbaceous plants of late-Tertiary central Arizona. Nevertheless, a dimension is added to the vegetation that is scarcely hinted at in megafossil floras. Most of the herbs (Table 1) are seldom found fossil, or lack previous Tertiary records.

The microflora is characterized by the dominant woody genera of brushland and savanna-woodland of central and southeastern Arizona uplands, but lacks the common associated species which today give floristic entity to these communities, and includes some (as unknowns) which apparently do not now occur in these assemblages. Still, the similarity between the microflora and pollen rains from these contemporary communities is marked, although this likeness provides no proof of the stability of these plant associations through time. It is appropriate to question whether chaparral, conifer (juniper-pinyon) woodland, and encinal (oak-juniper-pinyon woodland) were differentiated as they now exist in Arizona (climatic conditions today favor their optimal development in different parts of the State), or whether the Tertiary vegetation was a "generalized" assemblage from which species composing these communities have been segregated because of climatic changes since the Mio-Pliocene, with regard to their varying tolerances and adaptabilities.

The microflora is at an elevation (5600 feet) where pine now largely dominates the vegetation of central Arizona. The relatively low frequency of fossil pine pollen in the flora implies that the basin of deposition was lower, or the climate was drier [average annual rainfall at Prescott (5355 feet) about 18 inches], or both, when the polliniferous sediments were deposited. The presence of birch, alder, and elm might appear to raise rather than lower the moisture requirements of the fossil flora, but their relative scarcity (in fossil and modern pollen rains) indicate distant transport from more mesic uplands (*12*).

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23 February 1960

Avian Uptake of Fission Products from an Area Contaminated by Low-Level Atomic Wastes

Abstract. Birds living on the Oak Ridge White Oak Lake bed, an area contaminated by low-level atomic wastes, revealed a striking seasonal difference in uptake of fission products. Because the omnivorous diet of passerine birds is ecologically comparable to the mixed diet of man, uptake of radionuclides by wild birds provides an assay of amounts to be expected at the trophic level of primary interest to man.

The fate of radioactive materials introduced into the environment must be understood before their effects on man and nature can be evaluated. It is particularly important to know what fraction of the total radioactivity entering the environment may be expected to reach successive trophic levels in the major types of ecosystems of the world. At Oak Ridge National Laboratory, the White Oak Lake basin is a waste disposal area in which a slowly fluctuating level of soil contamination occurs (*1*). Avian uptake from a given level of environmental contamination should indicate both the average and the maximum concentration of radionuclides to be expected at the trophic level of particular interest to man, since the seed-fruit-insect diet of a terrestrial bird population is similar, in an ecological sense, to the grain-fruit-meat diet of man. The present paper is concerned with gross beta radioactivity and with concentrations of Sr^{90} and Cs^{137} in birds living on the White Oak Lake bed in 1958–59.

From the ecological standpoint, White Oak Lake bed in 1958, three years after the lake itself had been drained, could be divided conveniently into two zones: an inner "bush" zone of sediments covered by vigorous growths of herbaceous plants, shrubs, and scattered clumps of willows; and an outer "thicket" zone representing the former lake margin, covered with dense growths of alder, pokeweed, and young trees. Summer birds, especially those breeding in the inner zone, were largely replaced by different species or different individuals (that is, "races") of the same species in winter.

Specimens were collected by means of Japanese mist nets, and dissected into several components: feathers, skin, muscle, viscera, eyes, and bone. Bone was separated from muscle by boiling, and the fluid was added to the muscle component. Radioassay of tissues, and of the birds' food, was accomplished by a wet digestion technique previously employed and described by Krumholz and Emmons (*2*). The procedure of Willard and Goodspeed (*3*), was used in the radiochemical analysis for Sr^{90}.

The Cs^{137} analysis employed was one modified by L. B. Farabee after Mizzan (*4*).

Gross beta radioactivities of the total biomass of breeding birds in the summer of 1958 are shown in Fig. 1. Since feathers and the contents of the gastrointestinal tract are not included, the values represent the radioactivity of beta-emitting radionuclides actually assimilated by the bird(s). For either maximum or average values, three orders of magnitude correlate with the known habitat selection of the species. Song sparrows (*Melospiza melodia*), field sparrows (*Spizella pusilla*), water thrushes (*Seiurus motacilla*), and chats (*Icteria virens*), which occupy the inner zone and feed close to the ground, exhibited the highest tissue levels; some individuals of these species approached 10^4 count/min per gram of wet tissue. In contrast, gross beta radioactivity was only about 1/10 as high in goldfinches (*Spinus tristis*) and indigo buntings (*Passerina cyanea*), birds which ranged between the tall and the low vegetation, and only about 1/20 as high in thicket birds such as catbirds (*Dumatella carolinensis*), white-eyed vireos (*Vireo griseus*), cardinals (*Richmondena cardinalis*), and Kentucky warblers (*Oporonis formosus*), which infrequently ranged into the inner zone. Tissues were scarcely above background in species such as the hummingbird (*Archilochus colubris*), which visited the lake bed only on periodic feeding excursions.

Gross beta radioactivity of feathers was quite variable, but high in some individuals (26,000 count/min per gram). Much of the feather radioactivity was the result of external contamination with soil and water, since most (but not all) of the radioactivity could be removed by thorough washings.

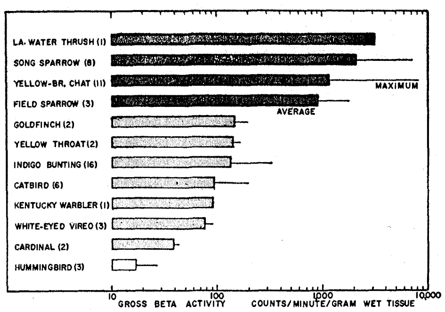

Fig. 1. Average (bars) and maximum (lines) gross beta activity of body tissues (exclusive of feathers and gastrointestinal tract) of species of birds living on the White Oak Lake basin during the summer of 1958. Species are arranged in a sequence from high to low average values. The first four species largely frequented the inner habitat zone, the next seven species nested largely in the outer shrub zone, while the hummingbirds only visited the basin to feed on nectar.

Table 1 compares radiostrontium in bone and radiocesium in muscle of birds from different habitat zones and seasons. The higher levels of inner- as compared with outer-zone birds, and the relatively large amounts of muscle Cs^{137} in winter are noteworthy. The winter specimens, which probably had not been living on the lake bed during the previous summer, were collected in March, so that body burdens presumedly were accumulated during the previous 2 or 3 months; summer birds were collected in July and August and probably had a similar time period (since arrival in April and May) for the accumulation of a body burden under conditions existing during the breeding season.

Table 1. Comparison of specific activity (per gram wet tissue) of radiostrontium in bone and radiocesium in muscle of birds from different zones and seasons.

N	Sr^{90}–Y^{90} ($\mu\mu$c/gm) Av.	Sr^{90}–Y^{90} ($\mu\mu$c/gm) Range	Cs^{137} ($\mu\mu$c/gm) Av.	Cs^{137} ($\mu\mu$c/gm) Range
	Summer, inner habitat zone			
6	302	13–595	50	11–102
	Summer, outer habitat zone			
8	68	17–160	22	3–62
	Winter, inner habitat zone			
7	229	0–1487	2801	43–18600

Table 2 shows the concentration of the two fission products in three food items which were commonly found in the stomachs of the birds collected in summer. Although less abundant in the soil, Sr^{90} concentration in fruit and insects was approximately equal to that of Cs^{137}. In birds, the final concentration of Sr^{90} in bone was about six times greater than that of Cs^{137} in muscle.

Table 2. Concentration (per gram fresh tissue) of radiostrontium and radiocesium in three important summer bird food items.

Sr^{90}–Y^{90} ($\mu\mu$c/gm) Av.	Sr^{90}–Y^{90} ($\mu\mu$c/gm) Range	Cs^{137} ($\mu\mu$c/gm) Av.	Cs^{137} ($\mu\mu$c/gm) Range
	Pokeberries (*Phytolacca*)		
9	7–10	6	4–9
	Blackberries (*Rubus*)		
8	7–9	3	2–4
	Beetles (*Carabidae*)		
108	87–121	90	80–105

In winter the birds were feeding primarily on seeds. Only in winter did the birds have mud adhering to their bills, indicating that they were probing into the soft soil for seeds, and thereby ingesting soil. The concentration of Cs^{137} in muscle was extremely variable but quite high in one or two individuals, up to 19,000 $\mu\mu$c/gm (or almost 0.02 μc/gm). In view of the low Cs^{137} concentration in summer birds, these high winter values could have resulted only from direct ingestion of soil.

Table 3 summarizes the amount per acre of radiostrontium and radiocesium estimated to be present at different trophic levels at a given time in summer. Although the specific concentrations at the higher trophic levels were appreciable, the absolute amount of fission products actually reaching these levels was very small. The amount of radioactivity which might be removed permanently from the area by migrating birds is thus negligible.

The seasonal change in the Sr^{90}-Cs^{137} ratio in tissues strongly suggests that uptake by the bird population in summer was primarily through the food chain (chiefly via insects), while in winter appreciable uptake occurred by ingestion of contaminated soil.

In Table 4 the concentration of radiostrontium in birds of the White Oak Lake basin is compared with the present maximum permissible concentration for man and the observed concentrations in the bones of sheep and children resulting from world-wide fallout. These comparative data show that the average, and especially the maximum, levels in the birds are higher than we would want to risk in man. At present, it is not known whether these levels are actually harmful to the birds. In addition to the dose received by the internally deposited radionuclides, the birds living on the inner zone also receive continuous external gamma

Table 3. Estimated amounts (per acre) of Sr^{90} and Cs^{137} present at different trophic levels. Data pertain to White Oak Lake bed, Oak Ridge, Tennessee. Plant and soil data from Auerbach (*7*). Estimate for bird population based on data of Table 1 and a density of 20 birds per acre.

Trophic level	Sr^{90} (mc/acre)	Cs^{137} (mc/acre)
Birds	0.7×10^{-5}	1.9×10^{-5}
Plants	1.4	0.2
Soil	290	15000

Table 4. Comparison of Sr^{90} levels in calcium and bone with the maximum permissible concentration for man.

Items	Sr^{90} ($\mu\mu$c/gm Ca)	Sr^{90} ($\mu\mu$c/gm bone)
Maximum permissible concentration, man (*8*)	100–2000	25–250
Sheep in Wales 1956 (*9*)	160	57
Children 0–3 years of age, Northern Hemisphere, 1959 (*10*)	1.19	0.42
Oak Ridge birds:		
Average	700	172
Maximum	6000	1487

radiation (emanating from the lake bed) which varies from 10 to 50 mr/hr 1 m above the soil (*5*). Adults, eggs, and young of wild birds are now being subjected to controlled sublethal doses at the Atomic Energy Commission's Savannah River Plant to determine the effects, if any, which might be expected at various doses and at key stages in the life cycle (*6*).

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9 February 1960

Antiozonants To Protect Plants from Ozone Damage

Abstract. Manganous 1,2-naphthoquinone-2-oxime protected tomato foliage in the field from damage apparently caused by excessive atmospheric ozone. The compound proved to be a very effective antiozonant. The similar cobaltous and manganous chelates of 8-quinolinol were also effective antiozonants. The materials were applied to cloth of the type used to make field tents for shade-grown tobacco. Tomato plants covered with cloth treated with cobaltous 8-quinolinolate were protected against otherwise damaging concentrations of ozone. These materials and methods may afford a useful way to reduce weather fleck of tobacco and other plant injuries caused by excessive atmospheric ozone.

Crop damage from excessive atmospheric ozone is becoming a serious problem throughout the country. Two of the best known examples of ozone damage are stipple of grape in southern California (*1*) and weather fleck of tobacco in Connecticut and Massachusetts (*2*). In New Jersey, ozone damage has been observed on spinach, alfalfa, cereals, red clover, beans, parsley, and grapes (*3*). Recently, Ledbetter *et al.* (*4*) demonstrated that many species of common plants can be readily injured by exposure to ozone.

During 1959, a wide variety of plants in Connecticut, such as tomatoes, potatoes, apples, and many kinds of weeds, showed severe damage after a weather period which resulted in serious fleck on tobacco. The type of injury on the various plants and its coincidence with the appearance of fleck on tobacco indicated that ozone was the damaging agent.

During this period we observed that tomato plants sprayed with a trial fungicide, manganous 1,2-naphthoquinone-2-oxime (*5*), were much less injured than were other tomato plants in the same plot. This suggested that the experimental fungicide is an effective antiozonant. The structural similarity of this compound to 8-quinolinol suggests the possible antiozonant action of the manganous and the cobaltous 8-quinolinolate. The antiozonant action of these compounds was determined experimentally, together with that of diphenyl-*p*-phenylenediamine and other compounds which are used in the rubber industry as antiozonants.

Because these materials have not been thoroughly tested on plants, it became of practical interest to see whether plants could be protected from ozone by covering the plants with standard tobacco shade cloth treated with the compounds.

The testing equipment consisted of an ozone-producing chamber, a gassing chamber, and ozone-measuring meters. Two different ozone-producing chambers were used. Both were glass boxes containing ultraviolet lamps. One box had four "Odor Out" Westinghouse bulbs, producing a total of 0.08 gm of ozone per hour. The other box, for greater ozone production, enclosed a Rayonet Superkill fixture with two high-ozone lamps, producing 2 gm of ozone per hour at full voltage. The ozone-laden air was pumped into either a glass-enclosed gassing chamber for exposing plants or cellophane bags for measuring the antiozonant effect of treated cloth strips. The ozone level in the chamber or bags was measured with a Mast portable atmospheric ozone recorder (model 724-1).

A strip of shade tent cloth dusted with a 25-percent formulation of manganous 1,2-naphthoquinone-2-oxime was sealed into a cellophane bag continuously supplied with ozone. The treated cloth reduced the ozone level from 0.7 to less than 0.1 part per million and held it at the lower level for 24 hours. Other test cloths were prepared as follows: they were dipped into chloroform solutions of 8-quinolinol, air-dried, then dipped into water solutions of the appropriate metal salt to form the chelate complex on the cloth. The cloths were air-dried again. The final weight of compound was 405 mg/m^2 of cloth. Both 8-quinolinolates proved to be good antiozonants, the cobaltous complex being more effective than the manganous complex.

Compounds used as antiozonants in the rubber industry were tested in the same manner as the 8-quinolinolates and proved to be even more effective. Table 1 compares the antiozonant action of the more effective materials with that of zinc ethylenebis(dithiocarbamate). The latter compound is now used in agriculture to protect crops against atmospheric ozone. The data from Table 1 show that the dialkyl-*p*-phenylenediamines and nickel di-N-butyldithiocarbamate are much more effective as antiozonants than is zinc ethylenebis(dithiocarbamate).

Can treated shade cloth protect plants against ozone damage? Young tomato plants covered with untreated shade cloth and gassed with ozone (0.8 part per million) for 4½ hours were severely damaged. Another set of tomato plants covered with tobacco shade cloth treated with cobaltous 8-quinolinolate showed practically no injury after 4½ hours in the ozone gassing chamber.

In tobacco fields, shade cloth treated with these materials may well reduce weather fleck to a considerable extent, although this has not been determined as yet. Because these materials are quite insoluble in water, cloth treated with them should be highly resistant to weathering. The use of catalytic antiozonants, such as nickel di-N-

Table 1. The antiozonant effect of cloth treated with antiozonants used in the rubber industry as compared with that of a cloth treated with zinc ethylenebis(dithiocarbamate), a material now used to protect crops against ozone. The cloths were tested in a chamber constantly gassed with ozone (0.4 to 0.7 part per million).

Lowest reading (in parts of ozone per million) after treated cloth was placed in chamber	Time chamber was held at lowest reading by cloth (hr)
Nickel di-N-butyldithiocarbamate	
0	67
*N-Isopropyl-N′-phenyl-*p*-phenylenediamine*	
0	18
*N,N′-Di-sec-octyl-*p*-phenylenediamine*	
0.01	12
Zinc ethylenebis(dithiocarbamate)	
0.06	0.5