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EARTHWORM POPULATIONS AS RELATED TO WOODCOCK HABITAT USAGE IN CENTRAL MAINE

by
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EARTHWORM POPULATIONS AS RELATED TO WOODCOCK HABITAT USAGE IN CENTRAL MAINE

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Abstract: Lumbricid earthworms were sampled on two central Maine study areas between late April and early September, 1974, to relate earthworm abundance to use of feeding covers by American woodcock *(Philohela minor)*. On sampling days, occurring at 2 to 3 week intervals, a formalin solution was applied to thirty 0.25m^2 areas in heavjly, commonly, and rarely used woodcock covers (5 samples/type of feedjng cover/study area). The extent of cover usage was based on use of vegetation by 51 radio-equipped woodcock, 1970-73 (605 woodcock-days). A total of 2,546 earthworms of nine species was collected; species and age compositions of collected lumbricids were similar on both study areas. Similarly, number and biomass (dry weight) of earthworms extracted did not differ significantly between study areas. However, the number and biomass of sampled earthworms were directly and significantly related to the intensity to which woodcock used covers. Those diurnal covers most heavily used by woodcock sustained the highest lumbricid populations, ostensibly because these covers provided earthworms with preferred foods (i.e., leaf litters) and optimum soil moisture-temperature conditions. In terms of earthworms and woodcock supported per unit area, management of second-growth hardwoods appears more efficient than attempting to alter coniferous or mixed forests.

Reynolds, J.W., W.B. Krohn, et G.A. Jordan. 1977. Les populations de vers de terre reliés aux habitats utilisés par la bécasse dans le centre du Maine.

Résumé: Les lombricidés furent échantillonnés dans deux régions des centre du Maine entre la fin avril et le début septembre 1974 afin d'établir la relation entre l'abondance des vers de terre et les gîtes nourriciers de la bécasse *(Philohela minor)*. Les jours d'échantillonnage, faits à intervalle de 2 à 3 semaines, une solution de formaline était répandue sur 30 surfaces de 0.25 m^2 qui étaient soient, très fréquemment, habituellement ou rarement utilisées par la bécasse comme gîtes (5 échantillons/sorte de gites nourriciers/lieux de recherche). L'évaluation de l'emploi des gites était basée sur l'utilisation individuelle d'unités de végétation faite par 51 bécasses équipées de radio, 1970-73 (605 bécasses-jours). Un total de 2546 vers de terre de neuf espèces furent ainsi ramassés; les espèces et les répartitions d'âge des lombricidés recueillis étaient similaires dans les deux lieux de recherche. De même, le nombre et la biomasse (poids sec) des vers de terre extraits du sol ne différaient pas de maniere significative entre les lieux de recherche. Toutefois, le nombre et la biomasse des vers de terre échantillonnés étaient reliés directement, et de façon significative, à la fréquence à laquelle la bécasse profitait des gîtes. Les gites diurnes les plus fréquemment utilisés par la bécasse possédaient la population la plus elevée de lombricidés, parce que, de toute évidence, ces gîtes fournissaient aux vers de terre leur nouriture préférée (i.e., les déchets de feuilles) et des conditions optimales de sol en fait d'humidité et de température. En termes de vers de terre et de bécasse nourries par unité de surface, l'aménagement des rejetons de bois franc semble plus efficace qu'essayer de changer les forêts de conifères ou les forêts mélangées.

The intensity with which a game species is managed depends, in part, upon harvest and habitat trends. In the case of American woodcock, hunter interest is rapidly increasing while habitats in many areas are decreasing (Owen 1977). Future management of this migratory bird, if both trends continue and the species is to be maintained at levels capable of supporting sport hunting by a relatively unrestricted public, must include efforts to influence the quantity and quality of habitats. Such efforts will require a detailed understanding of woodcock-habitat relationships.

Vegetative types used by woodcock on northern breeding grounds have been thoroughly documented (Pettingill 1936, Mendall and Aldous 1943, Sheldon 1967, Liscinsky 1972, Wishart and Bider 1976 and others). In central Maine, radio-equipped woodcock most frequently used second-growth hardwoods for daytime feeding and roosted in various types of openings during the night,

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especially in abandoned farm-fields (Dunford and Owen 1973, Owen and Morgan 1975a). Essentially, these recent Maine findings confirmed earlier studies of habitats selected by woodcock during daylight.

Investigations of food habits have shown that earthworms are the main items in the diet of woodcock (Pettingill 1936, Sperry 1940, Mendall and Aldous 1943, Miller 1957, Krohn 1970, Krohn *et al.* 1977, and others). The importance of understanding relationships between woodcock habitats and the bird's foods has long been recognized. Mendall and Aldous (1943:130) stated that "The distribution of earthworms ... the favorite food of the woodcock ... and the extent to which it is affected by soil and cover relationships will probably eventually prove of importance in woodcock management." Liscinsky (1972) studied earthworm abundance as related to use of habitats by woodcock in Pennsylvania. Wishart and Bider (1976) sampled earthworms in nocturnal and diurnal woodcock habitats in southwestern Quebec. A recent report by Reynolds (1977a) indicated earthworm habitat usage and their availability to woodcock.

The objectives of this investigation were to (1) document the species and age compositions of earthworms (Lumbricidae) present on two central Maine study areas, (2) test the hypothesis that woodcock usage of covers was directly related to the abundance of lumbricids, and (3) relate the abundance of earthworms to cover types, leaf litter, soil moisture, soil temperature, and season.

The authors thank R.B. Owen, Jr. for generously allowing us the use of telemetry data to quantify woodcock cover usage. We are indebted to P.V. O'Neil for supervising the collection of field data. Also, we appreciate the contributions of F.M. Forrester in preparing data for analyses and V.S. Patterson for drawing all figures. Finally, We thank J.V. Dobell for being an available sounding board on woodcock when immediate information was needed, and for reviewing an early draft of this manuscript.

STUDY AREAS

Approximately 85 percent of Penobscot County, Maine, is covered by forests and wetlands with some 15 percent of the area in woodlots and farms (less than 5 percent croplands). Most of the farmland is located in the southern portion of the county and during the last three decades the area cultivated has decreased (USDA 1963). Abandonment of the smaller and less productive farms has resulted in numerous fields reverting into woodlands.

Our study centered around two abandoned fields in southern Penobscot County, approximately 13 km west of Old Town, Maine. The fields, Pea Cove and University Forest, were focal points for woodcock telemetry studies conducted from the University of Maine (Dunford and Owen 1973, Owen and Morgan 1975a, Owen and Morgan 1975b). Although the exact years in which the study areas were abandoned are unknown to the authors, we suspect that most of the area immediately surrounding both fields was uncultivated for 20-30 years prior to this study.

METHODS

Measuring Woodcock Habitat Usage

Data from the previously mentioned University of Maine telemetry studies were used to measure the extent to which woodcock used individual stands of vegetation (i.e., covers). Telemetry data give an unbiased measure of habitat usage by woodcock only when each cover has an equal chance of being used by a radio-equipped bird. Although these probabilities could not be calculated, we believe that the usage of covers adjacent to fields was representatively measured.

Covers more than 400 m from the two fields were not studied although radio-tagged birds, especially immatures, occasionally used covers far from Pea Cove or the University Forest. Usage of diurnal feeding covers was quantified according to the number of different radio-equipped birds using a cover and the number of woodcock-days a cover was used. A woodcock-day was defined as one radio-tagged bird spending the daylight period in a given cover between the presunrise and postsunset flights. Thirty-eight woodcock were monitored at Pea Cove for a total of 426 woodcock-days between 1970 and 1973. Thirteen birds, totalling 179 woodcock-days of use from 1971 through 1973, were radio-equipped at the University Forest. Radio- tracking was done between June and September each year.

Feeding covers were classified and mapped (Fig. 1) according to the extent of woodcock usage as follows:

	Number of radio-equipped birds	Number of woodcock-days
Heavily used	4 +	25 +
Commonly used	1-3	1-24
Rarely used	0	0

Vegetation surrounding study fields were classified as alder (*Alnus* spp.), aspen (*Populus* spp.), aspen-alder, aspen-hardwoods (mostly *Populus* and *Betula* spp.), hardwood (mostly *Betula, Acer, Prunus,* and *Ulmus* spp.), mixed, and softwoods (mostly *Abies* and *Pinus* spp.) covers. Enlarged aerial photographs (scale of 1.0 cm = 6.6 m), and on-the-ground inspection were used to classify and map the vegetation adjacent to both fields (Fig. 2).

Measuring Earthworm Populations

Reviews of the various earthworm sampling methods were given by Reynolds (1973, 1977b:8-10). In this study, a formalin solution was used to extract earthworms from the soil since digging would drastically alter the habitats. There were eight sampling periods, 2 to 3 weeks apart, from 30 April to 8 September, 1974. On each of the three types of feeding covers adjacent to the two fields, five 0.25 m^2 areas (quadrats) of surface soil were sampled for earthworms each period. Quadrat locations were randomly determined on maps prior to sampling. A solution of 25 ml of formalin (37 percent Formaldehyde Solution, U.S.P.) in 4.5 liters of water was sprinkled over each quadrat at such a rate that it would completely infiltrate the soil. Earthworms surfacing within 10 minutes of expellant application were collected. Soil temperature, measured 5 to 7 cm below the surface, was taken near each quadrat as was a soil sample for determination of soil moisture by the gravimetric method (percent moisture by weight).

Each earthworm collected was identified as to species, put into one of four age classes, and dry weight biomass estimated from the first of the following equations corrected from Reynolds (1972:66) :

$$\log D = 2.3362 + 0.2800 \log L$$

$$\log W = 2.3900 + 0.4055 \log L$$

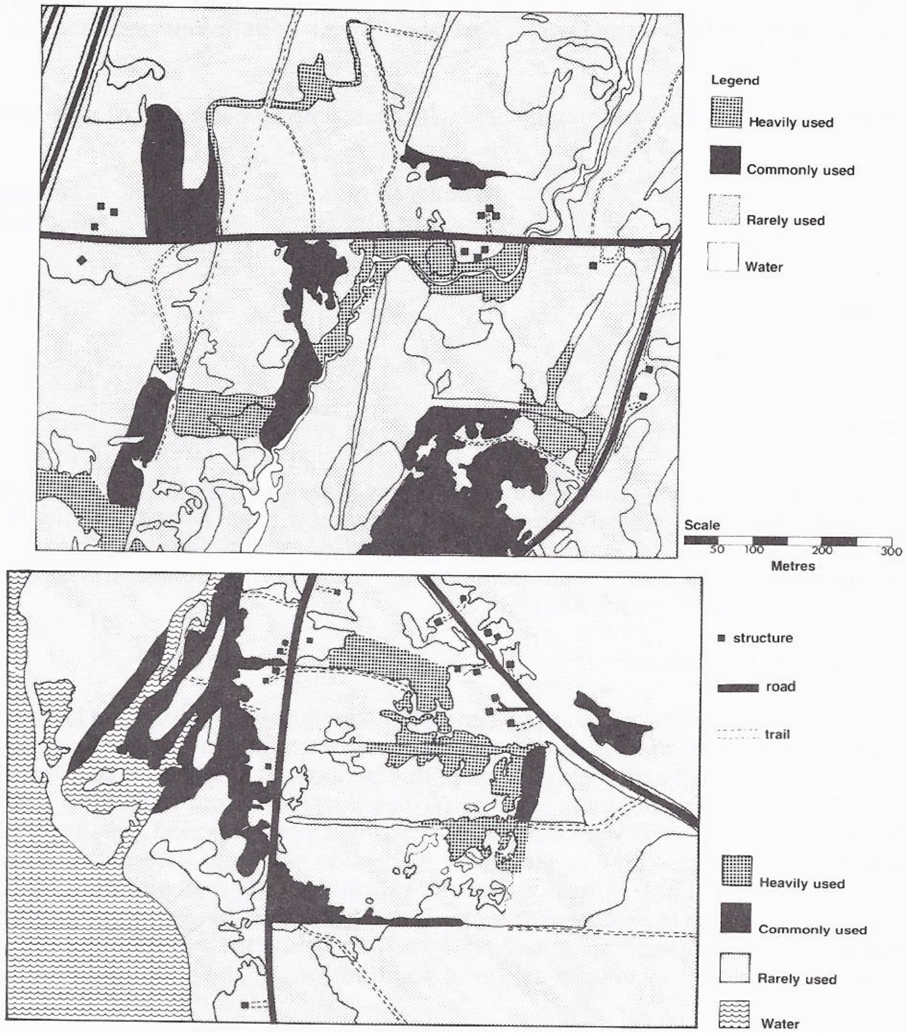


Fig. 1. Woodcock cover usage on the Pea Cove (upper) and University Forest (lower) study areas, Penobscot County, Maine.

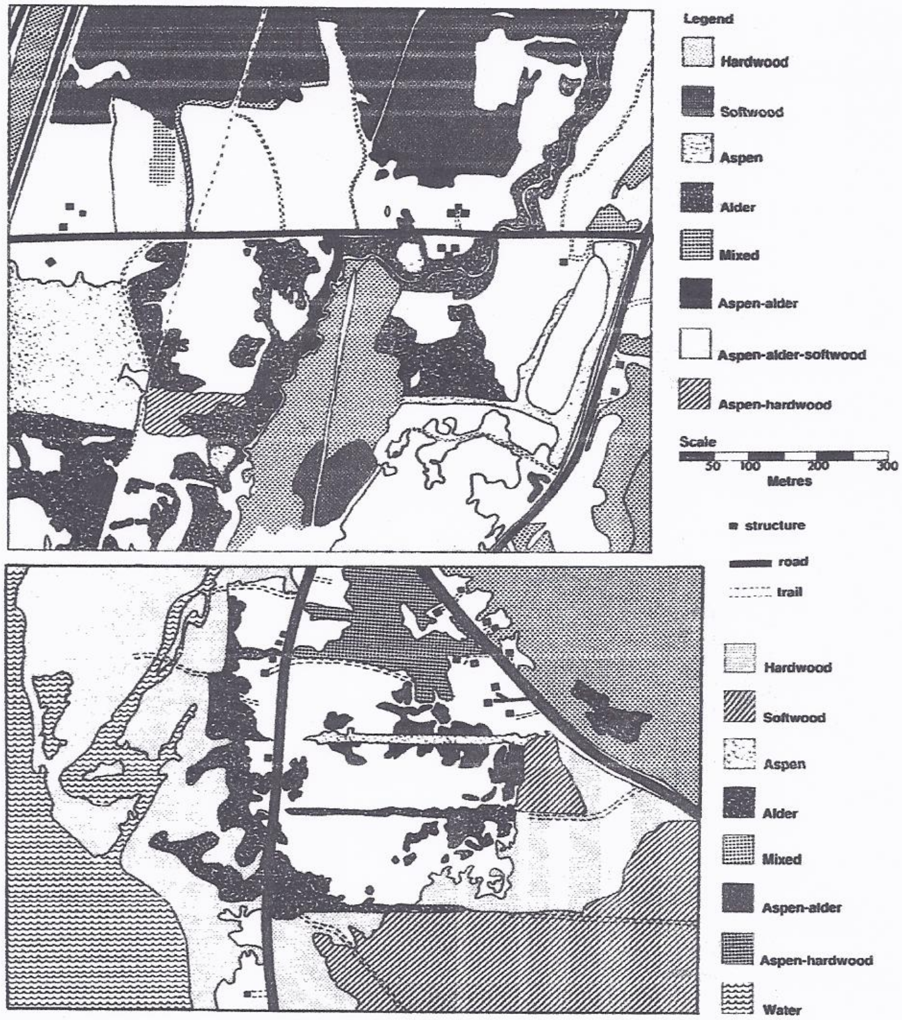


Fig. 2. Vegetative cover on the Pea Cove (upper) and University Forest (lower) study areas, Penobscot County, Maine.

where L = earthworm length in cm (contracted), D = dry Weight in mg, and w = wet weight in mg. Coefficients of determination (r^2) for both equations are 0.83; the second equation is presented for researchers interested in estimating live weights of collected earthworms.

The *optimum area* for active earthworms was defined as the range of soil moisture and temperature conditions in which 85 percent of all earthworm biomass (dry weight) was collected. We suspect that relatively few active (i.e., non-estivating) lumbricids, the ones woodcock would prey upon, are available for extended periods outside this area. Thus, we evaluated the relationship between earthworm abundance as related to woodcock habitat usage in terms of only those lumbricids extracted within the *optimum area*.

RESULTS AND DISCUSSION

Earthworm Species and Age Compositions

A total of 1,261 lumbricids was collected on Pea Cove compared to 1,285 on the University Forest (Table 1). Overall, 2,546 earthworms were taken on 240 quadrats during eight sampling periods (120 quadrats/study area). Relative abundance of the nine species encountered, and the four age classes recognized, did not differ noticeably ($P > 0.05$) between Pea Cove and University Forest (Table 1). Similarly,neither total number nor biomass of lumbricids differed significantly between study areas ($P > 0.05$, 2-way ANOVA). Thus, earthworm data from Pea Cove and University Forest were pooled.

Table 1. Total number of lumbricid earthworms collected on two woodcock study areas in central Maine during April through September, 1974.

		Study area							
	Total number of	Pea Cove				University Forest			
Earthworm species	earthworms (%)	J[1]	A	C	P	J	A	C	P
Aporrectodea tuberculata	1,0C2 (39)	257	101	105	80	232	101	72	54
Lumbricus terrestris[2]	983 (38)	358	41	53	0	414	48	69	0
Lumbricus castaneus	166 (6)	57	5	17	0	55	20	12	0
Eisenia rosea	118 (5)	32	7	13	0	36	14	16	0
Miscellaneous[3]	104 (4)	45	0	0	0	59	0	0	0
Lumbricus rubellus	87 (3)	49	0	2	0	35	1	0	0
Dendrobaena octaedra	50 (2)	13	7	7	0	7	7	9	0
Octolasion tyrtaeum	17 (1)	3	1	2	0	9	0	2	0
Eiseniella tetraedra	12 (1)	0	1	0	0	3	3	5	0
Dendrodrilus rubidus	7 (1)	1	2	2	0	0	0	2	0
Totals	2,546 (100)		1.261				1.285		

[1]J = juveniles; A = aclitellate adults; C = clitellate adults; P = postclitellate adults. See Reynolds (1977b:18) for an explanation of age classes.

[2]This species is unavailable to woodcock (Reynolds 1977a).

[3]This category was used to include specimens that were collected and recorded in the field but lost before identification and biomass determinations could be made. Each specimen was given an assumed length of 1 cm and a weight of 216.6 mg (smallest in collection, easily lost).

Four species of earthworms obtained (*Aporrectodea tuberculata, Dendrobaena octaedra, Lumbricus rubellus* and *Dendrodrilus rubidus*) were from woodcock stomachs in other analyses (Reynolds 1977a), and these made up 45-49 percent of the individual earthworms collected. *Aporrectodea tuberculata*, the most abundant species encountered, consisted of 39 percent of the collection. *Lumbricus terrestris*, the second most abundant species present with 38 percent of the individual earthworms collected, was not found in woodcock stomachs (Reynolds 1977a). Three of the four remaining earthworm species collected by us could be available to foraging woodcock but their contribution to its energy budget is minimal (Reynolds 1977a). *Lumbricus castaneus* was the most numerous of these three species, with six percent of the individual earthworms collected; yet outside the state of Maine it is a relatively insignificant part of the earthworm fauna (Reynolds 1977b).

Earthworm Abundance and Woodcock Habitat Usage

Total number and biomass of extracted earthworms differed significantly between the three types of woodcock feeding covers ($P<0.01$, 2-way ANOVA). This relationship held whether the data were analyzed by individual sampling periods or combined over the season. Thus, the degree to which woodcock used feeding covers seemed to be directly related to the abundance of lumbricids. Liscinsky (1972:32-39) reported similar results in Pennsylvania, both in relation to four different habitat types and as related to alder habitats classified as poor, good, and fair woodcock covers.

Wishart and Bider (1976) found that there was no statistical difference in earthworm numbers or biomass between good and poor woodcock habitats (evidently they did not sample unused covers). However, these researchers did report that good habitats averaged 87±11 percent ($\bar{X}$±S.D.). Thus, they concluded that vegetative structure, as related to security from predators and foraging strategy, was more critical in cover selection than quantity of food. Similarly, Liscinsky (1972:28) concluded that ground cover characteristics were also essential to woodcock habitat usage. Based on a better sampling design, we conclude that earthworm abundance did influence woodcock distribution (Table 2, Fig. 3). However, we acknowledge that vegetative structure and perhaps other unmeasured environmental factors can also affect the feeding ecology of woodcock.

Table 2. Mean (±S.E.) number and biomass (dry weight) of earthworms extracted per quadrat (0.25 m^2) according to levels of woodcock habitat usage on two central Maine study areas, April through September, 1974.

Levels of woodcock habitat usage	Lumbricids extracted/quadrat[1]	
	Number	Biomass (mg)
Heavily used	14 ± 1	4,552.0 ± 406.3
Commonly used	12 ± 1	3,841.6 ± 403.0
Rarely used	6 ± 1	1,944.0 ± 293.0
Total	11 ± 1	3,445.9 ± 225.0

[1]Based on 240 total quadrats, or 80 quadrats per habitat usage level.

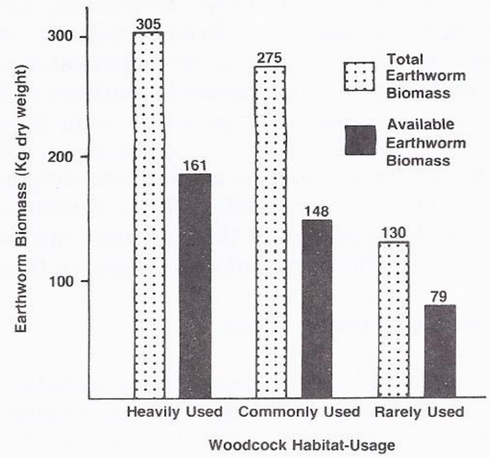


Fig. 3. Woodcock habitat usage as related to total biomass (kg, dry weight) of total and available earthworms collected within the *optimum area* (85% of total biomass occurred within soil moisture of 15-80% and temperature of 10-18°C) on two study areas in Penobscot County, Maine.

Factors Affecting Earthworm Abundance

A comparison of Figs. 1 and 2 shows a general relationship between woodcock habitat usage and vegetative cover. In general, covers most heavily used by woodcock (and earthworms) tended to be young second-growth hardwoods (alder, aspen) whereas rarely used covers were mostly coniferous or mixed stands. A likely explanation for the relationship between earthworm abundance and cover types can be found in the foods preferred by earthworms. Lumbricids eat mainly leaf litter and decomposed organic in the A horizon. Reynolds and Jordan (1975:4) presented a leaf palatability scale for earthworms which, when limited to the major plants encountered in this study, is as follows: alder = aspen > birch = maple = cherry = elm > conifers. Thus, it appears that woodcock use of covers is related to earthworm abundance which in turn is influenced by vegetation providing lumbricids with their preferred foods.

In addition to foods, earthworms are influenced by many physical factors with soil moisture and soil temperature being two of the most critical (Reynolds and Jordan 1975). A three-variable plot of dry weights (mg) of collected earthworms, percent soil moisture and soil temperature (°C) indicates that the *optimum area* for earthworms in our study was 10 to 18°C and 15 to 80 percent moisture (Fig. 4).

We found significant seasonal differences in the number and biomass of lumbricids with the fewest earthworms, and hence lowest biomasses, obtained in late April (too cold) and throughout August (too dry) ($P < 0.01$, 2-way ANOVA). These patterns held whether the data were analyzed separately by study area or combined over both areas.

Data in Fig. 4 do have habitat management implications. Since there are limits for the *optimum area* for earthworms these are the guidlines one should employ in the management of woodcock habitats. Soil temperature can be altered very little without considerable expense or destroying the

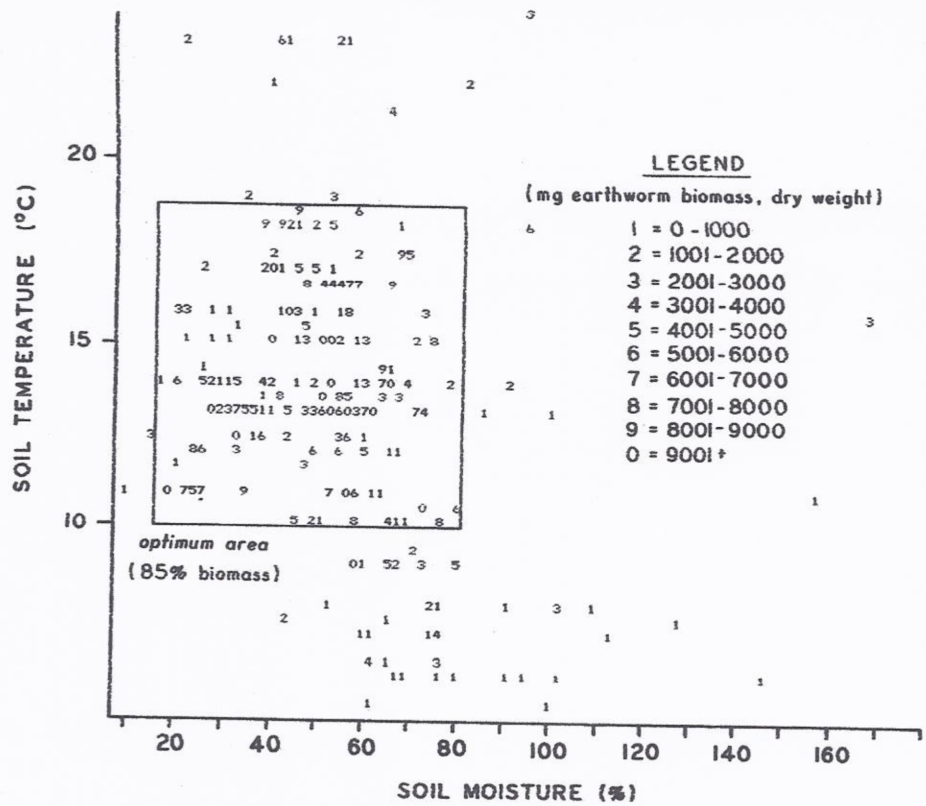


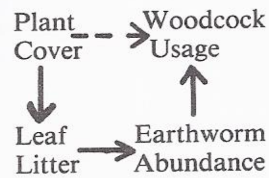
Fig. 4. Dry weight (mg) of collected earthworms as related to soil moisture (percent weight) and soil temperature (°C) for all lumbricids obtained between April and September, 1974, on two study areas in Penobscot County, Maine.

habitat for woodcock (i.e., stand thinning, planting, etc.). Therefore, soil moisture which can be regulated relatively easily offers the best possibility. Our data indicate that if soil habitats can be maintained within the *optimum area* limits the earthworm biomass will be sufficient for woodcock. Sites most favorable to earthworms (alder-aspen) are frequently adjacent to water. Thus, if some sort of inexpensive irrigation system could be established, an *optimum area* could be established or maintained longer during woodcock presence in a given portion of the range. The use of warmer or cooler water might influence marginal temperatures. The presence of a weir system could maintain a higher water table during drier portions of the year. Since earthworms will become inactive during unfavorable environmental conditions, their availability to woodcock is reduced. Therefore, woodcock will move to more productive earthworm areas. Monitoring soil temperature and moisture might be a method of predicting probable woodcock movement. Also, the creation of optimum earthworm habitats will increase earthworm activity and ultimately earthworm biomass. Eventually the increased earthworm biomass will lead to an increase in the carrying capacity of the habitat for woodcock.

CONCLUDING REMARKS

Formalin solutions do not extract all earthworms present but select only a portion of those active individuals nearest the surface. Presumably, these non-estivating earthworms are the ones woodcock would most likely find and eat. Unfortunately, we have no data to test for possible differences between species, or ages, in the susceptibility of lumbricids to formalin extraction. Additionally, it is possible that the fraction of earthworms extracted varies with soil moisture. Although we suspect species-, age-, and moisture-related differences in extraction rates to be minimal, we point out that our data are based only on "collected earthworms" which may not be completely representative of the lumbricids in the study area.

Relationships between woodcock usage, plant cover, leaf litter, and earthworm abundance can be tentatively diagrammed as follows:



Biologists have long recognized that woodcock prefer specific types of vegetation (indicated by the dashed line above). However, Liscinsky (1972), Reynolds (1972), and the present study are some of the first approximations at understanding what causes these preferences (solid lines). Only by continuing to probe cause-effect relationships involved in woodcock cover selection can habitat management be improved.

What effect does woodcock predation have on earthworm populations? In a study of golden plovers (*Pluvialis apricaria*) on a 1.2 km^2 hayfield in Iceland, Bengtson *et al.*(1976) found that a few birds (2-5) in spring reduced the number of earthworms by 50 percent in only 3 weeks. Presently, we have no similar data regarding woodcock predation although the literature and personal observations do provide clues. Earthworm species vary considerably throughout the North American range of the woodcock (Reynolds 1977a, Fig. 1). In the southern part of the bird's range, two nearctic earthworm species widely distributed in the upper A horizon of the soil and easily accessible to foraging woodcock are collected in large quantities for fish-bait. In two Florida counties during the past 40 years, between 100,000 and 200,000 earthworms have been collected from limited areas each day, without any apparent stress on the population (Reynolds 1973:106, 109). If earthworm populations can withstand this amount of predation by man, it is doubtful that woodcock could deplete or severely reduce earthworm populations in the southern portion of their range in North America. From the senior author's observations in Maine, New Brunswick, Quebec and Ontario, he doubts that such a drastic depletion of the spring earthworm populations would be as severe as the Icelandic situation recorded for plovers (Bengston *et al.* 1976).

Sheldon (1967:80) found that penned woodcock, during summer, ate an average of 150 g of worms/bird/day. Liscinsky (1972:22-23) reported that two captive woodcock consumed 60 g of worms/bird/day, but both birds lost considerable weight. Both studies were based on live, or wet, earthworm weights. More data are needed, especially as related to seasonal variations in consumption rates and cold stress, but it appears that woodcock must eat approximately their own body weight in live earthworms every 24 hours (Sheldon 1967:80). Consumption rates only indicate the amount of food needed and additional field studies, similar in design to Bengston *et al.* (1976), could reveal the impact of woodcock on their prey base. Such studies will eventually lead to a better understanding of carrying capacities of woodcock feeding habitats.

In terms of the number of earthworms, and hence woodcock, sustained per unit area, this study clearly showed the importance of second-growth hardwoods. Furthermore, direct efforts aimed at improving woodcock habitats should focus on management of young hardwoods, especially alders and aspens, instead of softwoods or mixed forests in the northern portion of the bird's range. This does not apply to indirect efforts to influence woodcock habitats, such as modified forestry practices where increasing woodcock numbers is, at best, generally a secondary objective. Such large-scale manipulations of habitats can have great overall impacts on woodcock, and other wildlife, although increases in woodcock per unit area are often small. Thus, in terms of specific efforts to increase woodcock *density* it appears more efficient to manage second-growth hardwoods rather than alter coniferous or mixed stands.

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