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E. A. Osgood, Jr.

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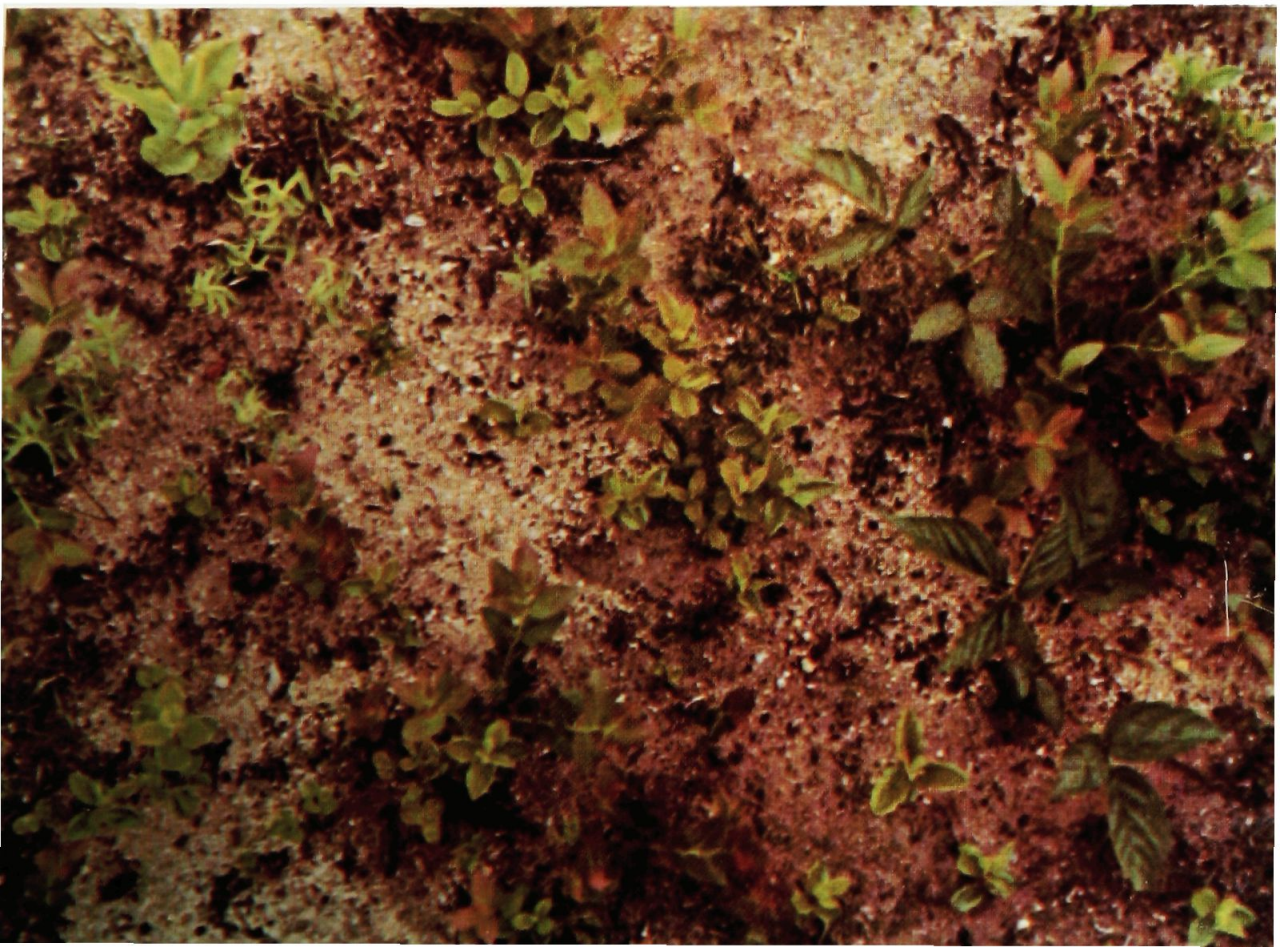

Soil Characteristics of Nesting Sites of Native Bees Associated with the Low-Bush Blueberry in Maine

E. A. Osgood, Jr.[1]

INTRODUCTION

Fruit from the low-bush blueberry complex is an important source of income for growers in many areas of Maine. Blossoms of the species involved are dependent on insects for pollination and fruit set. Phipps (1930) listed several species of native bees collected on low-bush blueberries in Maine. Boulanger *et al.* (1967) listed 59 species of native bees which were collected on *Vaccinium* spp.; 38 of these species occur in the general area in which the present study was conducted. Most of these species of wild bees nest in the soil, and they are important pollinators of the low-bush blueberry.

In recent years much work has been done in the western states on the artificial propagation of the soil-nesting alkali bee for the purpose of increasing production of alfalfa seed, and this work has recently been reviewed by Bohart (1972). Information concerning nesting sites is needed if there is ever to be an attempt at increasing populations of native bees by altering soil characteristics. Such information will also be useful when planning other biological studies of these insects.

During the course of ecological studies of certain native bees which pollinate the low-bush blueberry in Maine, it was noted that several species chose particular areas in which to construct their nests. It is the object of this bulletin to make known the characteristics of these chosen sites and to compare them to areas that are not conducive to nesting.

This study was carried out in Deblois, Washington County, on areas known as "blueberry-barrens." The predominant soil in the area is Colton gravelly sandy loam.

PROCEDURE

Five areas containing good populations of nesting solitary bees were chosen for study. These ranged in size from 200 to 500 square feet. For each selected nesting area, a nearby area in which bees did not nest was used as a control. For each of these 10 areas, general observations of plant cover, aspect and slope were recorded.

By use of a cylindrical metal sampler, soil cores were taken and the depth of the organic (O_2) and albic (A_2) horizons was measured to the

[1] Associate Professor of Entomology, University of Maine, Orono, Maine 04473.

nearest quarter inch. The O_2, A_2 and spodic (B_2) layers were then placed in separate containers. Sufficient soil from each of the three layers was obtained for further tests. The number of random samples taken in each area varied from 22-29 and was governed by the layer in minimum supply.

The soil reaction of duplicate samples of each horizon from each area was measured by a Beckman, battery powered pH meter. A soil: water ratio of 1:1 was used.

It was thought that the amount of organic matter in the O_2 layer was an important factor in selection of nesting sites by solitary bees; therefore, the percentage of organic-C in this layer and in the A_2 layer was determined by use of the Walkley-Black method (1965b).

A double-cylinder, hammer-driven core sampler was used to obtain triplicate soil core samples. The determination of moisture retained in these samples at 0.1 bar suction was made by use of a ceramic pressure plate and the 15 bar moisture retention was determined by use of a pressure membrane apparatus (1965a). Moisture retention was reported as percentage of dry weight of soil. Bulk density of each soil layer sampled was based upon oven-dry weight of the soil cores. Available water in inches was taken as the difference in water retention at 0.1 and 15 bars times bulk density. Significance of variables was determined by use of Students "t" test.

RESULTS

As mentioned previously, observations of plant cover, aspect, and slope were made on each of five nesting areas and five control areas. Cover was divided into three general categories: dense, intermediate and sparse. Plant stand in the nesting areas was mostly in the intermediate range, with some portions of three areas being dense and one area sparse. The control areas were all in the dense category.

Nesting sites were generally the highest point in the immediate area or were on south to west slopes. Control areas were in lower locations on southwest to west slopes or in relatively flat areas. Consequently, surface flow of water was higher in the nesting areas. Drainage was good in both areas.

Results of the measurements and determinations of pH, horizon depth and percentage of organic-C are shown in Table 1. The pH data for each area are averages of duplicate measurements and there was seldom a variation greater than one-tenth of a pH unit in these duplicate samples. Nest and control means of pH measurements in the O_2 horizon were not significantly different at the 0.10 level. Data for the A_2 and B_2 horizons were equally as uniform as those in the O_2 horizon and tests of significance were not conducted.

Individual sample measurements of depth of the O_2 and A_2 horizons were somewhat arbitrary since the lines of demarcation between the O_2 and A_2 horizons were not always sharply defined. Since these average depths are based on 22-29 measurements, this posed no problem. Means of nesting areas of the depth of the O_2 and A_2 horizons were significantly different from the respective control means at the 0.02 level.

TABLE 1

Relationship of nesting areas to control areas as regards pH, horizon depth, and percentage of organic carbon.

Study area	Horizon	pH Nesting area	pH Control	Av. Depth (inches) Nesting area	Av. Depth (inches) Control	% Organic-C Nesting area	% Organic-C Control
1	O_2	4.9	4.8	1.42	2.02	10.6	14.7
	A_2	4.8	4.8	1.34	2.40	2.1	1.4
	B_2	5.5	5.4				
2	O_2	4.8	5.1	1.31	1.49	6.7	12.9
	A_2	4.8	4.8	0.87	1.90	2.0	1.9
	B_2	5.2	5.5				
3	O_2	5.1	5.2	0.97	1.44	6.9	12.6
	A_2	4.6	4.6	0.60	1.06	2.6	2.4
	B_2	5.1	5.3				
4	O_2	5.1	4.7	1.26	1.59	8.2	20.4
	A_2	4.9	4.7	0.60	1.56	2.9	2.8
	B_2	5.3	5.4				
5	O_2	4.9	4.8	1.12	1.70	9.8	18.2
	A_2	4.7	4.7	1.03	1.62	1.9	1.9
	B_2	5.3	5.5				
Mean±SE	O_2	4.96±.06	4.92±.10	1.22±.08	1.65±.10	8.4±.8	15.8±1.5
	A_2			0.89±.14	1.71±.22	2.3±.2	2.1± .2

The A_2 horizon is an undulating layer and varies considerably from sample to sample in both nesting areas and controls. It was deeper in the controls since many of the samples taken were in lower areas, and the increase in depth of the A_2 horizon represents excessive leaching, possibly from accumulated runoff. Bees were often found constructing galleries in areas where the A_2 horizon was both deep and shallow. As far as selection of nesting sites by bees is concerned, the O_2 horizon is probably more important than the A_2 horizon since it must be penetrated first. The most important factor appears to be the amount of surface organic matter. The A_2 horizon is of a fine, uniform consistency and undoubtedly is the easiest layer for bees to penetrate.

Data for percentage of organic-C are averages of duplicate tests using the Walkley-Black method. This is a more precise method of determining the organic matter content of the O_2 level than measuring the depth. These data were very uniform; the greatest difference in percentage of organic-C within duplicate tests being 0.6%, and this occurred in just two instances. Nesting and control means of percentages of organic-C present in the O_2 horizon were significantly different at the 0.01 level. Nesting and control means for the A_2 horizon were not significantly different at the 0.10 level.

Results of the determinations of bulk density and available water are shown in Table 2.

TABLE 2

Relationship of nesting areas to control areas as regards bulk density and available water.

Study Area	Depth of Sample in inches	Bulk Density g/cm³		Available Water in inches	
		Nesting Area	Control	Nesting Area	Control
1	surface	.8	.5	.17	.13
	4	.9	.9	.17	.15
	8	1.2	1.0	.14	.13
2	surface	.9	.6	.15	.24
	4	1.3	1.0	.16	.15
	8	1.2	1.0	.12	.12
3	surface	.8	.6	.14	.26
	4	1.0	.8	.15	.17
	8	1.1	1.0	.14	.13
4	surface	.9	.6	.19	.14
	4	1.1	1.0	.18	.14
	8	1.1	1.2	.15	.11
5	surface	.6	.3	.23	.22
	4	1.0	1.0	.13	.15
	8	1.2	1.1	.11	.16
Mean ± SE	surface	.80±.054	.52±.057	.18±.016	.20±.026

Means of nesting areas of bulk density of the surface layer were different from the respective control means at the 0.01 level of significance. This is further evidence that the surface layer is an important factor in selection of nesting sites by solitary bees, as one would certainly suspect that it would be. Lower bulk density of controls and a greater amount of organic-C is indicative of more pore space in these samples. Data for bulk density at the four and eight inch levels were very uniform (Table 2) and tests of significance were not conducted.

Nesting and control means of available water in the surface layer were not significantly different at the 0.10 level. Data at four and eight inch levels were even more uniform and tests of significance were not performed.

DISCUSSION

The most important characteristic of nesting areas for native pollinators appears to be the amount of organic matter in the O_2 horizon. The most precise measurement of this factor (percentage of organic-C) was determined by the Walkley-Black method. The mean of nesting areas was significantly different from the control area mean at the 0.01 level. Native bees do not nest in any great numbers where most of the ground surface is covered with a relatively deep, continuous O_2 horizon, probably because they experience great difficulty in penetrating this layer. The A_2 and B_2 horizons of nesting and control areas were not found to be different in any way which appeared to be detrimental to nesting.

Areas chosen by bees for nesting are usually well drained areas with a good surface flow and a plant stand of sparse to intermediate density. The O_2 horizon is relatively loose or pliable and the percentage of organic-C is relatively low. Generally, there is a considerable amount of the leached A_2 layer visible on the surface (cover photo) and occasionally the B_2 horizon is visible. Many species of native bees have been observed to nest in such areas and include:

Colletidae
- *Colletes inaequalis* Say

Andrenidae
- *Andrena carlini* Cockerell
- *A. regularis* Malloch
- *A. vicina* Smith
- *A. alleghaniensis* Viereck
- *A. crataegi* Robertson
- *A. bradleyi* Viereck
- **A. dunningi* Cockerell

Halictidae
- *Halictus confusus* Smith
- *Lasioglossum forbesii* (Robertson)
- *L. leucozonium* (Schrank)
- *Dialictus pilosus pilosus* (Smith)

Megachilidae
- *Osmia* sp.

Undoubtedly, with time, many additional species will be found to utilize the same kinds of areas. Many species are small and galleries are not easy to locate and identify. Also, many species are not abundant in the area studied. Many large areas of the "blueberry-barrens" where the study was carried out do not have suitable nesting areas.

* Has not been collected on blueberry.

The Pollination Problem

There may be many reasons why native bees are not able to accomplish adequate pollination of the low-bush blueberry. Foraging distance of these bees is not known, but they probably provision fewer cells if flight distance is great, as is often the case on large burns in Maine. Lee (1958) noted that in New Hampshire the population of native pollinating insects probably pollinated small fields adequately, but not large fields of several hundred acres which have a lot of bloom for a short time in relation to the number of native pollinators. Others have subsequently mentioned this for other areas. The large fields simply dilute the local population of native pollinators.

Free (1970) states that:

> "It is also evident that clean and intensive cultivation of the land has destroyed many natural food sources and nesting sites of wild pollinating insects; in pioneer conditions in North America wild pollinators were adequate to pollinate the small areas of cultivated crops, but as land clearing progressed they became insufficient. It is supposed that there has been a decrease in the numbers of our wild insect pollinators as a result of applications of insecticides and herbicides. Although this may well be true, there is no sound evidence to support this supposition; any such evidence would be very difficult to obtain. Planting of large areas of a single crop tends to provide ample forage for a limited period of the season only, and there may be little or no forage available to pollinating insects at other times."

It is interesting in this respect that G. W. Wood (personal comm.) states that direct counts of native bee populations in New Brunswick are about the same on large areas that have recently been cleared for blueberry production as on land that has been in blueberry production for many years and on which various insecticides have been used.

Limited forage may be an important factor with our native bees which pollinate the low-bush blueberry in many areas of Maine. Many of these bees have a life-span of 4-6 weeks and need food sources other than the blueberry. They cannot increase their population simply in response to increased acreage of blueberry bloom.

Two of the most successful attempts at managing wild pollinators involve the alkali bee, *Nomia melanderi* and the alfalfa leaf-cutter bee, *Megachile rotundata* for the pollination of alfalfa. Alfalfa is not adequately pollinated by honey bees and Bohart (1972) states that "management of wild bees has been tried only for crops which, under at least some circumstances, are poorly or inefficiently pollinated by honey bees." Free (1970) mentions that:

> to be of use commercially a species must be gregarious, rapidly increase its population in man-made nests, visit a particular commercial crop in preference to other species, have its peak of activity coincide with that of the crops, be easily manipulated and managed, and not be subject to uncontrollable parasitism and disease."

It may well be that most, if not all, of the native bees which are now known to pollinate the low-bush blueberry in Maine do not fit these criteria. However, there is a large complex of species of native bees present in all blueberry fields. It is known that their numbers may fluctuate greatly from year to year and from field to field, and that the species complex may be considerably different from field to field. We should attempt to determine the reasons why some fields harbor higher native bee populations than others and consequently why some fields have an excellent fruit set in most years without using honey bees, while other fields do not.

Research Approaches to the Pollination Problem

Several possible reasons have been mentioned for the inadequate number of native bees found in many fields and therefore necessitating the use of honey bees for adequate fruit set. Suitability of the soil for nesting, the subject of this paper, is just another reason for low bee populations in a given area.

There are at least two major approaches to the problem of determining the reasons for low native bee populations in some fields. One approach would be to attempt to correlate populations of the more abundant species of native bees with factors (many of which have been mentioned in this paper) which are thought to limit their numbers. The number, size and perhaps location of nesting areas should be one of the variables. By attempting such correlations one hopefully would gain leads to the important factors or combination of factors governing the abundance of native pollinators.

Long term studies utilizing existing knowledge might be another approach which would elucidate factors responsible for governing native bee abundance. The greatest population of native bees that I have observed to date is on abandoned agricultural land in New Brunswick which has just recently been converted to blueberries by burning. In this particular field the B_2 layer is visible on the surface in many areas and bees are able to excavate galleries in a large proportion of the field. Long term study in the simplest sense would mean measuring the population of native bees in such fields from year to year over a long period of time to determine if changes which affect populations take place in these fields.

Other types of long term studies could be established also. Alternate food sources undoubtedly are important for native bees. Although it has frequently been mentioned in the literature, I am not aware of any direct attempt to assess the effect on native bees of increasing the supply of alternate food sources, i.e., plants that bloom

both before and after blueberry. One should census native bee populations for several years, then change one of the variables such as increasing alternate food sources or increasing the attractiveness of areas for nesting by mechanically altering the O_2 horizons in limited areas. These two variables and many others such as size, age and elevation of fields, slope, burning practices, and insecticide use could be studied separately and in combinations.

With either approach I believe we can go a long way toward determining the factors responsible for determining the abundance of native pollinators on the "blueberry-barrens" of Maine.

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