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# Management of Habitats for Wild Bees

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## MANAGEMENT OF HABITATS FOR WILD BEES<sup>1</sup>

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THE NORTH AMERICAN BEE FAUNA is composed of over 5,000 species, most of which are nonsocial and make nest burrows in the soil. About 500 species nest above ground in small cavities such as beetle holes, hollow stems, and rock pockets or dig their own tunnels in pithy stems or wood. Also, about 100 social species (bumble bees, stingless bees, and the honey bee) establish their colonies in relatively large cavities, both below and above ground.

The honey bee (*Apis mellifera* L.) was brought to the New World by European colonists. Consequently, on this continent, it had no influence on the long evolutionary cooperation between plants and their pollinators. About 10 other species of bees, all of them solitary, have been established accidentally in North America, but only one, the alfalfa leafcutter bee, has become abundant enough to have a noticeable impact on the native bee fauna or to significantly affect the pollination of crops.

### ABUNDANCE OF BEES

Except in the most northern arctic regions, bees are found wherever flowering plants occur. However, they are relatively scarce in unbroken forests because they are dependent on flowers which develop best in sunlit areas. Furthermore, most bees prefer to fly in bright sunshine. Therefore, it is probable that, at least in the eastern half of the United States, wild bees are more abundant now than when white men first arrived. This suggestion runs counter to statements frequently made by apiculturists to the effect that wild bees are rapidly disappearing from the scene. I do not say that wild bees

<sup>1</sup> The term "wild bees," as herein employed, refers to all species of bees of several families, but not to the honey bee and its Old World congeners in the genus *Apis*.

are uniformly benefited by man's activities or that some species have not suffered severe setbacks. In areas largely paved with concrete and asphalt, in those given over to intensive clean-culture farming, or in areas subjected to unusually intensive treatments with insecticides, nearly all kinds of wild bees are indeed becoming scarce. However, man's activities have tended to increase the populations of most species of wild bees (1) by opening up forested areas, which creates more favorable conditions for flowering and nesting; (2) by constructing highways in desert and semidesert areas, which concentrates moisture along the road shoulders and provides ribbons of bloom in otherwise barren areas; (3) by introducing and otherwise fostering the increase of many vigorously blooming weeds such as sweetclover, star thistle, and sunflower; (4) by growing many acres of crops that provide additional forage; and (5) by irrigating desert areas to allow for more plant growth, much of which provides useful forage and nesting places.

Other of man's activities have also provided nesting places for many species of bees. For example, when areas of ground are scraped free of vegetation and packed, ground-nesting species move in. Man-made vertical embankments are adopted by another group. In the West, irrigation often results in the development of moist, alkaline areas favored for nesting by some bees. Also, some of man's structures such as adobe walls, shingled siding, reed-covered roofs, and outbuildings full of nail holes provide nesting places for selected species. Even browsing by domestic animals and by man-increased deer populations exposes the pithy centers of plant stems to a succession of pith-burrowing and tunnel-adopting species of bees and wasps.

On the debit side, man has often destroyed or damaged bee habitats. The widespread use of herbicides along roads and drains and in fields greatly reduces the number of flowers, which reduces bee populations, especially in arid and semi-arid areas where bloom tends to be concentrated. Also, man-created nesting areas are often so temporary that they serve as traps rather than havens, and intensively farmed areas with underground drains, clean fence lines, and large, weed-free acreages of crops do not encourage bee habitation. Finally, applications of insecticides are nearly always destructive, sometimes highly so, to bee populations. In a few cases, when insecticides are

applied to budding plants such as alfalfa, they may actually benefit bees by killing the sucking insects that destroy the flowering potential. More commonly, however, insecticides applied directly to blooming plants or drifting onto them result in extensive killing of bees, and leafcutter bees also fall victim to residues of insecticide on the leaves they use for nesting material.

It seems probable (but cannot, of course, be proved) that populations of wild bees reached their peak in the depression years when many farms were abandoned, fields were often weedy and only partially cultivated, and relatively small amounts of insecticides were used. The present trend is probably downward, though in limited areas some success has been achieved in the purposeful increase of two species, the alkali bee and the alfalfa leafcutter bee.

### THE ALKALI BEE

The alkali bee, *Nomia melanderi* Cockerell, was recognized as an important pollinator of alfalfa by Vansell and Todd as early as 1946. By the early 1950's, a number of seed growers in the northwestern states were trying to maintain and expand existing nesting areas for these bees and to create new ones. Then in 1959, after the development of "artificial" nesting sites (Stephen, 1960), many growers began building and maintaining such sites—with varying degrees of success. Interest in the alkali bee gradually declined during the 1960's because of increasing interest in the management of the alfalfa leafcutter bee and a succession of several poor years for alkali bees (resulting from untimely rains). However, interest remained high in central and southeastern Washington and an area west of Fresno, California where the bee was rather newly established.

The alkali bee is found from the eastern slopes of the Rocky Mountains to the west coast except for the extreme northwest and southwest. The principal domain is the larger irrigated valleys of the Intermountain Region where the species forms large nesting aggregations in those alkaline soils that have a nearly constant supply of sub-surface moisture. It prefers a loamy texture and tolerates a bare to moderately vegetated surface. At the time of nest establishment, it is particularly important that the soil be moderately moist from 8 or

10 inches below ground to the surface and that the surface be well drained, firm, and smooth or nearly so. The necessary conditions are met in nature in widely scattered localities, especially in the larger valleys, and often close to river banks where the soil is sandy or silty and seepage enters from the higher surrounding ground. Thus the advent of extensive irrigation with the consequent seepage along the canal banks and the reappearance of percolated water below the irrigated fields has resulted in a great increase in the number of potential nesting areas.

Alkali bees collect pollen from many kinds of plants, but they are not as catholic in their tastes as the honey bee. Their favorite host plants include alfalfa, sweetclover, spearmint and peppermint, Canada thistle, bindweed, Russian thistle, perennial peppergrass, and purple bee plant. Of these, only the purple bee plant is native, and even it is found principally in ground disturbed by man. Therefore, by unwittingly increasing the number of potential nesting areas and vastly increasing the available forage, farmers have changed the alkali bee from an uncommon species to one that is abundant and important.

The older farmers in central Utah recall that in the 1920's and 1930's there were many alkali bee nesting sites with populations running into the millions. Although they did not realize it, these bees were responsible for the high yields of alfalfa seed that made Utah one of the nation's principal producers at that time. Then the increasing demand for seed induced many farmers to plough their sites, even though the soil was highly alkaline. Reduction in the population of alkali bees was immediate. I recall hearing a farmer from Delta, Utah describe the huge flocks of seagulls that followed his plough to feed on the overwintering bee larvae which were strewn behind him like popcorn as he ploughed. In the 1940's, much of the area around Delta had been drained and ploughed, and in the 1950's, and early 1960's, dieldrin and parathion, which are highly toxic to alkali bees, were used extensively on alfalfa seed crops to control lygus bugs. As a result, the size and number of alkali bee nesting sites dwindled, and the bees were no longer important as pollinators except in peripheral areas where they partially escaped the hazards.

In contrast, alfalfa seed growers in Idaho, Oregon, and Washington were apprised of the value of the alkali bees in the late 1940's and

began preserving nesting sites and entering into covenants to control the use of insecticides. As a result, through the 1950's, these areas greatly increased the acreage and per-acre yields of alfalfa grown for seed, and Utah became a relatively minor producer.

The first measures taken to manage alkali bees consisted mainly of extending parallel ditches through areas of suitable soil and filling them with water to create seepage in the intervening spaces. This method often succeeded when a natural hardpan layer underlay the area, but today, such ditches have been replaced by series of reservoirs which provide more water and need less frequent filling. However, in most areas, reliable and continuous seepage did not result from ditches and reservoirs, and it was necessary to construct excavations that were 3 to 4 feet deep and to line them with plastic film to form an artificial hardpan. The plastic was then covered with a layer of gravel which would distribute and store the water. The excavation was backfilled with soil through which the water seeped. In most cases, salt (sodium chloride) had to be added to the surface to seal it and inhibit the growth of weeds. Thereafter water was added as needed through pipes extending from the surface to the gravel layer (Bohart and Knowlton, 1968). The resulting nesting places, though expensive, promised to maintain attractive and relatively stable conditions for a number of years in otherwise unsuitable tracts of ground. Various minor refinements in design were added through the late 1950's and 1960's. However, in spite of rather careful construction and maintenance, many such "artificial" sites suffered severe declines in the population of bees after the initial success.

Many factors can contribute to a decline in populations of alkali bees, even when the basic soil conditions remain fairly stable. A drastic decline is most commonly the result of heavy rain during the nesting season (late June to early August in the northwest). This condition kills many adults, floods the brood cells, and creates an environment favorable for the growth of yeasts and molds on the food stores. Transparent covers (fiberglass or plastic) can be erected over the nesting sites, but their construction and maintenance are so expensive that it is probably impractical to cover anything more than a small area which can serve as a refuge from which the population can expand later.

In the year following a favorable season, nesting populations in good sites quickly expand. This results from the large number of bees emerging from the site and also from bees flying in from other, perhaps overcrowded, sites. A number of farmers with large natural nesting sites sell blocks of soil containing overwintering bee larvae to farmers stocking new sites. The stripped area is then replaced with new soil, and bees from other parts of the site move into the new soil which often becomes more populous than the older area. It thus appears that a grower can sell a percentage of his bees each year and actually improve his site by gradually renewing it. However, untimely rains can cause as many spoiled food stores in fresh, relatively fungus-free soils as in old ones full of spores. Apparently, the yeasts which cause the initial spoilage do not remain viable in the soil but are carried by bees to flowers where they multiply in the nectar which is then taken to new brood cells where it can cause food spoilage when conditions are right for yeast growth. The major problem is thus not solved by using new soil though other less severe problems associated with ingestion of molds by older larvae are apparently reduced.

Vertebrate predators at the nesting site are also a problem in many areas. Skunks dig up and eat the larvae in the winter and sometimes literally plough large areas. Concerned growers usually control these skunks with baits poisoned with strychnine. Also, birds of several species sometimes flock to the sites and feed on adult bees, though their damage is somewhat mitigated by the fact that they prefer to eat the parasitic flies that destroy many bee larvae. Thus in the early part of the nesting season when the flies are most active, the birds are probably more beneficial than harmful to the bee population, and farmers, acting on this supposition, often leave the birds alone for the first 2 or 3 weeks. Then they start shooting, trapping, or scaring them away, usually with timed explosions. Unfortunately, many birds soon lose their fear of these devices.

#### THE ALFALFA LEAFCUTTER BEE

The alfalfa leafcutter bee, *Megachile rotundata* Fab. was accidentally introduced into the United States from either southeastern



Europe or southwestern Asia where it is native. It was first collected near the East Coast in the late 1930's. By the 1940's, it was found as far west as the Mississippi River, and in 1955, it was found in several western states including California. In the West, the alfalfa leafcutter bee was not recognized as a newcomer until 1958 when the populations had increased to the point that the potential of the insect was becoming apparent. This bee pollinates alfalfa readily, and its host range is similar (but not identical) to that of the alkali bee. Unlike native leafcutters, it does not damage shrubs or trees by using their leaves for its brood cells. Instead, it cuts mostly herbaceous leaves and petals without causing consequent damage to the plant. Its greatest selling points are the rapid population buildup it can achieve, its gregarious nature, and its adaptability to human manipulation.

At first, farmers were merely advised to drill holes in their out-buildings and hang up drilled blocks of wood to serve as nesting places. However, during the 1960's, a small industry gradually developed that was devoted to the manufacture of nesting materials and shelters, the raising and overwintering of the bees, and the use of them in the fields for alfalfa pollination. As a result, several systems of handling the bees developed, and there is still no uniformity in methods. Except in parts of Washington and a limited area in the San Joaquin Valley of California, farmers came to rely on alfalfa leafcutter bees more than they did on alkali bees, principally because the factors involved in their management seemed to be easier to control.

The alfalfa leafcutter bee nests in narrow pre-existing holes above-ground or in vertical banks. In nature, these sites include insect holes in banks, dead trees, and timbers, large nail holes, spaces between shingles, and tubing of various kinds. The species avoids the shade of trees, but it nests readily in open buildings. In general, it prefers spaces it can barely enter (about  $\frac{5}{32}$  in.), but holes as wide as  $\frac{8}{32}$  in. are accepted by large bees when smaller holes are not available.

Investigators and farmers soon started drilling holes in timbers and placing bundles of soda straws in boxes to serve as nesting material. Corrugated cardboard and grooved boards fastened together were tried next. Other materials such as particle board and several kinds of plastic were also investigated. The principal materials now in use are



Fig. 1. Cutting and removing soil blocks with overwintering alkali bee larvae. (H. W. Potter)



Fig. 2. "Artificial" alkali bee nesting site with rain shelter over one area. (H. W. Potter)



Fig. 3. "A-frame" type of shelter for nest boards of alfalfa leaf-cutter bees. (H. W. Potter)

Fig. 4. Small colony of bumble bees (*Bombus griseocollis* De-Geer) in old mouse nest. Visible cocoons contain new queens, indicating that colony development has been terminated. (W. P. Nye)



Fig. 5. Alfalfa leafcutter bees (*Megachile rotundata* F.) entering and leaving their nests in boxes of soda straws. (W. P. Nye)



Fig. 6. A chalcid wasp (*Monodontomerus obscurus* Westwood) ovipositing in an alfalfa leafcutter bee leaf cell. (H. W. Potter)

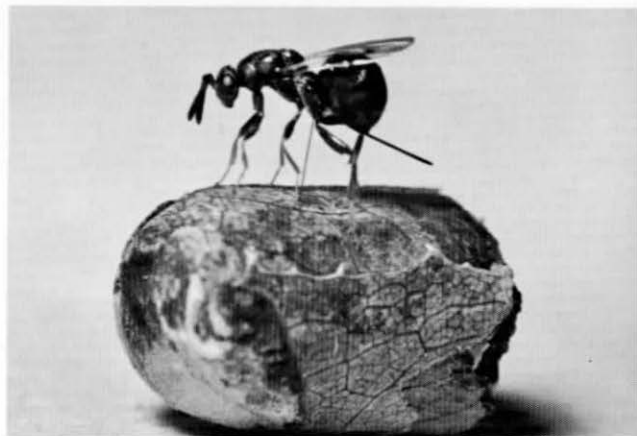




Fig. 7. A female alkali bee (*Nomia melanderi* Ckll). (W. P. Nye)



Fig. 8. Construction of experimental alkali bee nesting sites. Plastic in place, protective soil layer being installed. (H. W. Potter)



Fig. 9. Adult bee fly (*Heterostylum robustum* Osten Sacken) emerging from pupal case. (W. P. Nye)

soda straws (paper and plastic), drilled 4 × 6 timbers, and units made of grooved boards (wood or plastic).

The two principal methods of management involve: (1) overwintering the mature larvae in their nesting materials; or (2) using free cells which are removed from the nesting materials prior to overwintering (Bohart and Knowlton, 1967). With method one, the nesting materials are sometimes merely brought from the field to an unheated outbuilding and then in the spring returned to the field about 2 months before the expected date of emergence. For more careful management, they are placed in a cold storage facility and then incubated in the spring for about 25 days before the emerging bees are placed in the field. With method two, free cells are scraped from disassembled grooved nesting units or punched from drilled boards from which a separate backing has been removed. Loose cells are held in controlled cold storage and incubation, then placed in trays under a layer of sawdust and finally removed to field shelters that contain fresh nesting materials.

The field shelters in which the bees emerge in the field are designed to expose them to sunlight in the morning and to protect them from rain, wind, and afternoon temperatures above 95°F. The shelters are usually large enough to house about 50,000 females and are distributed through the field in such a way that bees from each shelter do not have to cover more than 10 acres to find adequate forage. Larger populations per shelter increase the orientation problems of returning bees, and greater distances between shelters sometimes result in a spotty pattern of pollination with reduced seed set midway between the shelters.

Control of several species of scavenger-predator beetles and several chalcid wasps that parasitize mature larvae is necessary to prevent rapid declines in populations of the leafcutter bees (Johansen and Eves, 1969). Most such control of insects takes place during incubation when water traps are used against wasps and bait traps are used for the beetles, but Naled is sometimes used as a spray on the surface of the nesting materials while the bees are dormant. Birds of various kinds take a toll of the bees by eating the adults at the shelters and pulling out and removing larvae from the soda straws. Chicken wire stretched across the open face of the shelter takes care of this

problem. Since horses and cows sometimes chew on polystyrene nesting materials, these materials have to be kept out of their reach.

The most serious problem of habitat management of the alfalfa leafcutter bees is the so-called "unexplained mortality of eggs and young larvae" which may account for the death of 60% or more of the brood. Prolonged temperatures over 95°F can kill the eggs and young larvae, but the observed mortality is not always correlated with temperature. Farmers in Idaho and Oregon are convinced that the problem is much greater in alfalfa seed fields than in areas with a variety of forage, and there is some evidence to support this view since individual bees seem to deliberately forage from more than one kind of plant when possible. However, the unexplained mortality does not always occur, even when only alfalfa is available. Insecticides are probably seldom, if ever, responsible since the problem occurs even when no insecticides have been applied and tests with the materials most commonly applied have shown no effect on larval survival.

### BUMBLE BEES

Most species of bumble bees are excellent pollinators of red clover and, as such, have received a great deal of attention. Their purposeful introduction over 60 years ago from England to New Zealand to save the red clover seed industry there was an early success story. More recently, efforts by Swedish, Danish, French, Canadian, and U. S. investigators to develop a practical system of bumble beekeeping have been only partially successful.

Bumble bees form small annual colonies in temperate and subarctic regions. In the spring, the solitary queens usually have to contend with bad weather while they search for a nesting place and provision from 6 to 8 cells. After the first progeny emerges, the queen remains in the nest to lay eggs while her offspring forage and tend the brood. Unfortunately for the bumble beekeeper, the queen's egg laying capacity is not nearly as great as that of the honey bee queen. Colony growth ends by mid or late summer when the new queens are developed. Few species of bumble bees have colonies that number more than 100 workers at a time, and less than half these are likely to be foraging. However, when conditions of climate, bloom,

and care are ideal, a few species are able to develop colonies with as many as 1,000 workers. It seems impractical to attempt to maintain the thousands of colonies that would be needed to pollinate large acreages, though in Europe, management of enough colonies to take care of small isolated seed plots is sometimes undertaken successfully (Holm, 1966).

#### OTHER BEES

In Japan, *Osmia cornifrons* (Radoszkowski), a bee that nests in hollow stems, is being managed on a small scale for pollination of apples. Since insecticides are used extensively in Japan for control of apple insects, the honey beekeepers keep their colonies away from apple orchards. Consequently, many apple growers develop nesting populations of *Osmia* in bundles of reeds and move them into the orchards for the pollination period (Maeta and Kitamura, 1964).

In India, a small carpenter bee, *Pithitis smaragdula* (F.), which nests in pithy stems, has been studied as a pollinator of cruciferous and leguminous crops. These bees are now being tried on an experimental scale in the Punjab area (Kapil and Kumar, 1969).

In Latin America and equatorial Africa, several species of social stingless bees (*Trigona* spp.) which provide honey and wax have been managed for centuries by the natives. In Africa, these bees are probably used primarily because African honey bees, *Apis mellifera adansonii* Latreille, are so fierce, but in Latin America, no honey bees were present until Europeans arrived. At present, the management of these small bees is largely on a hobbyist basis, but it is probable that some species could have a useful role in pollination (Nogueira-Neto, 1953).

In 1962, I advocated the introduction of foreign pollinators into the United States for the pollination of alfalfa and/or other crops for which the honey bee is not an ideal pollinator.<sup>2</sup> As a result, several candidate bees have been screened in a greenhouse at Logan, Utah with rather promising results. Also, a release of *P. smaragdula* was tried near Davis, California, but establishment was apparently not

<sup>2</sup>The honey bee is the principal pollinator of most crops and has been used successfully for alfalfa in the southwestern United States where it collects alfalfa pollen more commonly than elsewhere.



achieved. Continued studies are planned, but they will be on a small scale until adequate financing is obtained.

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*Descriptors:* Hymenoptera; Apidae; *Apis* spp., alfalfa leafcutter bee; bumble bees; *Osmia cornifrons*, in Japan; *Pithitis smaragdula*, in India; *Trigona* spp., in Latin America and Africa; African honey bee.