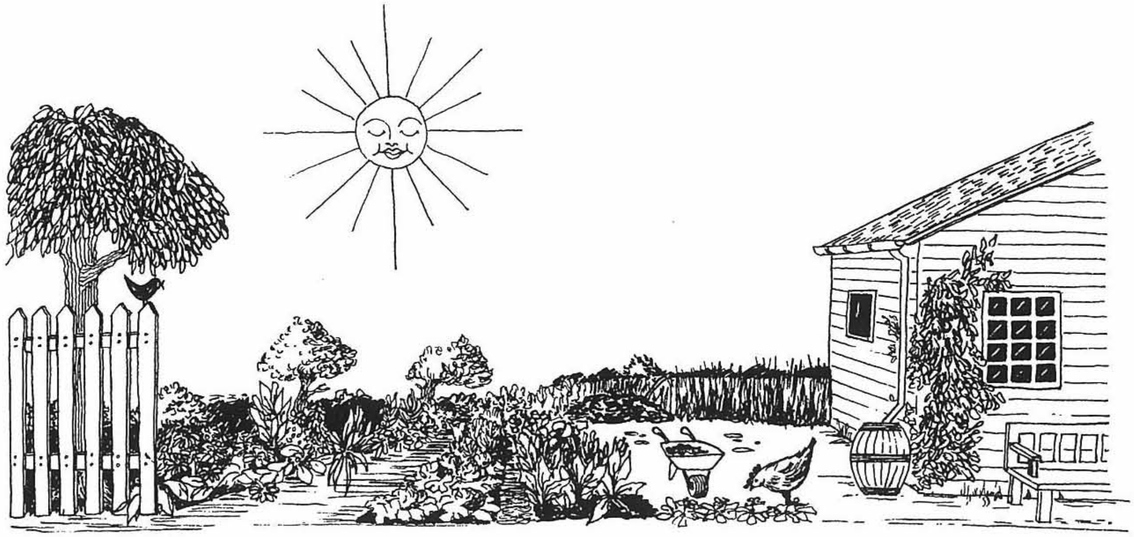
Land and Its Use

Thumbing through back issues of the journal, starting with the fifth, a trend becomes apparent. It was in the fifth journal that Earle Barnhart first wrote of his interest in tree crops in the article entitled "On the Feasibility of a Permanent Agricultural Landscape." Earle wrote it just before he became acquainted with the work of Bill Mollison of Australia. He had submitted it to me when, just prior to its publication, he appeared one day looking a bit disconcerted and announced that he had just discovered a book that he felt, in his words, "completely eclipsed" his own piece. We were both in something of a quandary. We finally decided that the best we could do at the eleventh hour was to have Earle write a book review of Mollison's Permaculture One *that we would include as well. Since then Earle has published a second article, "Tree Crops," and* Permaculture Two *by Mollison has appeared. Bill Mollison is rapidly gaining a deserved reputation as a world leader in the field. Our own tree crops program under Earle and John Quinney also progresses satisfactorily.*

The idea of tree crops is gaining strength rapidly these days. There are many reasons for this; the most obvious being the need to find forms of agriculture less dependent on fossil fuel than is the present norm. A more subtle reason is the slowly dawning realization that ecosystems might have something to teach us. In most of New England, for example, neglect a piece of cleared land for a while, it becomes evident that trees are what are intended to grow there. Gives one pause. At least it gave Earle sufficient pause to begin thinking about and then to begin planting trees. This has resulted in a recorded progression from theory to practice, from writing about the idea of tree culture to writing about our trees. The "Report From the Tree People" describes the work that each of the people involved in our tree research has done, reflecting the fact that permaculture has become an important part of New Alchemy's agriculture.

Our emphasis on gardening is by no means less for our newer interest in trees. Journal readers will have become familiar with Susan Ervin's report on her experiments with mulching, biological pest control, and irrigating with pond water. With this issue she is instituting a regular feature that she has called "Garden Notes." In it she still plans to record the results of scientific experiments and in addition some more casual observations based on her seven years of gardening experience.

N.J.T.



Henrike Kroeker

Garden Notes

Susan Ervin

Mulching

For five years we have been studying the effects of mulches on soil conditions and crop yields. Biodegradable mulches add organic material to the soil as they decompose at the same time they perform such functions generally attributed to mulch as water retention, temperature moderation, and weed control.

To summarize previous studies briefly: we have found that a mulch of azolla, a nitrogen-fixing aquatic fern, did not improve lettuce yields. Seaweed mulch tended to increase yields of beets, tomatoes, and Swiss chard, but resulted in decreasing yields of lettuce and peppers. Nitrate, potash, and soluble salt levels in the soil all increased under seaweed. Leaf mold was not as effective a mulch as seaweed. Supplemental watering did not significantly increase yields of either mulched or unmulched crops. Mulching reduces water runoff and the necessity of cultivation.[1]

Over the summer of 1979 we tested the effects of a straw mulch, as straw and spoiled hay are generally readily available. The plants on which the mulch was tested were Rutgers tomatoes, Salad Bowl lettuce, Early Wonder beets, and Cubannelle peppers. We divided the test field into eight lengthwise plots, four of which we mulched with a 6 inch deep layer of straw. Four were not mulched. We did supplemental watering only at seeding and transplanting time.

We took soil moisture and temperature readings at a 5 inch depth daily at 4 P.M., when temperatures tend to be highest. Two sensors were installed at each of the sites at which data were collected. We decided to use two sensors although we have observed that two sensors frequently do not agree, a perversity I found frustrating. Despite differences of opinion among sensors, however, the trends of the effect of mulch on both moisture and temperature are consistent. The temperature variation between mulched and unmulched plots is as much as 11°F., a variation similar to that under seaweed mulch. These results are summarized in the accompanying graph.

Moisture readings were similar for plots with and without mulch until mid-July (see graph) when those without mulch rapidly became drier. The unmulched areas got a better soaking during several light rains; but the mulched areas tended to retain the moisture they received longer. However, in mid-August, a heavy all-night rain saturated all plots equally, and it was the mulched plots that dried out more quickly. The seaweed mulches we

[1]Susan Ervin. 1977. The effects of mulching with seaweed and azolla on lettuce productivity. *Journal of The New Alchemists* **4**: 58.

Susan Ervin. 1979. The effects of mulches. *Journal of The New Alchemists* **5**: 56–61.

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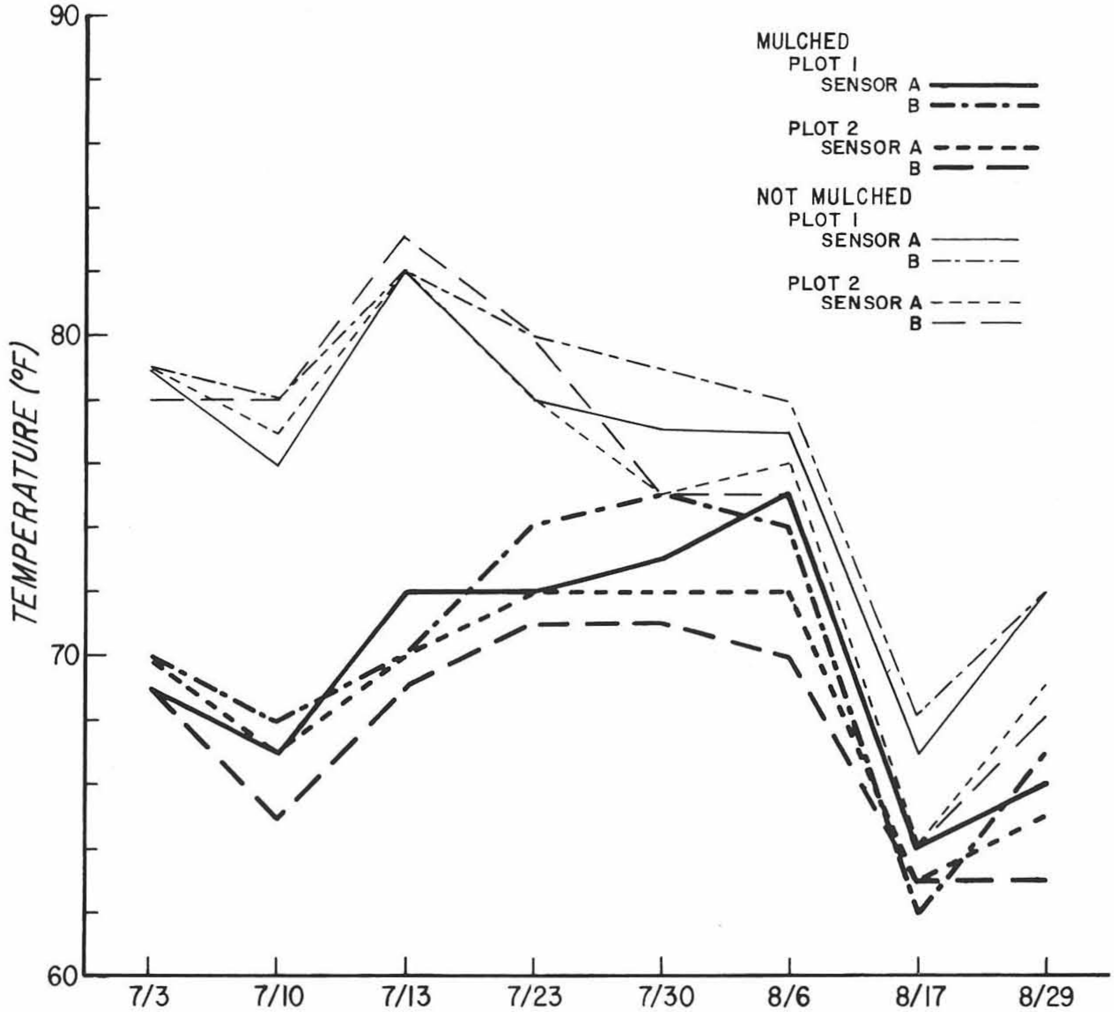
EFFECT OF MULCHING ON SOIL TEMPERATURE



Total lettuce yields were 1.72% higher for plots without mulch.

Total beet yields were 49.92% higher for plots with mulch, the only yield difference likely to be statistically significant.

Total tomato yields were 29.4% higher for plots with mulch.

Total pepper yields were 37.1% higher in plots without mulch.

used in previous years seemed to absorb and retain moisture better than the straw mulch.

We found no mulch-related nutrient differences under straw mulch as we had under seaweed. The straw mulch did not increase the nitrogen, potash, or soluble salt levels of the soil. Whereas nitrogen and potash increases would be beneficial, the increase in salt caused by the seaweed could be damaging to some crops, although one winter's leaching subsequently returned all areas to equally low salt levels, whether or not they had been mulched with seaweed. Nitrate levels were quite low in all plots in mid-August, but rose again by fall.

In earlier trials beet yields were as much as 225% higher, and tomatoes, 7.3% higher under the seaweed mulch. Lettuce yields, however, were 33.9% greater without seaweed mulch. The straw-mulched crops of the most recent experiment followed the tendencies of earlier years; yields were higher under mulch for beets and tomatoes, but better without mulch for lettuce and peppers.

Whereas these experiments have increased our understanding of the effects of mulches, they have also pointed up the difficulty of isolating the effects of one particular aspect of soil management on "organically" managed soils. Early in the experiments we found that supplemental watering on a weekly basis did not significantly affect yields in either mulched or unmulched areas. Some irrigated areas were, in fact, drier at times than other unirrigated ones. This could possibly be caused by a very localized sand substrate. This countered our expectation that mulch would be especially beneficial when there was a lack of water. Subsequently, neither those experimental plots with nor those without mulch have been watered except to establish plants after transplanting or to facilitate germination. Although we have a four-to-six-week period without rain each summer, crops have done well, with no evidence of needing more water. We think the water retention capability of our soil has improved because of its increased content of organic material, which is now 8%. The effects of mulch would be more pronounced on soils low in organic material. Whether organic material is on top of the soil as a mulch or mixed into the soil, it will retain water. In the future we plan to compare moisture retention in both improved and unimproved sandy soils as well as crop response to different watering schedules on these soils. It is probable that the main advantage of mulching a soil already rich in humus is in weed control and further prevention of water runoff. In areas with extreme climates, temperature moderation would be an added benefit.

Some Tactical Maneuvers for Protecting Pumpkins and Squash

Squash vine borers and cucumber beetles are serious competitors for our squash and pumpkins. Early in the season the cucumber beetles eat the leaves and can kill young plants, especially if the infestation is heavy when the plants have only their seed leaves. We plant most of the winter squash and pumpkins in peat pots in the Ark, and we have found that if we hold them there or in the cold frame until late May instead of setting them out as early as possible, there are fewer cucumber beetles and the larger plants can withstand what damage they do receive much better.

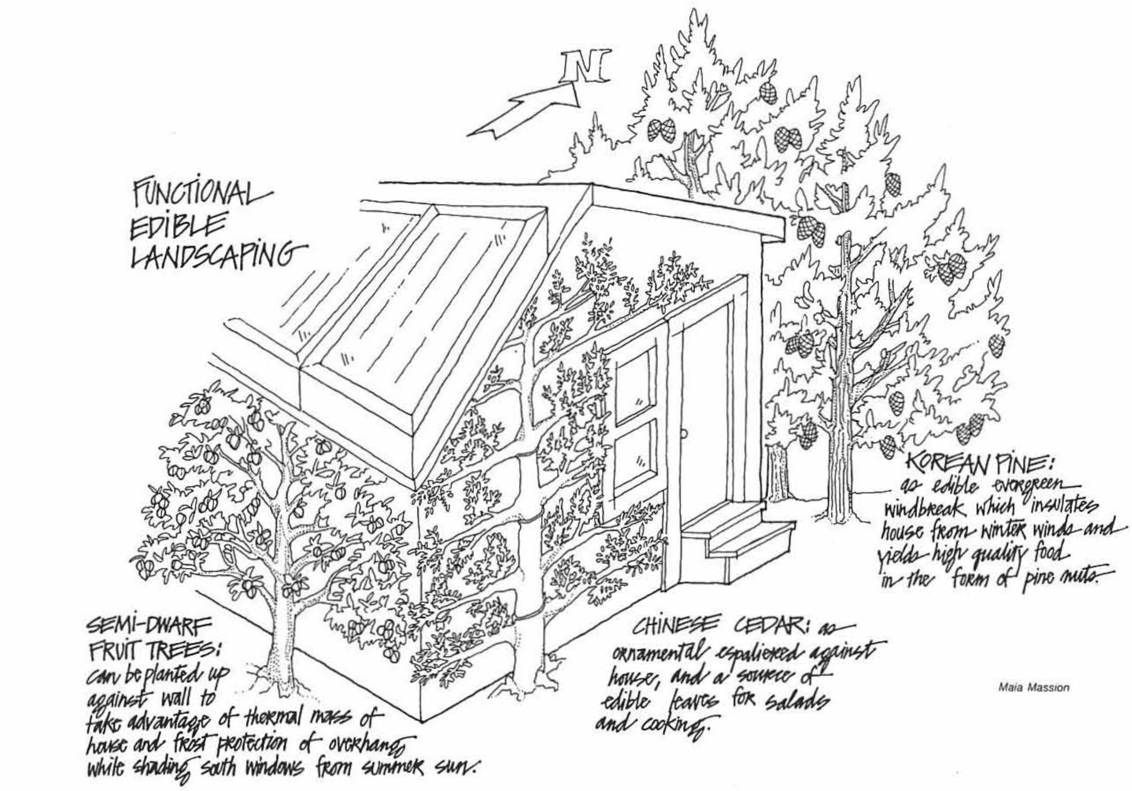
Henrike Kroeker

The vine borers bore into the base of the pumpkin and squash vines. We have tried slitting the stems, stabbing the ugly creatures, and rubbing rotenone in the slits. This kills the borers—and often the plants as well. We have also tried heaping dirt over the vines as they begin to run in an attempt to help them develop a second root system in case the primary stalk is destroyed. In some cases this helped. The most encouraging thing we have learned is that as our soil has improved, the loss to the borers has seemed to decline, especially in well-mulched, cool, moist areas. During the summer of 1979 the squash field, which was very fertile, had a deep mulch of leaf mold with a little straw and seaweed, and there was virtually no borer damage.

We did, however, acquire a new ailment, one we think we understand. Most of our apparently healthy pumpkins rotted from the inside and collapsed in the field. We had put a layer of fresh horsestable manure mixed with the inevitable woodchips on top of the thick leaf mulch, thinking the mulch would protect the plants from burning and allow the nutrients from the manure to leach through. The vines ran across the manure, and the fruits set on it. This probably caused some sort of bacterial disease. Perhaps after this rather disappointing experiment and the other rather more encouraging discoveries, we can look forward to a respectable harvest of squash and pumpkins with some degree of certainty.

Beans and Bean Beetles

Our bean beetle population has been much lower for several years. We don't know whether this fortunate development is due to the heavy parasitization by parasitic wasps as reported in the fifth journal, "Mexican Bean Battles," pp. 53–55, to hard winters that could kill overwintering adults, to improved soil conditions, or to a combination of events. In the summer of 1979 we put 100 parasitized beetle larvae in the bean field. Evidently the wasp hatch was low, because little subsequent parasitization occurred. Bean beetle damage was not severe. We grew two old New England varieties of beans for the first time this summer, Black Beauty and Brown Beauty. Both yielded quite well.



Maia Massion

A REPORT from the TREE PEOPLE

Introduction

John Quinney

In recent New Alchemy journals, Earle Barnhart has written on the nature of an ecologically inspired agricultural landscape. His article in the fifth journal begins with a critique of modern agricultural practices and then proceeds to abstract from ecological theory in order to arrive at a description of agriculture modeled on the patterns of native ecosystems. Earle's article in the sixth journal stresses the importance of perennial plants, especially trees, and describes various cultural techniques for propagation, transplanting, and food production in both urban and rural environments. Bill Mollison, a world authority on perennial agriculture working in Australia, has recently described perennial agricultural systems as *permacultures*. In his 1978 book *Permaculture One*[1] he defines the term: "Permaculture is a word we have coined for an integrated, evolving system of perennial or self-perpetuating plant and animal species useful to man [*sic*]. It is, in essence, a complete agricultural ecosystem, modeled on existing but simpler examples."

Taken together, these publications have provided us with the theoretical basis for our agricultural forestry program at New Alchemy. The transition from theory to practice is now gaining expression in sections of the farm; subsequent contributions to this article diagram the process. Much of this work is experimental: we have access to considerations developed by ecologists and foresters, orchardists, and farmers but ultimately our Cape Cod landscape will speak to us more clearly than journals and books.

[1]See reference 3.

In addition to the work described herein, we have recently commenced several other projects.

Over the past three years, the number of Chinese weeding geese grazing a grass-alfalfa pasture beneath fruit, nut, and fodder trees has steadily increased. In their own unique and often loveable manner these creatures have impressed us. As biological lawnmowers, fertilizer spreaders, and herbicides they are effective replacements for machinery and fossil fuels. And they taste a lot better than oil!

In this same area a small ecological island has been planted to perennials used by our bees-in-residence. The lee of an evergreen windbreak contains staghorn sumacs (*Rhus typhina*) and a mature pussy willow (*Salix discolor*) interplanted with herbs and flowers.

Near the nurseries we have planted over fifty species of herbs. Over the next few years we will be watching this area closely to determine insect population levels. We will then be able to use particular herbs to provide habitats for specific insects. These predators will assist in establishing biological controls in our gardens and forest.

We continue to collect and propagate potentially valuable trees and shrubs. Among these are Oriental and American persimmons (*Diospyros kaki* and *D. virginiana*), Kiwi fruit (*Actinidia chinensis*), jujube (*Zizyphus jujuba*), blueberries (*Vaccinium* sp.), elderberries (*Sambucus* sp.), catalpa (*Catalpa* sp.), Buckeyes (*Aesculus* sp.), the Korean nut pine (*Pinus koraiensis*), and shagbark hickory (*Carya ovata*).

Future developments within the agricultural forestry program may include establishing fast-growing hardwoods for firewood, placing nutrient-retrieving plants near trees, working with mycorrhizal fungi, innoculating soils with active earthworm species, evaluating seaweed products for disease control in fruit trees, and establishing living mulches around fruit and nut trees.

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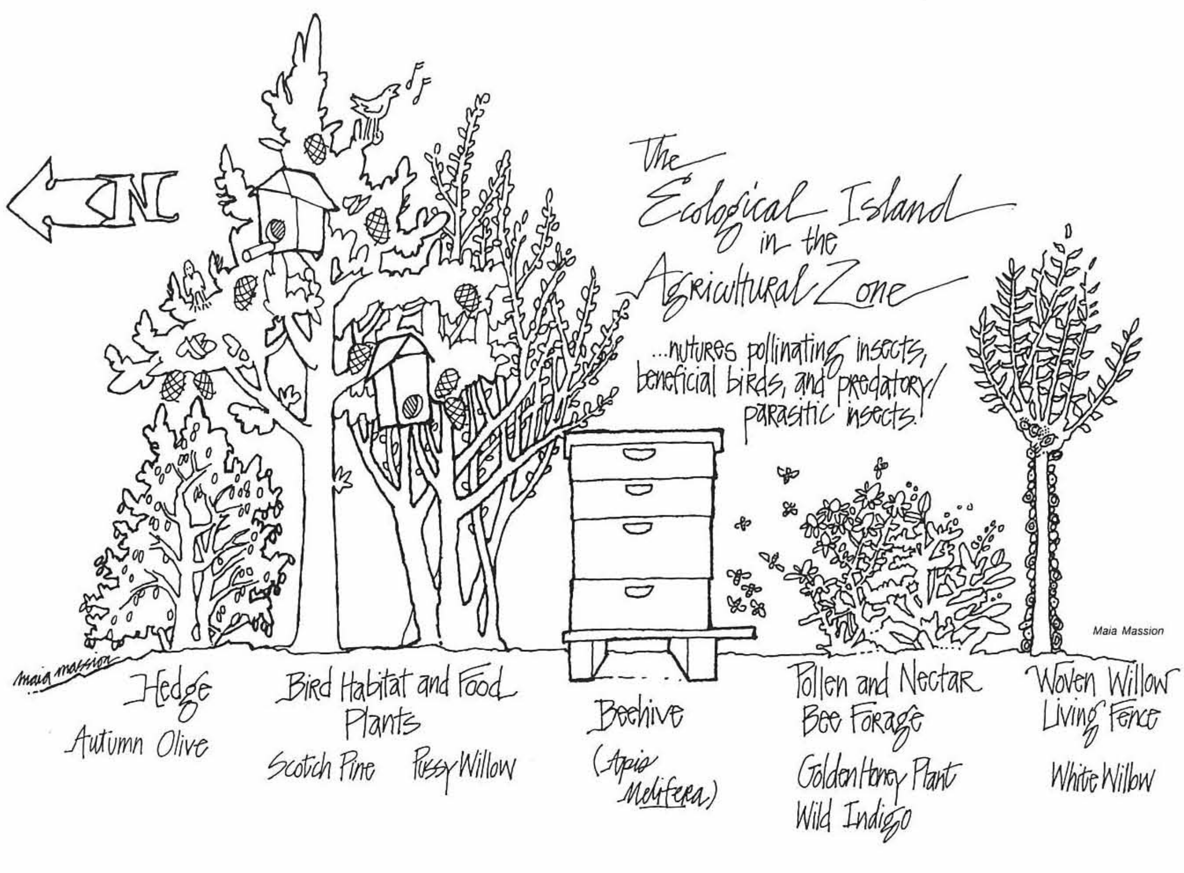


Surveying and Grafting Local and Antique Fruit Trees

Mavis Clark

We have undertaken the task of surveying the growth of fruit trees in the Upper Cape area in an effort to find varieties that are adapted to grow well under our local climatic conditions and to show resistance to diseases prevailing in the area. We aim to propagate such trees for further planting throughout the town of Falmouth.

Cape Cod has the reputation of being a very poor area for growing fruit, because its moist, foggy weather favors the rapid spread of fungal diseases, blights, and scabs. Commercial orchardists, now very few in number, spray their trees once every week during the growing season to combat these diseases and aphids, scale insects, borers, and caterpillars as well.

In 1977 and 1978, Earle Barnhart began the search for trees that seem well adapted to the Cape and are known for bearing consistently good crops. He enlisted the reliable food-foraging instincts of adolescents by asking Falmouth High School students to pinpoint such trees. This source of local lore produced a list of apple, pear, and peach trees that we started to check out in more detail. The 1977 research, which also included a survey of all the local history books in the Falmouth Public Library, revealed that the earliest settlers brought stock and seeds of fruit trees with them and established orchards that supplied them with plentiful fruit.

Once Earle had tracked down high-bearing trees, he encountered owners that were usually apologetic that their trees had been neglected. Everyone was very generous in allowing us to cut off young branches for scions in February 1978. After cold storage, these either were used for whip or wedge grafts in April, or budded in June. In 1977 Earle had planted the rootstock apple trees onto which these grafts were later made, using seeds from a commercial nursery. The seeds originated from wild trees in upstate New York. We have kept growth records of the rootstock trees, photographed them each year. They now stand about three feet tall. During the summer of 1979 we successfully grafted scions from several dozen grafts of local trees onto the rootstock. At that time we planted four antique trees and they were ready to have scions taken from them by the following spring. We shall check the local trees at harvest to try to identify varieties or at least to suggest possible parentage for them. As peach trees are better propagated by late spring budding, we shall graft local tree buds onto New Alchemy trees and onto some planted in a neighboring yard as well.

We were given much help and information by Howard Crowell, of Crow Farm, Sandwich, Massachusetts, who runs a fine commercial orchard. He retains some antique apple varieties along with many newer ones, numbering nineteen in all. He finds that although the russet apple does not bear as heavily as newer varieties, devotees of this fruit will come to buy russets and usually go off with other fruits and vegetables too. This old variety also shows a high natural resistance to diseases. We returned from Crow Farm with many scions, chiefly the antique and more naturally resistant varieties.

We are seeking out other resource people on the Cape knowledgeable of fruit orchardry. Their hard-earned experience could help point up to us early mistakes and lead us in turn to new investigations.

Recycling Leaf Nutrients

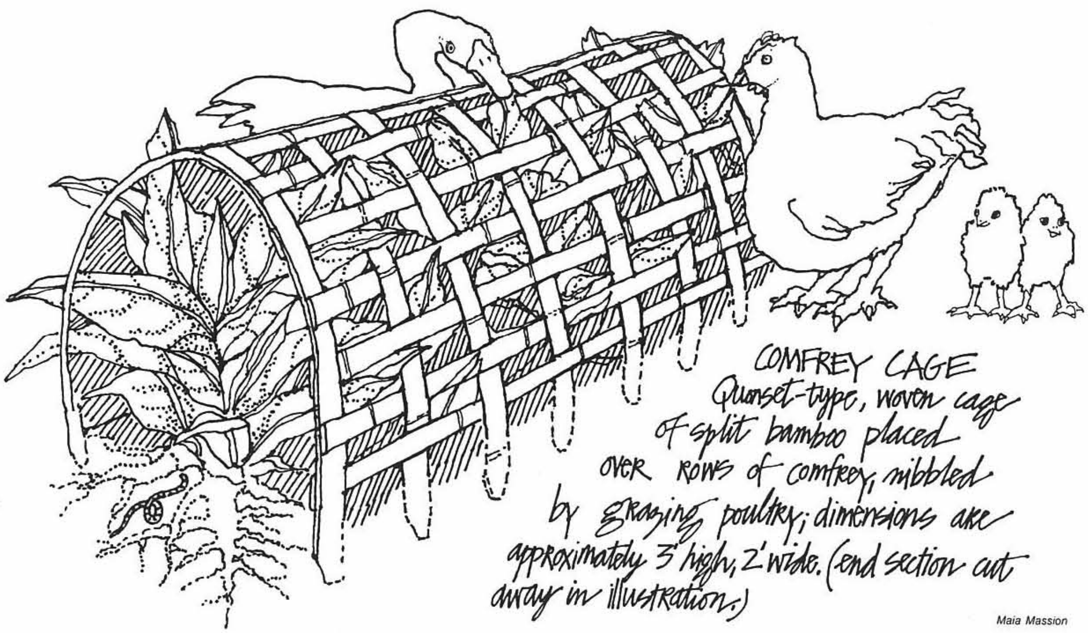
Ed Goodell

For a good many years now we have been asking area residents to bring us their leaves in the fall. People seem to like to do this, and our soil thereby receives a sizeable amount of nutrients.

The soil-conditioning properties of leaves are especially appreciated on our poor, sandy soils. Because of its capacity to absorb water and exchange nutrients, adequate humus is essential for a healthy soil. The humus formed from leaf decay has a long life because leaves contain relatively high proportions of lignin and hemicellulose, the most lasting constituents of humus.

At New Alchemy we have realized the value of leaves for quite a while. An early demonstration of the benefits they confer was provided when a young Chinese chestnut tree was planted on the site where a leaf pile had been the preceding year. Of 20 Chinese chestnuts planted at the same time, it rapidly outgrew the others.

We have used leaves regularly in moderate amounts for winter mulches, for trench composting between intensive garden beds, and for mulching trees. The leaf mold—the dark, crumbly humus formed by gradual fungal decay and weathering—from underneath the piles is in high



Maia Massion

demand for potting soil. We have turned leaves under the soil in the fall to decompose over the winter. We have also tried transforming sod into a growing medium by mulching it thickly. This was useful for growing potatoes and winter squashes. We are planning to use a large bin of leaves in the first stage of graywater treatment. Bags of leaves can be convenient and effective insulators around foundations, beehives, and tender young plants.

The amount of leaves at our disposal has increased dramatically since the fall of 1978, when we put up a sign at the Falmouth dump directing potential leaf donors to the farm. The leaf pile has advanced 100 yards from the original storage area. We remove leaves from the end opposite that to which they are added. As a result, the pile creeps slowly across the landscape, leaving a swath of nicely mulched, worm-worked soil. You may have heard of chicken tractors.[1] Apparently we have created a leaf tractor. Steering is easily accomplished with movable signs that indicate where the leaves should be deposited.

During the winter of 1979–1980 we estimate that we were given 750 cubic yards (575 cubic meters) of leaves weighing over 15 tons (13.6 metric tons). This amount of mixed leaves contains 230 lb, or 105 kilograms (kg), of nitrogen, 80 lb (36 kg) of phosphorus, and 130 lb (59 kg) of potash.[2] In terms of N-P-K (nitrogen-phosphorus-potassium), this is roughly equivalent to 1,000 lb (455 kg) of 20-10-10 fertilizer, or enough to apply more than 100 lb/acre (112 kg/hectare) annually to the entire farm. In addition to the other nutrients the leaves contain significant amounts of calcium, magnesium, and trace minerals.

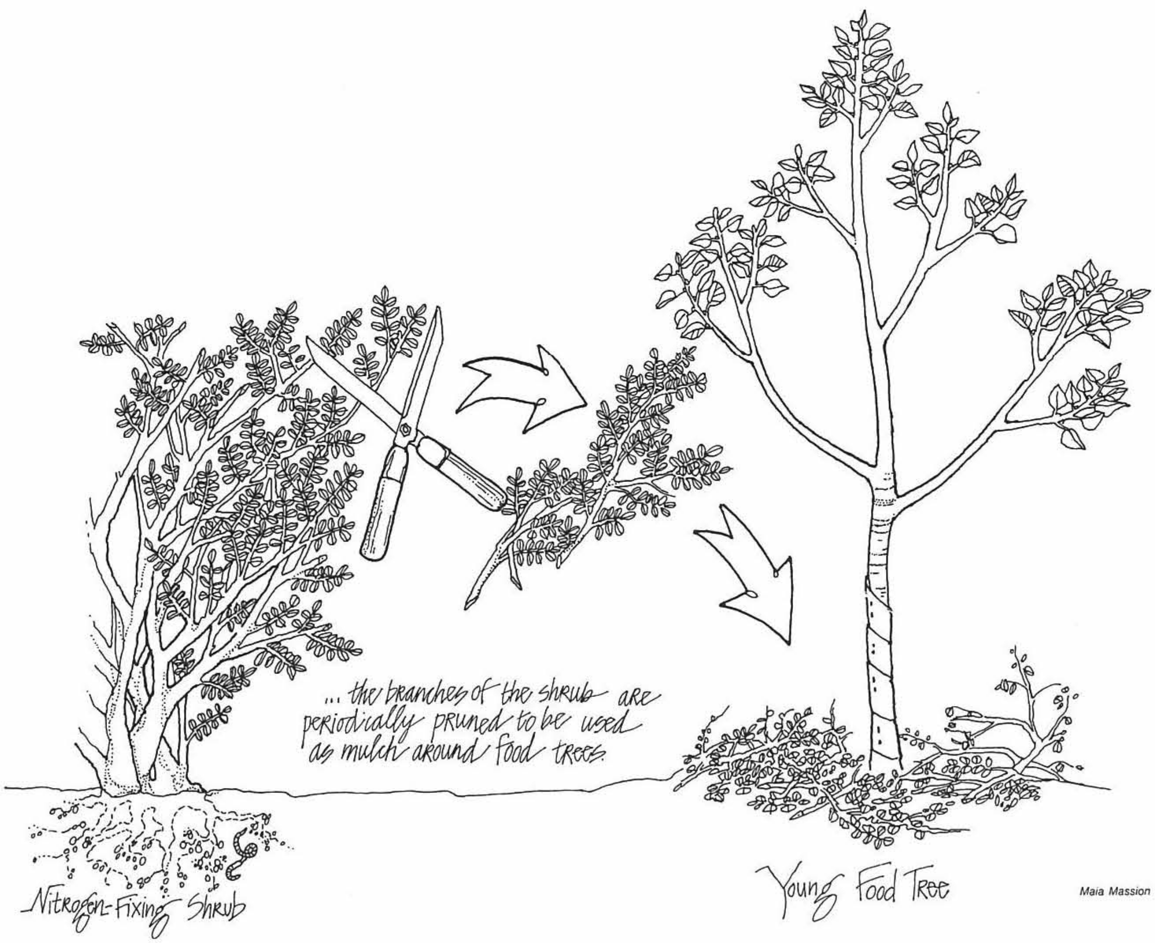
Unlike the soluble nutrients in chemical fertilizers, those contained in leaves are released gradually as the leaves decay. Leaf decay can be thought of in terms of the half life of the leaves—the time it takes half of the material to decay. The half life of a leaf on the forest floor is 12–18 months. The decay process can be hastened by turning the leaves into the soil, shredding them, or piling them together.

Our current contributions of leaves far exceeds New Alchemy's capacity to use them. This enables us to accumulate large amounts of leaves for the two or three years required for them to decompose fully into leaf mold. A delight for worms and gardeners alike, leaf mold holds three to five times its weight in water, has no weed seeds, has a pH of 5.5–5.0, and is very enduring in the soil. We use it for potting soil, to top-dress individual plants, and, when available, for broad-scale mulching. Since New Alchemy has prospects of a generous supply of leaf mold, it will probably become our all-purpose soil amendment.

Ultimately, we would prefer that the leaves return to the soil from which they grew, to enrich that soil directly. We would like to see our leaf donors use their own leaves, and some of our educational efforts concern ways to encourage this. In the meantime, the productive capacity of our soil will continue to grow as we enrich it with a fertile mantle of leaf mold.

[1]Richard Merrill, ed. *Radical Agriculture*. N.Y.: Harper & Row.

[2]Bulletin No. 92, Clemson Agricultural College, Clemson University, South Carolina.



Nitrogen-Fixing Trees and Shrubs

John Quinney

Nitrogen is the most abundant element in the earth's atmosphere and is essential for plant growth and reproduction. However, atmospheric nitrogen can be utilized directly by plants only after it has been converted to either its nitrate or its ammonium forms. This process is known as fixation and can be achieved either chemically or biologically.

Chemical fixation involves the reaction of atmospheric nitrogen with hydrogen from natural gas at elevated temperatures and pressures in the presence of a catalyst—the Haber process. The ammonia thus produced can be applied directly to farmland or converted chemically to other nitrogenous fertilizers.

Biological fixation of nitrogen is carried out by a number of free-living organisms and also, most importantly, by virtue of two symbiotic associations between plants and bacteria—the rhizobium-legume association and the actinomycete–nonleguminous-angiosperm association (Table 1).

Chemical fixation is an energy-intensive process; it depends on diminishing supplies of fossil fuels. The chemical production of 150 kilograms (kg) of nitrogenous fertilizer (a typical per hectare application) requires 1.53 million kilocalories (kcal). For comparison, biological fixation of the same amount of nitrogen by the legume winter vetch (*Vicia villosa*) involves a seeding cost of only 90,000 kcal.[1]

Many farmers meet the nitrogen requirements of their land by planting legumes as green manure crops or as a part of crop rotations. Used in these

[1]Pimental et al., 1973. Reference 7.

Table 1. MAJOR PRESENT-DAY NITROGEN-FIXING PLANTS.[a]

1. *Free-Living Organisms:*
   a) Heterotrophic bacteria, e.g., *Azobacter, Clostridium, Spirillum, Beijerinckia, Klebsiella.*
   b) Autotrophic bacteria, e.g., *Rhodopseudomonas, Rhodospirillum, Thiobacillus.*
   c) Blue-green algae, e.g., *Anabaena, Calothrix, Nostoc, Plectonema,* etc.
2. *Root Nodule-Forming Symbioses:*
   a) Rhizobium-legume associations, e.g., *Glycine max* (soybean), *Phaseolus vulgaris, Vicia faba* (vetch), *Trifolium repens* (clover), etc.
   b) Actinomycete–nonleguminous-angiosperm associations, e.g., *Alnus glutinosa* (alder), *Robinia pseudoacacia* (black locust), *Hippophae rhamnoides* (sea buckthorn), etc.
   c) Cycad–blue-green-algae associations, e.g., *Bowenia, Cycas, Encephalartos,* etc.

[a]Source: W. P. D. Stewart, 1977. *Ambio* **6**:166.

ways alfalfa (*Medicago sativa*) and soybeans (*Glycine max*) can supply up to 450 and 100 kg nitrogen per hectare per year (N/ha/yr) respectively. However, not all legumes are capable of fixing nitrogen; for example, the legume Eastern redbud (*Cercis canadensis*) does not form root nodules and thus does not fix nitrogen.

The nonleguminous nitrogen-fixing plants, which are all trees and woody shrubs, have recently been recognized as an important source of fixed nitrogen. For example, alders (*Alnus* sp.) can fix up to 300 kg N/ha/yr and the sea buckthorn (*Hippophae rhamnoides*) up to 180 kg N/ha/yr. In temperate-region forested biomes the nitrogen-fixing trees and shrubs are usually pioneer species modifying the soil environment and establishing favorable conditions for succeeding trees. For example, in the Pacific Northwest the red alder (*Alnus rubra*) is succeeded by Douglas fir (*Pseudotsuga menziesii*); on Cape Cod, bayberry (*Myrica pensylvanica*), sweet fern (*Comptonia peregrina*), and black locust (*Robinia pseudoacacia*) are followed by pitch pine (*Pinus rigida*), and various oaks (*Quercus* sp.).

The nitrogen-fixing trees and shrubs make nitrate available to other species mainly through leaf fall; the nitrate enters the soil when the leaves are decomposed by soil microorganisms. Only when the bacterial root nodules are sloughed off or the host plant dies can nitrogen be made available more directly. As a forest matures and the nutrient cycles tighten because the forest has become increasingly efficient at processing organic matter, nitrogen usage is increasingly conservative, and the need for nitrogen fixation is correspondingly reduced. In these ecosystems the small nitrogen requirements needed for plant structural tissue and to replace losses by leaching are met mainly through fixation by various free-living organisms (see Table 1).

In the agricultural forestry work at New Alchemy, nitrogen-fixing trees and shrubs are important components of the overall ecology.

At New Alchemy the following nitrogen-fixing trees and shrubs are being studied:

Legumes:	black locust, Scotch broom (*Cytisus scoparius*), Siberian pea shrub (*Caragana arborescens*), *Albizzia julibrissin,* and honey locust (*Gleditsia triacanthos*) (nitrogen-fixing ability not firmly established).
Nonlegumes:	bayberry, sweet fern, autumn olive (*Elaeagnus umbellata*), Russian olive (*Elaeagnus angustifolia*), *Ceanothus* sp., alders (*Alnus rugosa, A. glutinosa*), and sea buckthorn.

A collection has been established that now consists of plantings of honey locust, *Albizzia*, black locust, Scotch broom, autumn olive, and bayberry. Additional species will be added over the years. This area will be used for education as well as for testing the growth of these trees and shrubs in the Cape Cod environment and providing propagation materials.

The honey locust and the alders are useful fodder trees. In New Zealand, cattle have been fed on honey locust pods; they fall from the trees over the three to four months of winter when other fodder is in short supply. Foliage from alders has been processed into silage and used to feed cattle, and at Hampshire College in western Massachusetts *A. rugosa* is being evaluated as a sheep feed. In due course these species will be tested at New Alchemy as livestock feeds, especially for geese and poultry.

We have begun various interplanting experiments in the polycultural forest area south of the Ark. Literature reports have documented the beneficial effects of black locust, alders, and autumn olive on the growth of interplanted lumber trees, apples, and black walnuts respectively. A stand of young black locust trees occurs naturally in a section of this area, and we shall manage these trees with some attendant controls on their propagation through vegetative spreading.

We have established experimental hedges of autumn olive and are propagating the tree by root and stem cuttings. The roots of these plants are well nodulated. We are planning hedgerow plantings of Siberian pea shrub, Russian olive, and *A. glutinosa.*

There is a named variety of the black locust (var. *"rectissima"*) that produces straight, durable lumber. Root cuttings of this variety, which is also known as the "ship-mast locust," are being sought. We hope to acquire and test additional species of nitrogen-fixing shrubs such as *Ceanothus* sp. and sea buckthorn.

We expect that careful integration of a variety of nitrogen-fixing species in our agricultural forests will make a substantial contribution to the productivity of the forests in a way that is both energetically conservative and environmentally gentle.

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Hedgerows and Living Fences

John Quinney

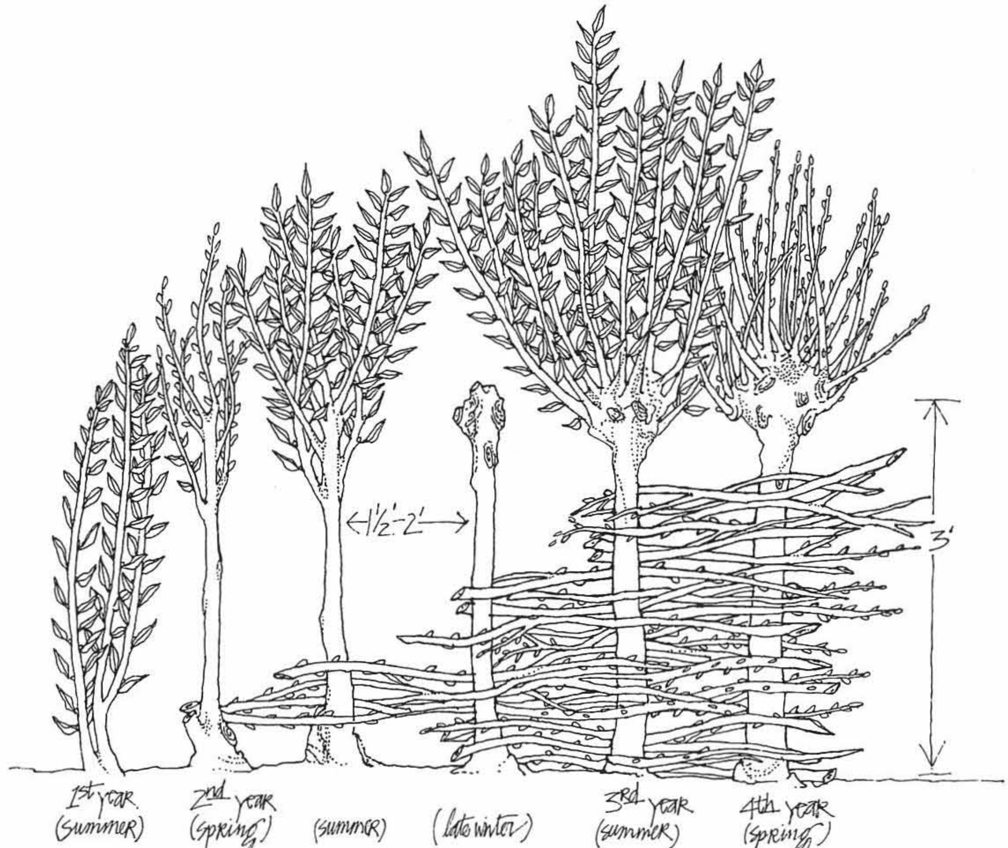
In any agricultural landscape the most obvious function of fences and hedgerows is to control the movement of animals—domestic and wild—so they will be excluded from food crops or selectively rotated through pastures. The advantage of hedge rows over fences is that they are multifunctional components of the landscape and as such can be integrated with the overall design strategy.

Perhaps one of the best-known examples occurs in the traditional English landscape. The English hawthorn (*Crataegus* sp.) was often originally planted to replace wooden post-and-rail fences, which are subject to inevitable decay. As well as providing an impenetrable barrier to the movement of sheep and cattle, such hedges have other important ecological functions. They provide a habitat for a wide variety of beneficial insects and birds. They facilitate the establishment of numerous volunteer herbs and "weeds." Cattle, sheep, and horses grazing on pastures thus enclosed have often been observed browsing these plants as well, presumably supplementing their diet with nutrients not available in the relatively simple pasture ecosystem. In windy areas of the country, especially East Anglia, the hedgerows reduced soil erosion, a function that has only become apparent since their removal for the sake of "efficient" large-scale agriculture.

At The New Alchemy Institute an experimental hedge of autumn olive (*Elaeagnus umbellata*) has been established and pruned to encourage dense bottom growth. An immediate goal of these plantings is to control the movement of domestic geese, restricting their access to the gardens and tree nursery.

We have also planted living fence posts of willows (*Salix* sp.). Eventually, prunings from the top of each fence post will be woven between them, providing an effective barrier. Ultimately, annual pruning will yield firewood.

These and other successive hedge plantings will be designed in order to create ecological landscape elements with diverse functions. They will be, in effect, ecological islands in which a variety of plants and animals may grow undisturbed by cultivation. They will be windbreaks and a source of food for a variety of birds and animals. For example, the Russian olive (*Elaeagnus angustifolia*), an important Midwest hedgerow species, is known to be used for food by at least forty birds, including chickens,



... Pollarded Willows as Living Fence, the live posts woven with the trimmed shoots.

Maia Massion

ducks, and turkeys. Hedgerows planted in an east-west orientation can create local microenvironments with raised temperatures on the southern exposure. Such microenvironments allow the survival of plants and animals that might otherwise be absent from the landscape. Prunings from nitrogen-fixing hedgerows can be used as mulches around fruit and nut trees in order to supply some of their nutrient needs.

Although our work at New Alchemy is mainly with hedgerows, another kind of boundary is traditional here. In the years when our part of Cape Cod was extensively farmed, local stone was used for the construction of dry stone walls. Many of these walls still remain in areas of the Cape that have become forested. Their construction is admittedly labor intensive, but they have the advantages of being relatively permanent, made from a local resource, and largely maintenance free. Although these walls are obviously limited in their ecological functions, they offer a viable alternative to hedgerows and introduce a pleasant diversity to the landscape.

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Birds and Biological Pest Control

Loie Urquhart

In observing the natural world, it is quite evident that birds help to regulate the numbers of insects and rodents. But since the advent of pesticides, comparatively little attention has been paid to encouraging birds as predators in the forest, orchard, field, and garden.

Birds can eat thousands of insects in a single day, especially in the spring, the season of highest consumption, when the birds are feeding their young. Owls and hawks prey upon mice, rabbits, and other small mammals that can damage fruit trees. In the winter, nonmigratory insect eaters such as woodpeckers, chickadees, and nuthatches search the bark of trees for hibernating insects.

By providing nesting sites, water, and winter shelter, we could encourage and foster populations of beneficial birds that would regulate insect and mammal pests.

Feeding Habits of Birds

Surveys of the feeding habits of birds conclude that the terms insectivorous and vegetivorous indicate predominance in a given diet, rather than restriction to one type of food. For instance, the most exclusive vegetarians—the finches, grouses, and pigeons—sometimes eat insects, while the most avid insect eaters—the swallows and flycatchers, will eat berries.

From the viewpoint of the farmer or orchard grower, insects can be classed as beneficial (which includes parasitic and predaceous varieties) injurious, and neutral. Birds do eat beneficial insects, but only, it seems, to the extent that keeps their numbers in proportion and maintains an equilibrium in the natural continuing flux.

Injurious insects are found in the air, on and within leaves, on and under the bark of trees (boring or hibernating insects), and on the ground. There are insects, such as the Mexican bean beetle, the monarch butterfly, and some insects of the suborder Heteroptera, that are protected from being eaten by birds by either a hard casing, a disagreeable odor and taste, or a camouflaging ability to meld into their surroundings. Birds that prey on insects can be grouped loosely, as the flying insect patrol, the foliage cleaners, the bark gleaners, and the ground eaters.

The Flying Insect Patrol

There are a number of birds who feed while in flight.

Daytime Patrol	*They Eat*
Swifts	Moths—gypsy moths
Swallows	Cabbage worm moths
Martins	Codling moths
Kingbirds	Cankerworm moths
Phoebes	Leaf-roller moths
Flycatchers	Locusts (short-horned grasshoppers)
Vireos	Long-legged crane flies
Redstarts	Leafhoppers
Peewees	Aphids
Mockingbirds	Long-horned grasshoppers
Catbirds	Hessian flies (wheat enemy)
Hawks	Horseflies
	Rose chafers
	Winged ants
	Butterflies
	Beetles

Nighttime Patrol	*They Eat*
Nighthawks	Night-flying or owlet moths (*Noctuidae*)
Whippoorwills	Moths—cotton boll worms
	Army worms
	Cutworms
	Mosquitoes
	Leafhoppers

Foliage Cleaners

Foliage cleaners concentrate on picking destructive insects off the leaves and branches of plants.

They Are	*They Eat*
Warblers	Leafhoppers (*Jassidae*)
Nuthatches	Plant lice or aphids (*Aphidiae*) including common "green fly"
Chickadees	Leaf-rollers (e.g., codling moths)
Kinglets	Leaf-miners (e.g., apple leaf miners)
Robins	Cankerworms
Catbirds	Cutworms
Thrushes	Cotton boll worms
Ruffed grouse	Army worms
Baltimore orioles	Hairy caterpillars
Blackbirds	Tent caterpillars of apple and wild cherry trees
Crows	Fall webworms
(many others)	Tussock caterpillars
	Gypsy moth larvae
	Leaf beetles—Colorado potato beetles
	Flea beetles

They Are	*They Eat*
	Striped cucumber beetles
	Asparagus beetles
	Corn root worms
	Rose beetle (larvae feed on roots)
	Snout beetles—plum and apple curculios
	Bean and pea weevils
	Grain weevils
	White pine borers
	Spruce budworms

Bark Gleaners

Many birds dig under the bark of trees for boring and hibernating insects, as well as devouring those on the bark itself.

They Are	*They Eat*
Woodpeckers	Bark borers
Nuthatches	Hibernating insects (e.g., codling moths)
Creepers	Trunk borers
Chickadees	Timber ants
Warblers	Plant lice
Kinglets	Bark lice
Wrens	

Scraping the old, rough bark from the trunk and branches of orchard trees and covering the bare spots with an adhesive organic mixture will help to prevent these insects from nesting. Ringing tree trunks with a metal piece or sticky substance deters some insects from climbing into the tree.

Ground Eaters

A number of birds work on the ground.

They Are	*They Eat*
Robins	May beetles or June bugs
Bluebirds	Tiger beetles
Blackbirds	Rose beetles
Chipping sparrows	Strawberry slugs
	Root worms
Song sparrows	Leafhoppers
Wrens	Aphids
Warblers	Crane-fly maggots
Vireos	Cutworms
Phoebes	Cabbage worms
Meadowlarks	Root maggots
Crows	Grasshoppers
Bobolinks	Chinch bugs
Flickers	Army worms
Quails	Craneflies
Woodpeckers	White grubs
Catbirds	Root borers
Thrushes	Wireworms
Owls	Bollworms

They Are	*They Eat*
Hawks	Ants
	Root lice
	Larvae of plum and apple curculios
	Bean and pea weevils
	Grain weevils
	White pine borers
	Ants (Formicidae)
	Thousand-legged worms (subclass Myriapoda; destructive to strawberries, but some predaceous.)
	Frogs
	Lizards
	Snakes
	Mice
	Moles
	Shrews
	Groundhogs
	Squirrels
	Gophers

Predatory Birds

In winter, mice, moles, groundhogs, rabbits, and other mammals can cause considerable damage to the roots and trunks of orchard trees. Such rodents normally can be discouraged from chewing the bark of trees by wrapping burlap and/or wire mesh around the trunks of trees. Not all damage is inflicted at this level, however. The pine mouse burrows underground to chew the trunk and roots below ground level. Groundhogs will tunnel throughout the root systems of orchard trees and expose the roots to oxygen in the atmosphere; this can dehydrate them and eventually kill the tree.

Owls and hawks frequent areas where small mammals are plentiful and help to keep their numbers down. Owls can be attracted to houses of an appropriate size and can act as live-in rodent controls.

Bird Habitat

There are birds who can be persuaded to forsake their natural habitats and live in artificial structures. The destruction of forests and the thinning out of dead trees in orchards and woodlands has reduced the number of available nesting sites for many birds. If birdhouses are erected in late winter, before the birds are scouting for nesting locations, many birds will take up residence in them, some returning year after year. If a specific bird is required, it is best to put up a birdhouse specifically designed for that bird. For example, if you

Table 1. BIRDHOUSE SPECIFICATIONS FOR SELECTED BIRDS.

Species	Entrance Diameter (In.)	Entrance Above Floor (In.)	Floor Dimensions (In.)	House Depth (In.)	Box Above Ground (Ft.)	Comments
Bluebird	1½	6–7	5 × 5	8–9	5–10	Prefers on top of fence post.
Chickadee	1⅛	6–8	4 × 4	8–10	5–15	2–3 in. wood shavings on floor. Prefers hollow log homes.
Red-breasted nuthatch	1	6–8	4 × 4	8–10	5–20	Prefers hollow log-type home.
Robin & phoebe	Open front and sides		7 × 7	8	8–12	
Barn owl	6	4	10 × 18	15–18	12–18	
Tufted titmouse	1¼	6–8	4 × 4	8–10	4–5	
Downy woodpecker	1¼	6–8	4 × 4	8–10	6–20	Prefers hollow log.Wood shavings 2–3 in. deep.
Hairy woodpecker	1½	9–12	6 × 6	12–16	12–20	Prefers hollow log. Wood shavings 2–3 in. deep.
House & winter wren	1 × 2½	4–6	4 × 4	6–8	5–10	Especially likes gourds.
Yellow flicker	3	14–16	7 × 7	16–24	6–20	Prefers hollow log homes. Sawdust 2–3 in. deep.
Flycatcher (crested)	2	6–8	6 × 6	8–10	8–20	2–3 in. wood shavings.

Wood used best at ¾ in. thickness
Martins only ½ in.

are having trouble with the cranberry moth, a box suited to the tree swallow is wise as the tree swallow relishes the taste of the cranberry moth. Birdhouses can be made from hollowed-out gourds, logs, old bark nailed into the trunk of a tree, or three-quarter-inch pine boards (see Table 1). Houses should have drainage and ventilation holes and entrance holes. Size and other particulars for each bird have been outlined by the Audubon Society.

Natural Habitat

By providing an environment in which birds can thrive, injurious insects and rodents can be kept to a minimum. Because birds need food, shelter, and water it is important, when purposely attracting birds to an orchard or garden area, to provide enough food for them as an alternative to cultivated fruits and grains. They prefer the taste of wild fruits to cultivated ones. The more diverse the plantings, the better. The following are some suggested plantings:

Shelterbelt plantings: Russian olive (*Elaeagnus angustifolia*), eastern red cedar (*Juniperus virgiania*), European beech (*Sylvatica fagus*).

Hedgerows: autumn olive (*Elaeagnus umbellata*), white mulberry (*Morus alba*), Siberian pea shrub (*Caragana aborescens*).

Fruit-bearing trees: mountain ash (*Pyrus aucuparia*), honey locust (*Gleditsia triacanthos*), staghorn sumac (*Rhus typhina*).

Many varieties of flowers with their bright colors, fragrant smells, and nectar attract birds. An area left wild as an ecological island in a garden area can provide shelter, food, and beauty for birds and some beneficial insects. Brushpiles provide cover and nesting sites, and can be used as a support for plantings of wild grape or Virginia creeper.

Birdhouses

Forty-nine species of birds have been recorded to have nested in boxes:

Mountain bluebird
Western bluebird
Eastern bluebird
Robin
Chestnut-backed chickadee
Mountain chickadee
Carolina chickadee
Black-capped chickadee
Plain titmouse
Tufted titmouse
Red-breasted nuthatch
White-breasted nuthatch
Brown creeper
House wren
Winter wren
Bewick's wren
Carolina wren
Mockingbird
Brown thrasher
Violet-green swallow
Tree swallow
Barn swallow
Cliff swallow
Purple martin
Song sparrow
English sparrow
House finch
Purple grackle
Bullock's oriole
Orchard oriole
Starling
Eastern phoebe
Ash-throated flycatcher
Crested flycatcher
Arkansas kingbird
Red-shafted flicker
Yellow-shafted flicker
Golden-fronted woodpecker
Red-headed woodpecker
Downy woodpecker
Hairy woodpecker
Screech owl
Saw-whet owl
Barn owl
Sparrow hawk
Mourning dove
Wood duck
American goldeneye
Hooded merganser

Birds that will nest in gourds include the following: bluebirds, crested flycatcher, tree swallow (attracted to boxes also, in cranberry bogs, as they relish the cranberry moth), tufted titmouse, wrens (these like gourds the best), downy woodpecker, house sparrow, starling, white-breasted nuthatch, purple martin (the gourds should be placed in direct sunlight, fifteen feet above ground, and far enough apart so they won't knock together).

Winter Storm Shelters

In winter, when temperatures drop, roosting boxes in the garden can serve as warming houses for overwintering species.

Winter Supplementary Food

Severe winter temperatures can be fatal to birds, so it is essential to provide supplementary food for them when the pickings are slim, as a guarantee that they will remain in the vicinity. Placing beef suet, sunflower seeds, millet, and other grains in the orchard will provide birds with the fat and protein that they need.

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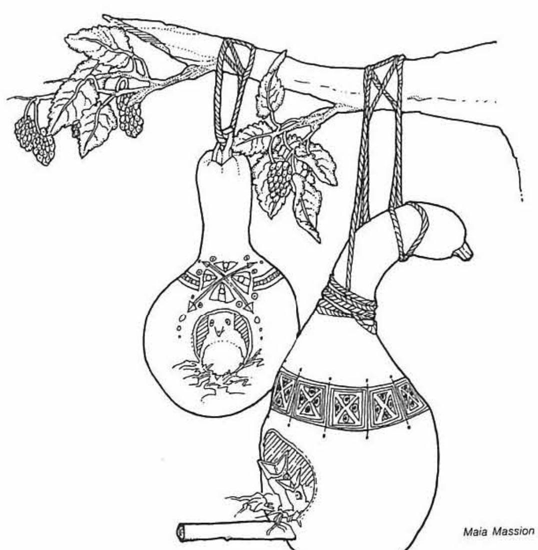
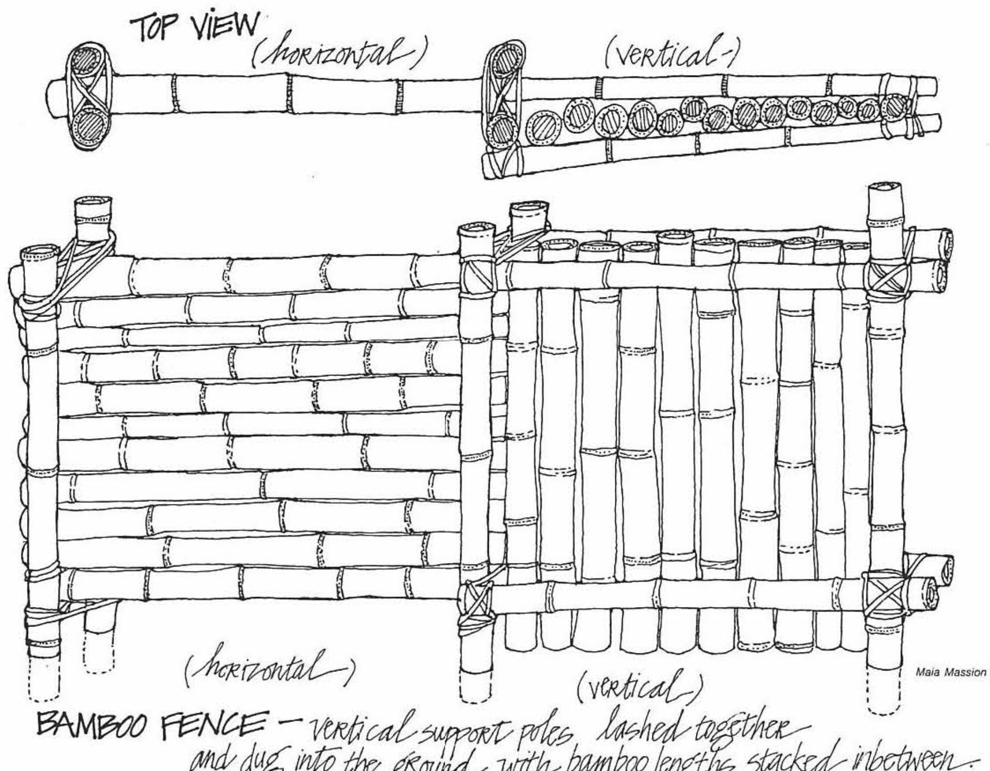


BIRD HOUSES carved out of ornamental gourds



Tree Crops for Structural Materials

Scott Stokoe

The cultivation of plants for structural materials is an important element of forest farming. Part of our research at New Alchemy is devoted to investigating and propagating perennial plants that yield construction materials. Throughout the long history of cultural development, indigenous wood products have been an important part of technical and material development. Wood and wood products were primary construction materials for many preindustrial civilizations. Wood for home construction, agricultural fencing, tools and equipment, plumbing, clothing, containers, fuel, artwork, manufacturing, and as a source of chemicals was utilized by virtually all societies, both in the East and the West. It was only with the advent of economically cheap (however, ecologically expensive) industrial materials that the reliance on wood waned. Abundant metal goods and fencing, ubiquitous plastic containers, connectors, and fibers, and a myriad of industrial byproducts all contributed to the decreased use of wood products. Yet wood is still used in many traditional ways. Part of our tree crops program is involved in collecting tree species with structural uses. By collecting and propagating such trees in our tree crops program, we expect to gain insight into their adaptability to the Cape Cod environment and their productivity and potential uses.

Bamboo

For centuries, throughout the tropical and subtropical areas of the East, bamboo has provided an abundant, naturally renewable source of building material, fabricating material, and food. It has been used in every aspect of shelter construction and furnishing, and serves as a durable, multipurpose material. Bamboo has a vast number of uses in the home, from framing members, sheathing, and roofing to plumbing, furniture, and kitchen utensils. Further processing of bamboo stalks, known as culms, results in materials for baskets, screens, and fences. Bamboo is also a source of paper pulp. Bamboo culms for construction are generally the strongest when cut at the age of three years. In central China, bamboo is raised in agricultural forestry programs for both food and structural materials. When cut at the sprouting stage, bamboo stalks are edible. They generally require peeling and steaming. With fertilization and thinning, a mature stand of bamboo can produce one ton of food on a hectare of land (2.47 acres) in one year. This planting also provides 800 mature culms for structural use. Thus today as in the past, bamboo offers a dual crop from a single planting.

Such attractive characteristics have prompted us to incorporate bamboo into our tree crops research. In early 1980 we made an expedition to a USDA research station near Savannah, Georgia, and came home with a fine collection of 22 hardy species of oriental bamboo. We are observing their growth and development at the farm, and are beginning to investigate their uses. We plan a spring harvest of sprouts for eating and processing of mature culms for weaving into baskets and to use as structural members for hangings and supports. We are presently designing a bamboo condensation-gutter system for the Ark taking advantage of some of the larger stalks we retrieved from Georgia. We split some of the large-diameter culms and removed the internodal membranes to form long troughs to catch and direct condensation to collecting basins. Stakes can be cut from culms and used to support tomatoes, beans, or other vining plants. For larger supports, such as trellises, sections of bamboo can be lashed or nailed together. Baskets are made from split bamboo frames and weavers. A sharp knife, machete, or fixed blade can be used to split bamboo lengths into pliable weaving materials.

It is important to stress here that we are taking a necessary precaution with the bamboo. We realize that care must be taken when introducing a new or foreign plant into a bioregion. As completely as possible, the ecological ramifications must be considered. The scope of such considerations should span more than a single human generation. The ideal projected cultivating regime should remain ecologically benign if left unattended. Bamboo that survives in colder climates generally will spread rapidly, a characteristic that merits concern. Running bamboo is a self-propagating plant that expands its domain by sending out shoots horizontally underneath the ground. These shoots are capable of traveling long distances and are able to penetrate the smallest crevices or openings. Its strength can be witnessed by noting its ability to sprout up through asphalt driveways and through cracks in foundations and into buildings. Because of this, a part of our bamboo research is a search for an effective, simple root wall to contain the bamboo plantings. We are testing a standard three foot deep, poured concrete retaining wall and a buried vertical fiberglass sheet for containing the roots.

Traditional Coppicing Trees

There has been a comparable coevolution of civilization and an annual cropping of woody plants in Western as well as Eastern cultures. Of particular interest to us is the coppicing tradition of Western Europe. Coppicing is a form of perennial harvesting of wood. The word *coppice* comes from the Norman French word *couper*, "to cut," and denotes a form of selectively cropping from trees without taking the life of the tree as occurs in timbering. Coppicing is generally done by the ground-level cutting of certain trees capable of producing a new growth of shoots from the original root system the following year. In Western European cultures traditional coppice trees included alder (*Alnus* sp.), hazel (*Corylus* sp.), oak (*Quarcus* sp.), poplar, (*Populus* sp.) beech (*Fagus* sp.), and willows (*Salix* sp.). Each wood derived from these trees had a specific use. Hazel trees were cropped for hoops for baskets, twine for tying, and poles and stakes for agricultural structures and fences. A seven-year harvesting cycle offered optimally sized wood for bending and staking. Alder trees, which were harvested every nine years, produced a continual supply of rafter poles for roofs and other constructions and a durable water-resilient sole for clogs. Willow is one of the most diverse and versatile producers. It is a flexible, fast-growing wood, and particular varieties were grown for certain products. Some species were coppiced for weaving materials for baskets after one or two years growth. Others were grown larger for carving and for making household items; yet others were grown for firewood. A unique system evolved for natural, growing fences. A series of willow trees was planted in a row, in a suitable position for fence posts. After the trees matured, smaller upper branches were cut and laid in and out, weaving fashion, between the trunk posts. These branches formed the fencing material, and were used to build up and maintain the proper fence height. The living fence posts would sprout and grow new branches, which would be later used in turn for fencing. This practice of cutting trees off at some height above the ground is known as *pollarding* and in European cultures was generally used on trees in pastures. The wood was taken at a height above the reach of the cattle to allow the foliage to regenerate. Pollarding beech trees provided firewood on a 10–16 year cycle and oak trees on a 24 year cycle. Oak bark was a commercial source of tannin, a chemical used in the tanning of leather.

We have begun to culture some of these traditional coppicing trees. We have created a willow nursery to propagate large numbers of young willow trees. These are mainly European varieties that we selected for specific functions like weaving, growing natural fences, and firewood. So far these trees have demonstrated their adaptability and hardiness. From the basket-weaving variety come long, thin one-year-old cuttings that we can peel or store for later use. When the branches are soaked, the wood becomes very pliable, best for weaving baskets, boxes, and pots. We can use some of the early growth of branches for twine and tying. And we are also planning to establish a living fence with one of the willow varieties. Another project is a coppicing program for our eight-year-old hazel trees. We will be coppicing a few trees each year and using the wood for a poultry forage system in the form of a woven protective structure that allows poultry to feed on living plants without overharvesting. The hazel poles will also be used as stakes in the gardens for tomato and bean plants.

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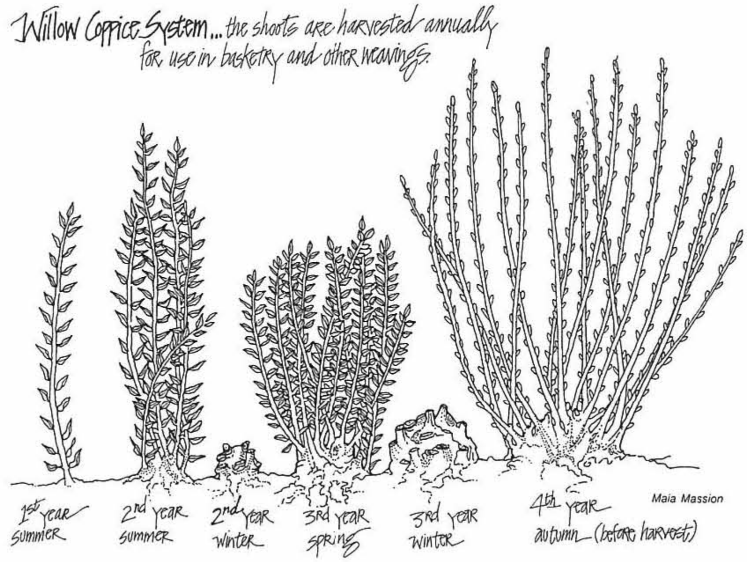

Weaving With Willow

Maryann Fameli and Earle Barnhart

Basketry is one of the oldest arts. It has been practiced by nearly all cultures and can be traced back over six thousand years. Baskets remain integral to many cultures and they have many uses in agriculture and commerce. Baskets are strong, durable, and functional; their construction and use is an important example of human-scale technology. Though the skills of basketry have been nearly forgotten by Americans, there are still a few artisans who practice this craft.

Many pliable materials are used for weaving baskets. Before easy transportation overtook us, the basketmaker made use of such natural materials as sweet grass, rye straw, grapevines, bramble briars, willow rods, and bamboo. In the United States today, weaving materials are largely imported.

At New Alchemy we have begun to grow our own weaving materials. We have been able to obtain cuttings from the varieties of willows grown for the basketry trade in Europe. These "basket willows" include several species and varieties (*Salix purpurea, Salix viminalis*, and others). We are aware of no commercial sources of willow rods in the United States, yet experiments indicate that they can be grown easily. By propagating them we shall soon have our own willow crop and be able to supply ourselves and others.

Willow has characteristics that allow it to be used for many agricultural purposes, the most common being garden baskets for harvesting and storing vegetables. Sifting sieves, trays, and drying racks are other common willow implements. Our plan is to use willow for potting shrubs and small trees because it is long lasting and relatively weather resistant.