# FORESTS IN PERMACULTURE

BY BILL MOLLISON

**Pamphlet X in the Permaculture Design Course Series**

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## Forests in Permaculture

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# X - FORESTS IN PERMACULTURE

There are two aspects to forests: one is the composition of the forest, and the other is the set of intrinsic reasons for the forest's existence. Only when we have concerned ourselves with both aspects can we begin to learn how to manage a particular forest system. There are different management strategies for timber, and coppice, and fruit. There is no single management procedure. There may be a dozen. There is no reason why you shouldn't manage any single forest as many as a dozen different ways for totally different reasons.

Of the forests that you can define, there are probably these types: There is the forest that has a right to exist. Maybe it is a ridge top and steep slope forest, a forest that, because of its intrinsic value, we shouldn't think of trying to manage. The job they are doing is enormous. They are doing a lot for the whole of the country. When you get to the brow of the hill and start going down to the beaver pond, from that brow to the beaver pond is holy forest. You can bury your dead in it. Close your dead in the trees, so that the forest is dedicated. There's that sort of forest. Shall we call it the essential forest?

Then there are food forests–food for man. We can call them orchards, but there are other types also.

There is a forest for fuel production. Now here is where you can get really smart. Fuel is not necessarily wood.

Then there are forage forests. The elements of forage convert to other usable stores. This type of forest is for the use of other species besides man.

There is no need to think about these forests in blocks. These elements of a forest can inextricably mix in a sort of patchwork situation. Then, some, like bee forages, need to be clumped, for cross pollination, etc.

Then there is a whole class of structural forests that are not fuel forests. Bamboo is a good example.

Our management strategies will differ concerning the elements of the forest. The forest breaks down into functional assemblies. Then it breaks down for individual elements of the forest. The forest is a canopy. We should perhaps regard it as a complex organism, rather than as a collection of trees and animals. It's just a mighty great organism. You don't look upon your bladder as being something separate from your body. How could you pull the blue jays out of the forest and say they are not forest, but this tree is forest? Down here and up there are physical and functional interconnections in which the elements inextricably bind.

I went into one of these forests to look at scrub wallabies. I found it impossible to look at scrub wallaby without its 38 to 40 critically related species, of which some were plants and others are animals. Scrub wallaby had predators, competitors, parasites, food, poisons. You can't pull the wallaby out of that mess. You just have to open out your eyes, and your understanding too.

We have species functioning around forest openings, species that are edge species, species that are detached elements, pioneers. So we have edge species; we have within-stand species; and we have species of the central forest. The forest is always in stage. It is never at standstill. Even on its own, it is not at standstill. It is marching up and down or round about. It is always in dynamic change.

We, therefore, recognize some stages, some serial staging, and some positioning in the forest. We use many of those edge species and pioneer species. When we construct a forest, we should pay attention to these rules, to the elements that best serve at these places.

Thus, we have functional divisions and we have movement divisions within the forest. When you look at the forest, it is all going on out there; it is all happening.

It is very interesting to look at the structure of language. Take the Oxford or the Webster's dictionary and strip out all the words in common usage in the dictionary that have anything to do with the landscape. You will find that you have hundreds, if not thousands, of sea qualifications–seacoasts, headlands, bays, estuaries, tides, etc.; you have a reasonable set of words to do with open areas and level plains; and you have a very, very minor vocabulary to attempt to explain a forest. That's us.

Shift to the vocabulary of the Eskimo and you will find that he has a mass of words to describe conditions of snow and ice, sea and sea ice, but practically none at all which have to do with the forest.

This leads me to conclude that we never did pay much attention to these forests. We don't have an easy vocabulary to explain some of the things that we know are happening in the forest.

We don't seem to be forest people. Bad luck for the forest. We are coastal people, sea people, and riverside people.

## Food Forests

So let's have a look at food forests. Two things about them may be of interest to us. One is yield. The other is equivalencies.

One interesting characteristic of the forest is that it doesn't fluctuate very much in its nutritional elements. Once you have measured up the proportion of sugar in the tree, you can propagate that tree, and are very likely to get those proportions. This is highly untrue for crops. Your grandfather was eating wheat at 17% protein, and you are eating wheat at 4% protein. All you have to do is throw a bit more nitrate on the ground and you have knocked out your lysine, or whatever–the little bit that was in there–and the wheat drops to an effective 2% protein. Those annual short-term crops are widely variable in nutritional yield. If you put high nitrate fertilizers on wheat and other grain crops, which you have to do once your soil is depleted, then one or two of the amino acids are not formed. I don't know why that is. Certainly there must be a pathway block somewhere.

Now what can we say about this? I think we can say that many tree species fulfill all our requirements for food. These are equivalent to foods that we would otherwise grow as row crops. This is particularly true of the tropics. We didn't design it this way. Any group that tries to sustain life in the tropics has to stick with trees that are all deep-rooted perennial systems. It is there that the nutrients cycle. This gets less true as we go toward cool, temperate, humid lands, where soil itself might hold much nutrient.

Nevertheless, if we look very closely at the total available food equivalence in trees, for example, we find that it is possible to go directly to that tree and eat its flowers and leaves. It is a salad tree. As you go toward the tropics, those trees start to proliferate, so that the necessity for 'green crop' is much less in the tropics; a few other trees are high value green-forage crop for man. The mulberry feeds many insects as well as silkworms and fish. Silkworm manure is good manure. Much conversion can be done from mulberry into agriculture. Fish feed directly on the mulberries that you plant beside the ponds. We should look amongst the trees and see how many of this type of green leaf trees would properly form a close-in trimmed or governed hedgerow for leaf production–a modest amount of it in northern climates, but in warmer climates, an immodest amount.

The drumstick tree, the old Moringa olifera, is just a common hedgerow around the annual gardens throughout the tropics. Eat the flowers, leaves, and the fruits. So blind are we that we don't often see these trees as a part of other people's gardens. We would see them as a hedgerow, rather than as an integral part of the garden.

Why did we neglect plants that produce all our food needs–the trees–in favor of clearing? Why did we ever start wheat in these quantities when we had forests that would out produce any wheat crop at those equivalencies–food as good, if not better, than wheat?

I'll tell you why. There have been two great factors responsible for the assault on the trees. One great loss of forest has been for war, particularly in the era of wooden vessels, which believe me, didn't end at least until the Second World War, during which vast numbers of wooden vessels were rammed and sunk. Moreover, we had a wooden airplane precursor, the Mosquito bomber. Most of the highly selected forests of Europe went out as armadas before the Industrial Revolution. It was in the early part of the Industrial Revolution that we cut trees for charcoal. That caused great loss of forest everywhere the Industrial Revolution reached. The tree, whatever its yield, was ignored for the fact that it produced charcoal. It was only when the supply of trees caved in that people started making a transfer to coal. Eventually, of course, petrol came. Petrol came along because of the urgent need to find fuel to continue the Industrial Revolution.

The people who came to this country came from a society already well into the Iron Age. If you want to look at the frontier of the Iron Age today, just look at where forests remain in the Third World. There they are–charcoal burners smelting iron. When they started mining, they used huge amounts of wood for smelting operations, and enormous amounts underground.

Who is shipping the wood out? Who is using it? Wood from the people who have forests is being shipped to people who used to have them.

The old Irish are always lamenting the death of the trees. The little black Irish were the forest people. Their oaks went to the British. The big ginger Irish were up on the hill slopes. They were meat eaters, closer to the ice, and less in the forests–big knees, big eyebrows, bit fat fingers, ginger hair, and they eat meat. They have short intestinal tracts, and can't deal with much vegetation.

The trouble is, once you've done the damage, you grow up in this naked landscape, and you think you belong in the fields. Once the damage is done, we grow accustomed to the damage. Our children are now growing up accustomed to extreme damage. That is the normality, to perpetuate the damage.

We are in a third period of waste today, the paper period. Every hippie you know is going to start a newsletter. Once, every hippie wanted to build a boat, sail across the sea, get some cattle and settle down. Now he wants to print a newspaper.

The Dark Ages were ages of forest culture. The information that remains about those times suggests that the trees were highly valued, highly selected, had high yields. You paid for the use of land based on the richness of the tree crop. From the forest, they derived all their bread, all their butter. The butter was made out of beechnuts–highly selected beechnuts. There are still casks and casks of beechnut butter in Europe, buried in the peat, still in good condition. All the bread and cakes in Tuscany and Sardinia and a few other places are still made from chestnuts. Corsican muffins are made of chestnuts, not wheat flour. All the bread was made from the trees, and all the butter was made from the trees. There are your basics.

In your American southwest, the pinion pine nut is a staple Indian food. In one day a family of six can gather thirty bushels of pine nuts, and that's a year's supply. In South America, six Auracaria trees support a family of Indians. Those great supports are a source of staple food. One white oak, in its year, will provide staple food for about six families. A good old American chestnut–how many pounds did we get off one of those trees? At least four or five hundred pounds. There's a couple of families' food for a year, with no hacking and digging and sowing and reaping and threshing. Just dash out in autumn, gather the nuts and stack them away. There are still hoards of acorns in America in the ground. Occasionally people find them. These are hoards put down in old times and never used, never needed. Maybe somebody put five pounds of sweet acorns down in a bog, and when we dry the bog and start to plow, boom! ...acorns sprout up everywhere! They still germinate.

There is a whole list of trees that grow from the tropics to up past here, that can supply a staple food for man. Now don't get the idea that I don't want you to eat rice and wheat. A small patch of that you can have, if you are really stuck on grain forage.

When the forests were managed for their yield and their food equivalence, they were highly managed. Now there are only a few remnants of this in the world, in Portugal, and southern France. In Portugal, you can still find highly selected, highly managed oak trees, often grafted, and olives. The pigs and the goats and the people live together in a very simple little 4,000-yard area in which nobody is racking around with plows. In that economic situation, there is no need for an industrial revolution.

A few of these tree ecologies still remain up on steep mountain slopes, where it has been difficult to get up there to cut the trees down for boat building and industrial uses. The whole of Europe, Poland, and the northern areas once were managed for a tree crop, and the forest supplied all the needs of the people.

When populations were reasonably small, the food forests of the aborigines represented a resource in which the last thing ever thought of was a food shortage. A shortage of food was a situation just impossible to imagine. Forests were stable, and they were self-perpetuating. Those forests were doing many other things besides feeding people. Those weren't little squatty pruned trees, pleached trees. They were enormous trees. The pears would have been trees of two hundred and three hundred feet. The apples would have been enormous edge trees and semi-isolated trees. The oaks were really enormous.

You can still see a few forests of this nature in the world, but not many. In Australia, we have primeval forests. You can go into some of those forests and stand there and you just can't believe what you see. You might be standing in five hundredweight of nutmeg–this is one tree. You get uphill a bit in these rain-forests and you start to run into bunya pines. Those bunya pines have 40-pound cones. The bunya is a tall tree. They go up a couple of hundred feet. Those cones would squash a cow. They fall with audible thumps all over the place. You only have to squat down there, lay down beside your cone and pick out that bunya seed–very good eating, too. The potato yams are there–you are up to your eyes in food. There is no way you need to go looking for food. There are large numbers of edible leaves and plums. Those forests have plums not even related to Prunus. They are all over the place. That is the sort of condition in which we can imagine that people once lived. Certainly, under these conditions there is no danger of losing soils and water and all the other accessory things. There is no danger of losing forests, because people who gather their food from the forest are in the business of propagating forests. There are enormous ranges of these food forests for which processing technology has been long forgotten. Many foods that are not food to us, in former times were staples.

Now, however, we can play new games, and we can make new assemblies of food forests. There are not one of those forests that are around us now that do not have all the secondary characteristics of forests: They are soil maintaining, moisture maintaining; they produce good wood–there's nothing wrong with apple wood. The forest also produces many other species, plant and animal, that provide food.

In a wood economy, a wood ecology, the houses were great. I was in a house in Wales that was nearly 900 years old, a good solid old house. I stuck my pocket knife in the oak and it was like iron, black. It was built in an old Irish enclave in Wales when it was then in the forest. At present, it has some other little homes around it. It was a little forest village. The house was built out of oak beams and filled with stones. Everything that made up that house came directly out of that forest. When your oak is not yielding too well, or has grown too old, or lightning hits it, there's a house. Some of the trees standing in Tasmania will make six ordinary homes, and it will provide firewood for them for 12 years–that's from an individual tree. Just one tree will house six families and give them their firewood for 12 years. The houses will last forever, or until they burn down.

In the tropics, it is possible to be food self sufficient from trees within two or three years. You start with things like bananas and papaya, and go on to a huge variety of fruits and nuts. There are lots of staples, too, like a coconut. Back about the 1940's, the coconut was fully used. "The Pacific Islands Year Book" gives 467 by-products around a tree like that. Breadfruit produces so much food that it becomes incredibly wasteful! The breadfruit is quick to propagate, and easy to grow.

I will tell you a little story. There is a man named Cliff Adam, living in a group of islands with about 40,000 people. Cliff got a grant from the United Nations to collect some food plants that might suit the area. They gave him $136,000. So he took off in his plane and kept sending home parcels. He left two or three friends there who kept planting all these trees. He sent back some 600 sorts of mango, 30 or 40 sorts of breadfruit, all sorts of guava, and so on. When he got back home, he then moved them out in rows on 68 acres near the shoreline. Then he got another 135 acres from the government, up on the hills. So he set out all these trees. About three or four years later, he had all sorts of cassava and all sorts of yams and taros that you could imagine. He said to me, "I am in a very embarrassing position."

I said, "What is wrong?".

He said, "Well I shipped this crop in that wasn't growing here traditionally." This was really a coconut economy. He shipped all these plants in, and he set them out as trials. So he said, "The problem is, what I was going to do was this: give the farmers different sorts of mangos, breadfruit trees, and all that, and I have been doing it; but already the production from my two hundred acres would feed the island, and that's experimental production. I am in the embarrassing position where, as agricultural research and nutrition officer, I am already alone responsible." He said to me, "What am I going to do?"

I said, "I dunno."

This is a difficulty wherever people undertake this sort of assembly. You haven't gotten very far along the road, maybe four to seven years along the road, when you've grown so much food the whole thing gets rather embarrassing, and if you are the agricultural officer of a small country, you could probably feed the country on the experimental plots. What's embarrassing is that there are dozens of small farmers. Values fall. They are not going to have any money any more.

So this is the problem in tropical areas. It is true for India. Our assessment of India is that there are six billion acres unplanted, planted to nothing. You can see it all over India. There is nothing on it. Yet India is starving on these little rice plots in the valleys, making a virtue out of it. The problem is that when we plant the land, people quickly become food self-sufficient. If you plant on an extended basis, then the whole structure of the economy is affected. What if nobody wants to trade or buy food? What if no one has to bother with it anymore? So there are problems. They are problems of a different order than the problems that we think we have. That has happened to several people who have tackled it seriously within the last five years.

There is another man who's pushing his food jungle just out of habit. He doesn't have to make money. He has an income from property–not much, but enough. A few years ago he started to build out the edge of a rain forest, moving out into the grasslands. He went about 30 yards, assembling trees. He has some 600 species of tropical trees. As soon as he had his trees going, he started to put in vines and epiphytes. By the second or third year, when I saw him, he was over his head in food. All around there was the sounds of food thudding to the ground. Now he's just gotten cracking. He had just assembled his species, and already he was in the embarrassing position where he could feed the whole coastline around him for miles. But he was still going on.

He developed some very interesting techniques. He used coconuts like a hand grenade. He would run out along the ridges into the grasslands, heaving coconuts down to the creeks. Boom! Boom! Of about every hundred, about four would take root and start up. He threw hundreds. So a person can run through the landscape bombing it with food.

He established his food pioneers, then grew coffee, cocoa, tea, grapefruit, mango–just about anything you might name.

Many of those fruits had never grown in Australia before. They are all doing right well, including a packet of brazil nuts that he bought and put in. They all came up, so he bought four thousand and put them in, and they all were coming up. So he put all those out, along with as many coconut trees as he could heave in.

It could be exactly the same in India. You could run all over India and just throw a food carpet across the whole continent. India is basically an unplanted continent, the world's largest empty space, as far as I can see. Yet people are dying of starvation. The problem is the economy, and land ownership. You don't have a food problem. I don't think you will ever have a food problem. If you seriously started this roll away stuff, started to roll all over that place, you wouldn't get very far before you would have an embarrassing amount of food. In a money economy, it's all right only while nobody else is doing it. But what if everybody started doing it? Terrifying thought!

Now the position is already being faced in some small communities where there is such a surplus of food that there is no real economy in food at all.

Take the great North American continent. If you put coconuts where there is now nothing, but where coconuts would grow–if we were to run around down there establishing three or four million coconut trees that would be yield in four years' time–you couldn't sell coconuts any more. You say, in Florida, coconuts are now all being wiped out by a disease? Hmmmmm.

Let's then have a look at a typical Indian situation–a few thousand miles of Indian road. Taxis are speeding down it; donkeys, and people; thousands of people walking up the sides of it. The main highways out of the cities are at least one hundred fifty yards wide, I would say. They run for hundreds of miles. I was setting off from central Bombay, trucking down the road. All along the road there were people starving and begging. The whole roadside area is rich with grasses that they feed the buffalo. Suppose that you plant coconuts just off the road, so they do not worry the traffic, and put papaws under the coconuts–papaws are good understory–and you can grow lots of other commercial crop between. Then you have food strips maybe 300 to 400 miles long, running out of Bombay in all directions. Enough food would grow there for the whole city of Bombay, where people are dying of starvation. You could do it within 18 months. We could put in bananas. India is the most heavily manured, unplanted farm in the world. She is six inches deep in human manure any time of the day or night–blood and bones, but much just ordinary manure. It would just grow into an instant food forest. In 12 months, people wouldn't have to go marching up and down the road going to work, would they? They could just sit at home and weave things and talk to each other.

Moreover, these are non-cooking foods. So it solves another gigantic Indian problem–the need to cut the forests to cook their grains. The reason that they are in deep trouble is that they have gone to grains and pulses, which is an end ecology. It is the last game you play before oblivion. The cooking times are horrific. To make edible some of the pulses, you must cook them for six hours, particularly the soybean. The consumption of fuel to cook soybeans is absolutely horrific, enormously in excess of the food value you obtain from soybeans. We can say the same of rice. To sustain a soybean or rice or wheat economy, you need a vast amount of external fuel just to make it viable as a food. India is running out of the fuel to cook her food because she chose the foods that you have to cook.

There is also the guava, and the mango, and the limes. We could set up a full island of nutrition along those highways with just five or six species, and you would lack nothing. With the coconut, the banana and the papaw, you have a complete diet. India was once a jungle; the people were jungle people, and in the times that we can remember, the Ganges plain was a jungle. They were not eating all this pulse and rice then. These foods came in as the jungles were cleared. As this annual food base expanded, what once was jungle became the fuel base for cooking. They were thrown into this position where they needed an enormous natural fuel reserve. In Kabul, for instance, the forest has retreated 85 kilometers within the last five to eight years. Only the last remnant of jungle forest remains, and there is not one part of it that is not under heavy attack for fuel.

This is your last act. Ninety-eight percent of this stuff is presently being cooked on dung. Therefore the fields are not being manured. That is the last act, and they are well into that one. In areas where they have been into it for a long enough time, there is no longer any food production. So the whole dilemma is right there in front of you.

The big error was to go toward a grain crop instead of towards a tree crop. Yet within India you have the best tree crop research institute in the world. That institute covers a few acres. You will find people there who know more about the coconut palm, its cultivation and its uses than maybe anywhere else in the world. Many areas of the world now grow coconuts and guava from that research station. India has the best, most carefully chosen, most carefully cultivated varieties of guava. The same goes for the lime, and the papaya.

These are frustrated people. The problem with that kind of game is the same problem–land ownership. The problem is that it threatens too much of the other economy. The whole question in everybody's mind is, "If we plant these fruit trees here–and we can do it tomorrow–and everybody's eating, what do we live on? How do we manage to pay the rent? How do we do that?"

A gentleman called Barry Slowgrove, who had the good fortune not to have had any experience in nutrition or in agriculture, an electronics man, and a business man, got sick in South Africa about ten years ago. His doctor told him to go and eat fruits and nuts, and only those that had been produced organically. So he ran around to see what he could get. He couldn't find such things. So he began looking for books that described their nurture. He picked out a set of fruits and nuts that for every month of the year gave him a complete food.

Then he sold his electronics business–he had branches all over. He got a couple of million dollars. Then he set out all of these trees, the actual varieties that he knew, and all others that were analyzed. He set up a 12-month tree nutrition program in a nursery. He never had a nursery before. He read in areas that we would never dream of reading, such as the root temperature of avocados. He went on with nutritional analysis, doing the annual cycle. He found some amazing things about the annual cycle of nutrients in the case of the avocado–the oil goes from 6% to 40%, and it all depends on the stage at which you eat them. He planted them all. Then he set them out.

He had six African assistants. By the fourth year from go, they and their families and he, himself, were eating 12 months of the year on a non-cook basis. After that, he set up an organization called "Trees Unlimited," and he sold whole nutrition, whole-year nursery kits, plus the implementation, to anyone who wanted it. Everybody who bought it got a guaranteed year-around uncooked food supply at top nutrition.

Then he came running over to Australia and said, "I want to do it here, and I am going to set up that nursery over here and then sell everybody in Australia these kits." He said, "I've got it worked out from temperate to tropical cool."

He handed his nursery system over to an institute. He does not have any personal part in it now. He is just running around trying to get everybody to adopt his system. He says, "This is it! This is it! This is the solution to everything–no more fuel problems, no more cooking problems, no one on bad nutrition, you know, quick to do."

Now his technique is absolutely fantastic. He uses different colors of plastic for root temperature. He has different shading systems for different ages of trees. He goes out and sells his program. Then says, "OK, I'll get it going." He comes in and he bores all the holes where he is going to put trees on the property. He transfers the soil from the holes into pots. He takes the pots back to the nursery. He blocks all the little holes that he took soil from with his cans, which numbers to correspond with numbers on the pots, so that the soil in the pot has the same number as its hole. He goes and treats that potted soil in a variety of very interesting ways. He uses, for instance, sodium salts where you don't have enough water. He uses those in the soil because the plants need them, just as you do. He uses a seaweed gel; he uses more in sandy soils, and very little, if any, in clay. So the plants grow in the soil they are going back to, treating that soil. Now as they respond to that, he runs back to the hole, and he treats the area around the hole. When he has the hole ticking over, and the plant ticking over, he comes in, and in one day he puts the whole orchard in. The plants are already very high, and he advises you to water them once, when he puts them in, and never again.

I think Slowgrove's approach is extremely interesting. He went about it as a businessman would, totally unlike any approach that you ever heard of; he just went at it. He made it succeed. He systematized the whole thing. He made a lot of money at it. I mean, he made another few million dollars while he was doing it. You should see his tree catalog. It is something to see.

Slowgrove took an interesting road. He took the soil from the area in which the trees were to be planted, instead of using made-up nursery soil. He grew that tree in its own soil. He went through many simple sequences of treatment. He had the subspecies and the varieties that suited the climate anyhow. Then he amended the soil with a minimal amount of treatment, and likewise treated the area where the tree would grow. He used sodium salts and seaweed concentrate with the whole idea of cutting the need for watering down to a minimum.

What he didn't do, though, was to put any companion plants with these trees. He was just laying them out in rows. He was really zonked out by Permaculture Two, or it may have been Permaculture One, that another businessman had bought and which was on sale at the airports in Australia (These books just travel on their own all over the world, see!) This other businessman came running up to Slowgrove, because he had bought Slowgrove's trees and said, "Look at that!" Then Slowgrove realized he had left all the understory out, and had not used any of the design features of the system.

However, what he had done already was of excellent use. His whole purpose was human nutrition. He runs around the world eating fruits and nuts and he looks perfectly fit to me, and reasonably happy.

While he tackled an extraordinarily wide range of environments, he didn't tackle anything like New England or Canada. Quite obviously, you had people living here in heavily forested country and looking fit. That was also true of Canada. However, those people weren't eating entirely from tree crops; they were eating a lot of meats, and the further north one goes, the less do you see people dependent on vegetation.

I point out to you, though, that the total food supply was enormously above the requirements of the population. That food supply was above what it is today. If you make a comparison of the American livestock of the early invasion period with American domestic livestock today, you just had an enormously greater biomass in livestock. You know you had a far greater biomass in trees. So you had a lot more food on the ground in the days of the Indians than you have in the days of the whites. Now you have a lot more whites on the ground.

If you live like a European, you cannot garden like an Indian. No way. You're in problems. People who are simply plowing-under native trees, then paving the area over with highways and cities, are blocking their ability to produce food.

Food forests, wherever they are tried, work extraordinarily well. There is a reasonably short delay between bringing trees in and taking their fruits off, but that delay is not critical because what you plant them into is a crop situation, as it is now. You go on cropping between them until you are swapping off what is now annual and biennial crop for tree crop, and even then you can go on cropping for quite a long while and take both.

In India, at the government pig killing station–the only Hindus that don't eat meat are a very small group; nearly all Hindus eat a little meat–well, this government pig-killing station is run by Hindus for Hindus. They raise pigs as they were taught by advisors, some of whom were Australians. They raise them on crushed grains. They have 68 acres around this piggery. But they haven't been taught what to do with pig manure. So they have a lot of little men with wheelbarrows carrying it out and dumping it all over those 68 acres.

About a quarter of a mile away there are some beautiful breadfruit trees, dropping breadfruit–a lot more breadfruit than anyone would ever need to feed all the pigs they've got. So I suggested to them that they combine this breadfruit situation with papaya. You can't bring banana in because you can't run pigs in the banana, but they had plenty of people there, if they wanted to, they could bring banana in, and carry the banana to the pigs.

So we worked out what to do, and as far as I know they started doing it. Now they could run all that pig operation and a lot more than a pig operation on 68 acres. I said to them, "And the next step is to take this and the pigs, little pigs, and start to give it as a kit to lots of other farmers. Then you just do the killing for them and processing, or whatever." As far as I know, they have started that. They can easily kit out a whole district from such a center–not just with its fruits, but with its meat base as well. They just hadn't thought of it. First, because they called in Western piggery experts, and second, because not one of the persons on the staff was a forester or fruit and nut person, or biologist. They were all technicians.

They were delighted. Now, not the person running it, but the second person, is an experienced forester, and he is getting on with this. They have very good foresters in India.

Those grains that they fed to the pigs came from Indian gardens, which amounts to a reduction downwards to one-tenth of its former food value. However, within eighteen months they should be a net exporter of fruit and pigs, which is a very rapid and resounding sort of change.

It is exactly the same with the government milking shed, and buffalo growing. They have people running around carrying grass, feeding all those buffalo.

Cliff Adam had tackled this, too, much to his own horror. Talk about growing livestock! Cliff had put in an acre of a thing called elephant grass, quick growing stuff, grows about four feet high. It looks like sugar cane, and it's not far off sugar cane. Between the rows of elephant grass, he grew a tree called leucaena that many of you will have heard about. Under those trees he grew annual plants. He put in an acre of this. He had cows in a modern dairy. It was just like any barn except that instead of storing food, he was cutting the food and feeding the cows and milking them in the barn. He was running ten cows to the acre. He said, "I was going to extend to 10 acres, but this won't do. I will supply the entire milk of these islands, and what is the point? What I'm really here for is to tell farmers how to do it."

I said to him, "Well, I'll tell you another thing you can do. There's a lot of room for comfrey in there, and comfrey doesn't care if you are walking up and down on it. You will get five cuts a year off that."

He washes all the manure from the dairy down on a very simple row flowing system, back into the crop. So he has a wheel running in which he has ten cows to the acre with these two crops. The cows look good. They have been running about two years on this. He eliminated artificial fertilizer from the system. So what he has is a real full-on, high production dairy system in the tropics. He doesn't take the cows to the pasture; he takes the pasture to the cows. If you look at the field, there is short leucaena–it just marches across the field. The whole field is bordered with coconuts, which are superb to the situation–lots of shelter and plenty of coconuts.

Only a little bit of capital and a little bit of land are needed to evolve these very simple systems of high intensity production. The best butter in the tropics, however, isn't butter; it is avocado. By a long, long way, it is much better than butter. There are many solutions for food forests–amazingly fast, amazingly simple solutions–and in forest forage, too, as we have just thrown in there.

Now the application of these systems is not confined to tropical areas. Using modern nursery techniques, we can get an initial year or two years in the nursery, while doing the ground preparation in the field. In the nursery, we can get the ordinary cold-temperate fruit and the nut trees to a stage that, in the field alone, they probably wouldn't reach in eight years. We can ship container specimens the year before they yield. So just by the application of good nursery technology and accelerated growth in the nursery, and then a field preparation, you can lead very quickly into it. The establishment and use of non-cook food forests is pretty simple. Cooking, by the way, is the major fuel use in the third world. So, you would never go into an island situation and advise them to put in a rice plot–never! That would be the end of the island. Cut more trees to cook the rice, to extend the rice, to cut more tree.

I don't expect you could find a more conservative set of eaters in the world than the average Australian. It is meat and potatoes country, with the highest per capita consumption of meat in the world, except Argentina. But that is changing rapidly. What now appears in the shops is large quantities of avocado and other fruits, and nuts. Formerly, they were never produced or even offered for sale locally. People are rapidly adopting them. I don't think there is any problem in changing people's food habits. I haven't been into a part of the world where a gardener doesn't leap on a packet of new seed, if you will give it to him.

Just say, "Look, I got something for you here, it's a brand new plant."

"Looks good. What will I do with it?"

"Stick it in and stand back, you know?"

"Good!"

I think the very interesting thing about the permaculture approach is that it predicates that you are going to be on reduced fuel consumption for cooking. I can't see any reason for using fuels for much of anything at all.

While I don't pretend to be a nurseryman–we've just started working in this area–I am very interested in Slowgrove's approach, and we are using some of his techniques. I have friends who are nurserymen, and they are carefully monitoring trees now. They find that by adjustment of shade and nutrients they can get probably four or five times the growth that we used to get in old open bed nursery conditions. They sell very large trees now in a very short time. Other nursery developments also are revolutionary, techniques such as cloning by root tip, single cell generation of plants. If we learn of a rare seed, we get one into Australia, and send it to a friend in Adelaide. He starts the seed. He starts from the root tip. One seed is enough to start a whole bunch of plants going. It's really the most rewarding domestic technique, to look after your plants and get them going in a sheltered and ideal environment. Meanwhile, you are working outside where they are going to go, to bring that environment up to optimal growing conditions. While you do that, you can be cropping the area and using it for purposes that might very well be manuring it. Then you move these trees out into the situation. It's not a broad scale technique; but as a domestic technique, setting up a family in food, it is a very good technique.

Slowgrove said that if you want to do a lot of this, if you want to do 4,000 acres for a community, first, start the nursery running while you get out on to the ground. He had set up a sort of nursery kit. We did that, too, in central Australia with the aborigines. We set up a small nursery kit, all of which fitted on the back of the truck. So when a group of aborigines goes to an outstation, they take their own nurseryman, who has been through a course of training and knows the nursery business. The nursery has everything with it. It has its own drip lines and sprinklers and shade house. They set up the nursery at the camp, and then they fill out as much as they want to around the area. It is really simple, because you give them a bundle of tamarisk sticks in water, and after they get them, they stick them in the sand, and they have tamarisk going. Then you give them a bundle of grape cuttings suited to their area, and they may have twenty varieties of grape cuttings. They get those going, and then away they go.

That nurseryman only needs to train for a couple of months. He is a tribal nurseryman, while he is needed. That nursery is built out of reinforcing mesh. It has a lot of grapes in it, and oranges, and all these goodies. They like their own foods, too, but they like these additional foods. There is absolutely no barrier to getting them to eat these foods.

All over India, you see big notices with Ghandi's name on them. Those notices carry one of old Mahatma's sort of instructions. They say that if every Indian planted a tree every year, the whole continent would be in very good order. They say it in Hindi; they say it in English. The trouble is, you can trudge for endless miles and you won't find a nursery or even a tree seed available. There isn't any. If you set up a nursery, you would rapidly become very rich, because all the people in India would come and get trees. They want trees; but there are no nurseries. There is not one nursery listed in the Yellow Pages in Bombay. (You can't get anyone on the phone there, but there are Yellow Pages.) So India could easily be revegetated, but it hasn't any trees for sale, not to anybody.

A group of interesting people in Bombay studied successful and non-successful undertakings. They found the most successful attempt to do anything to improve conditions within a village was made by a local farmer. He used a combination of very hard control and common sense. First, the problem was that there was a lot of disease in the village, and it affected his workers. So he forbade his workers to wash their clothes in the spring water on his farm. So they had to change their ways rapidly. They came downhill to wash their clothes instead of drinking the washing water. Thus he wiped out disease on his farm. Then he thought he would like to grow limes, because there was a big demand for limes, but none growing in the district. So he started a small nursery to grow limes. He grew rich by selling from the nursery, and he turned into a nurseryman, and enlarged his acreages. What he accomplished was a very simple thing locally, not a big deal. This was the most successful change in the village. There have been millions of dollars and thousand of Europeans coming and going with all sorts of free things, most having absolutely no effect, or no lasting effect.

But the real problem in India is land ownership. So maybe you will have to become a land owner to change things.

For a food forest, you must pay attention to the edge and to the species. Most trees bear on crown, but not all trees will stand within the clump. Some must remain on the edge. So when you set the thing up, you differentiate the crown bearers that are also edge species from the crown bearers that will stand within. These include the large nut trees. It is probably sensible to set your forest off with bark yielders and close planting in the interior of it, coming out. Then thin the forest for crown yields, then for edge yields. That way you have a structural forest within the food forest. It may be better to place your structural timber forest, as the core. As soon as we get a diameter of over 100 feet, we start to think of the center as maybe being structural. Then think about breaking the crowns and taking some edge in as a lake or something, and then starting again. That's the design.

However, within the tropical region we don't have to worry here, because we have stem bearers. Tropical forests, as soon as you get into there, you are into cocoa and all sorts of other trees, and into palms that are crown bearing. In the temperate forests, this is not the usual case.

Your oaks bear quite well within the canopy. So you can treat oaks as a forage and structural timber within the canopy. The way to get a really good mixed forest–and what most people don't do–is to put in a forest at very small intervals, with some species as little as three by three feet, but nearly any species as little as nine by nine, and put them in as seedlings. That forces them into a fast upright growth with a good trunk. You do modest trunk trimming, and you wait for bearing to start, and it will start with small trees. Then you might select for early bearings, easy nut crackability, low tannin, whatever. Start to cut out the trees that don't come up to your expectations, but that already have good trunk length. Then, keep on cutting them out until what you end up with is a good tree with excellent bearing potential on several characteristics, and then you let it develop the crown. The ideal way to go about it is in a graded way. It doesn't take so long either.

It wasn't more than a decade ago that some people bought an island and set it up–a very overcrowded island–with black walnut, because it was an investment thing. They were going to go along into the veneer trade. Well, black walnuts started to drop walnuts, and they found some really excellent walnuts among them. So they started to free these good walnuts. Now they are making a packet out of walnuts; they don't even know if they are going to bother with the veneer trade. They are heavily into a crushed nut business.

When you begin to get your trees established, then you can move in species like your striped maple and other useful plants. You might find it would be a good idea to put some grapes, or perhaps some other useful vine on some of them. One thing for sure, in fig country, as soon as figs are up and bearing, have a grape standing out there on the trellis, and when your fig is big enough, just lead your grape into the fig and then stop pruning it for good, because the grape reaches the crown of the fig and is wind pruned, and you just forget pruning it anymore. You do exactly the same with elm, black walnut, and blackwood–Tasmanian blackwood. They are all carrying grapes, and the grapes bear as heavily as they would if you pruned them. Because, in fact, they are pruned. No grapes can get out past the crown. I was standing by one of those trees down in West Australia, a fig tree. They were harvesting fig, grapes, fig, grapes. For grapes, obviously what you need is a tree of limited height, so that is a nice combination.

## Structural Forests

The strongest structural timber is growing round timber, uncut timber. You have species that are pioneer or edge species. Black locust is a very good example of this in America. It's a tree that is pioneering. It's a good soil builder. As fence posts, it is a very durable wood. It has the highest impact loading strength of any timber known. The black locust is the traditional mallet head. Therefore what you have is probably the best designed structural poles existing. We find black locust posts that have been setting ninety to one hundred years, and they are still near maximum strength. I don't know what you are paying for fence posts, but it's heading up towards $5 and $8 in Australia for six foot posts. You can put in those stems at 4,000 to 5,000 per acre, and you don't wait very long for a fence post. It's only about four to six years. And it coppices. That is another good thing about the black locust. The more you cut, the more you get. They also provide quite good chicken forage. In this way, they ideally suit to stocking with chickens. That will increase the nutrient level of that forest.

Another wood that has numerous domestic uses is bamboo. With bamboo you are not so fast into crop, unless you can persuade someone to let you break up their clump and dig out the root masses. Otherwise, you have to wait to develop your clumps of bamboo. It is generally 10 years before you can cut it. Bamboo very easily propagates. Mostly it is vegetatively propagated. There are two to four bamboos suited to the North American climate that are heavy seeders. These are useful for feeding wild life, but they are not particularly suitable structural bamboo. I don't know of any structural bamboos that are annual seeders. Even small bamboo, however, is useful for gardens. There is a large bamboo that I think may grow easily up here. It grows to about 60 feet, with a diameter of about four inches. You can look them up, probably in Boston.

You could use many thousands of clumps of that throughout New England. It is good for cups and knives and plates, gutters, and down pipes, and reinforcement of concrete. You have to follow the rules. You have to cut it at two to four years of age, dry it for about eight months, and then when used as reinforcement in concrete it is two-thirds the strength of steel. The comparison is per diameter. If you use inch bamboo where you would use one-quarter inch steel, you get a lot more strength. It has the advantage over steel, of course, in that it doesn't rust in concrete. It is a much better reinforcement if you treat it carefully. It bonds better in concrete. It has many additional uses. Bamboo shoots are excellent food. Fortunately, they can be eaten raw. So the bamboo is an excellent structural tree, as well as a food source. {There is some risk of cyanide poisoning from uncooked bamboo shoots. I've eaten small amounts of sweet shoots with no ill effects, though. –DH]

Let's take another–the cedar–your eastern red cedar. It's a good structural tree, a good pioneer tree. It naturally starts to disappear into the forest that succeeds it. That's the time to take it, as soon as it starts to become eclipsed by the next succession. Tamarisk is another good structural tree–excellent. There is a short list in Permaculture Two of the trees that are really worthwhile to set out by thousands for structural work, particularly for pole and fencing timbers. Arbor vitae belongs on this list. We could make a much more extensive list. Many of these long duration trees weren't recorded there. So when you are planting for a client, and he has the room for it, give him a considerable edge of structural timber for a thousand year future. All the better if those timbers are pioneer species.

You might want to buffer the large nut trees from the round fruit trees. Put maybe a 20- to 30-foot planting of other trees in, Acacias or something else. These trees that must be buffered against have a root exudate, which is a mixture of creosols that kills out the species that are pioneering. That is how they increase against the edge. This whole group–Juglandacea--hickories, pecans, walnuts (juglans, meaning the balls of Jove)–put out that excretion. The large fruit trees that bear at the edge, must have a buffer forest between them and the central forest of large nut trees. The mulberry is a very good buffer tree because it stands right in against those nut trees with no sign of loss of crop, and the mulberry will stand right against fruit trees without impairing their crop. The elderberry is another excellent buffer. They snuggle up to both those groups. The black locust is another good buffering tree.

There are two sorts of structural forests. You can manage, of course, for saw log. That is what everybody is urging you to do, because of the huge spin-offs to other people in saw logging. However, a round pole is of far more use to you or your client. A very limited amount of saw log is needed–only a small number of trees that you may need to rebuild your house, unless you are really interested in building houses for many other people. What we would have to weigh is how that use would compare with the trees' other uses in the forest.

So you have pole timbers and plank timbers. Management for these is different. You know how to manage for plank timber, or any forester can tell you, or there are books that will tell you. You pick out a true sort of tree with a clear trunk, and you free it a bit and look after it.

There are two ways to cut your forest. One is to continually fell the largest trees. When they come up to a certain diameter, you cut them. That gives you a continual production of round timbers in that forest. The other way to manage the forest is to cut out all the small and weak trees. The first method is a continual-product pole forest. The second, is an eventual-product forage forest. Now why not do some of both, if you are dealing with anything more than seven or eight acres of forest? If you manage timber for pole timber, and it is all posts of high duration, you are farther ahead on money value than you would be waiting 40 years for a plank.

I think you will find poles being used in construction much more commonly than in the past, particularly for accessory buildings. Australians now build houses in which they use about nine two-inch poles to build an entire framework. Then they just fill them in. There are many of those houses now being built. The whole structure is made of poles and then just filled in with mud, brick, stone, or whatever. The whole house framework costs around $800. The building stands on its poles, and is filled in with mud, wattling, board, or chicken wire and cement. Chicken wire and cement are great building materials. Some beautiful homes are chicken wire and cement homes.

Now let us look at coppice in terms of structural forests. A whole set of plants is cut-and-come-again. We have mentioned black locust. Willows, poplars, ashes are all plants that you run as coppice. They are useful for furniture, handles, basketry. Your classical coppicing tree is the willow.

There are different reasons why you might coppice. You might for the bark, or for the timber, or for the forage. If you coppice for forage, you start your coppice above cow level, but to coppice for basketry, you can start below ground level. What you use is striped willow. You bury it in a good wet site as billets in rows. It shoots up and you coppice it again. You wouldn't get away with that with your cow in there. The Tasmanian basket makers, who are to the fifth generation in basketry, used this method. They have just a little patch of it, a half acre right outside their door, and they manure it and look after it.

I think that also ought to be used a lot more as a forage. Consider a quarter acre of that sort of coppice, something the cows will really rip into. You just have it ready so you can turn your cattle in and take them out, watching the amount of damage done. In some extensive cattle areas, if you have five or six acres of that sort of fodder locked up, it would carry you right through droughts. You can either cut it and throw it over, or let the cattle in, depending on how much damage you observe.

If you want to keep a stump from coppicing, the simplest thing to do is to throw something over the stump, a piece of carpet. Just exclude light from the stump. Cut a hole in the stump and put a little road salt in it.

For woven fences, you use hazel, oak, or ash. All of those are used.

What is poplar used for? It is good forage, good splitting, and good for inside work. It is not much good for outside use because it doesn't last long. You can't go into bent-wood chairs, or whatever, with it.

Another good tree, which is not American, is the tea-tree. It grows very thick. You can hardly get your hand in between the stems of it. It weaves well. We make all our baskets and all our lobster traps out of it. It has a high value oil in the leaves, so when you cut your tea trees, you also distill the heads. These tea trees are long lasting in fences. They last thirty to forty years. It sells 30 cents a stick at present. You don't put the butts in the ground. You use the sticks to fill in between black locust posts and rails. They will be there for 50 years as a fence or trellis. I put a row of rocks under them and stand them on the rocks. They hang there indefinitely. Those trees grow very fast. In five years you are ready for another cut. The oil that you distill from the heads gives them a double value.

I would like to discuss at some length the American forest as we now see its potential for management. I think if we go about its management very carefully, we will find that it is a high value standing system. I think there are two or three ways we can go about its management.

There are already pole stands of reasonable value with very few large trees. We can keep that part of the forest as pole stands and start to look at how we could use the poles. There are big areas of birch pole. I would use white birch plantings as reflective species in design in the district. I would make it coppice, too.

Let's look at what we have in the forest. We have many dying young trees. They are over-run eastern red cedars and understory trees that were beaten to the crown. They really represent only one thing–firewood.

If we put in a dry distillation tank, which is just a simple brick system–there are quite a few models, for the French use them quite a lot–we would get charcoal, methane, creosote, methanol–all of that. We would still have a readily saleable fuel as charcoal. There is a lot of forest right here on this place, and nearly any of it worth more than a cord of wood. After distillation, you still have charcoal left, which is an excellent cooking fuel. So it would be advantageous to go into dry distillation.

One of the very first illustrations in Permaculture One is a diagram of how you could use that wood for a whole lot of products. The whole system is pretty low technology. You needn't release all your flue gases. Send your flue gases through pond water and get calcium carbonate. Precipitate it out and throw it on your fields. Throw it back in the lake. It releases a very clean gas to the environment, and you can recover methane. Now that would be a good way to use those dead and dying trees in the forest.

Your priorities in the forest at any time are to cut the trunks that are lying on the ground away from your live tree trunks. These are the ones which in fire scar the base of the living trees. The first tree you cut up on the ground is the one lying against the other trees. That is true still of many chestnuts. Old chestnut logs are often lodged against big standing trees. They don't seem to rot very quickly. Now in North Carolina, there is a lot of chestnut wood lying around. The reason it is good to move this material out, rather than leaving it there to rot is that, in North Carolina, for instance, it would never get to rot because the fire frequency is relatively high. What will happen is that all those ground fuels and any standing dead fuels will burn out. I think in most forests that ultimately is the plight of many cords of wood. It just simply goes in wildfire. At present, without knowing any more, I think it would be better to take those out for fuel. They are more than firewood. Dry distillation could be combined with the heating of homes, because we are going to get surplus heat from it.

What I am looking at is trees that have lost their bark already. Throughout the forest, there are many very old trees on their feet, still alive. Now we can leave those standing if we find occupancy in them of wild life and birds. Also, whenever we cut up old trees, we are going to get many hollow limbs. I think we should sell those as nest boxes. We should also fit them into the forest to increase the number of hole sites for squirrels and other forest animals, but particularly for the birds. Probably the reason there are so few birds in the forest is the lack of good nest sites. If we analyze what birds we have, we might find out we are missing on many of the hole nesters. At least we can put those hollow logs up as nests and try them out. It is not much trouble to refit hollow logs. You have good books on bird nest boxes and critical entrance sizes, etc.

If you put your nest boxes out in the open, you are going to get sparrows. We are more interested in the birds that nest within the woods. Sparrows don't fly very far into the woods to nest. I think we should be selling these nest boxes. It always saddens me to see hollow logs burned, good sound hollow logs. You can leave some of them in the forest; you can leave them standing upright, and flat down, and they will get occupied all right. We could leave the few in there that are riddled with holes, and there are but a few of them. They are not going to take up much space.

Then we should look at three or four management strategies in the forest. First, we need to lay out the end uses of their products. We have a whole set of bark, leaf, oil, and medicine products within these forests. We should attempt a crude economic analysis of the end product values. We might be very sorry if we were reducing some of that material to charcoal. Nevertheless, we do have to heat presently with wood. The best way to do that, I figure, would be to build a dry distillation basement system. You load a container lined with brick, and you close it off. You light a fire underneath it. The wood inside can't combust, and your fire is still a twiggy fire. You steam everything out of it, all the juices, and it cooks. You cook that wood to charcoal, you bake it. Up come volumes of gas. Methane comes off. You can use 4% of your methane to pump the rest of it down to bottles, or you can pump it through a pipe into a gasometer. Then you pump the rest of the gasses along. Lime water will soak up the $CO_2$, so you run these gases out in the open air or through a pond, and that cools them, and out comes your creosote, etc. You are into other sorts of games from then on. You get methane out of methanol. That cools rapidly in water. You close it up in a steel drum and lock it in.

In the old method of making charcoal, they covered it with mud, and they didn't collect any gases. They wasted most of the biomass. All the gases went to air. The French used to brick up a double area, one that was for the fire, and the other cooked the timber in it.

This system would supply all the gas for cooking and a great hot mass down below the house with which to heat the living area. We can take any amount of hot water off that. We have creosote for painting and proofing our planks. We can turn a black or silver birch into a non-rot product by creosote soak. And we have methanol to run the tractor on. I would like to see somebody set it up. Perhaps we have the practical situation for it right here.

Inner zones need to be far more productive in human and animal forages. So we decide which of these elements we will build into the animal forage systems. That will determine which elements of the forest we will favor, and which we will weaken, and in what direction we will steer the forest. We should look closely at the forest around here for their high potential for increased forage for man and animal. Their value as windbreak is also desperately important. If we were to go on clearing the forests without replanting close-in, wind stress would cut productivity on site. So we must manage for close-in windbreak. We next manage for human and domestic species forages.

Let's look at white pine. If we close up an area with white birch and put white pine behind, it might create a micro-habitat for food production, because we have a reflective system. We might screen with white birch near gardens.

We should be managing this near section of the forest for greatly increased productivity within the center of the site. So what we are managing toward is those high forage-drop species, such as oak and cherry and apple. We remove selectively and we replant or encourage selectively. If we are managing that area for oak drop, we can also do it in such a way that we are looking forward to maybe very long term, occasional oak tree cut.

In a large design, you may be selecting four or five house sites. Some of those can be in the open and some in the forest. Where do we want the forester? We want him in the forest. The one who takes care of the livestock needs to be near to the barn. Break your house sites up according to the functions of the half dozen people living and working on the site. The administrator needs to be closer. You have gardeners; you have nurserymen; you have foresters. A large forested area should take five families in forest product. It does not mean you necessarily have to have five houses in the forest. Some people might come in to be foresters. Or they might be living in a group situation.

Out there in that further zone of forest, we start to break up secondary and tertiary uses. We might try a few structural forests in close, or a few bamboo clumps–bring them in. Maybe they are still working like those birches are for secondary reason of shelter. Out here we might find a place that is very promising for future plank timbers. We need a plank forest. These areas all have to be managed differently. Some of them are already progressing towards what we want. The uses for which we manage a forest should not conflict with further foraging of wild life.

Maybe in every area we will find a patch of forest that should really be for itself. We must always try to keep these places, because they are going to be doing things that may help us a lot out here, that may stop us from doing silly things out here later. We might be doing the wrong thing out here for the long term. Instead of taking out the trees for firewood, we might find that what the falling and rotting trees are doing in there is essential. So then we stop. These undisturbed areas can act as a control. Also, parts of the site really may be too dangerous to disturb, to constantly manage. You may find that these are very beautiful places. What do we want to bugger around in there for? We don't have to. We have a vast excess of this resource. We could leave some of it alone.

We have to decide what we can get out of the American forest, what are really valuable products. Our aims should be to leave as much of the biomass in the situation as possible, and to take out the smaller, highest value products. Seed is a good example. The forester here on this site should be a very busy person.

It is essential first to determine what the forest products are, then to look to what's happening in the market. What's the price of acetone? We know the value of some things, like methane. We don't have to worry about who is going to buy that. All our cooking gas is in that forest. Two technologies will extract it. One consists of composting the twigs, and the other is just good distillation technology. Both give us volumes of methane.

We must not forget that we have to trim our white oak to maximize its value, and therefore we are going to get trimmings. We have to use them somehow. We don't want a triangle of trimmings lying between the trees or all over the ground. That is a bad situation for fire. We can pile the brush into heaps. Brush piles are a good winter shelter for a whole host of animals. So also is your firewood, your cordwood, if left in the woods, not brought in. It will be full of lizards and salamanders. They live in this year's pile. The next year, you must build another pile for them.

While there are other potentialities in the woods, I think determining what they are is a job that should be tackled on site. There is a lot of work to be done here. The largest design problem in these wooded areas is the management problem.

One strategy for forest management now starting up in North Carolina sounds good to me. They assemble people who are in touch with the forest. They say, "OK, as an individual, I can't supply enough beech for this order, but as a group we can." They also, share tools and equipment.

Everybody is urging them to manage the forest to burn. We know this is true, for why else are they making all these stoves and things?

## Forests & The Atmosphere

I want to discuss briefly what the forest is doing to the atmosphere. I will start off with one statement: Whatever it's doing, it is very, very complicated. It is not simple.

Let's take wind–what the forest is doing to wind. Wind completely disappears in an effective forest within a thousand meters. The forest is swallowing it. It is absorbing the total force of even gale force winds within a thousand meters, except at the crown, where winds still continue to have some effect. I am not certain that we have an adequate explanation of what that energy becomes. I believe it may be wood. If we anchor the trees, the stem diameter remains constant, whereas if we move them, the stem diameter rapidly increases. So it may be that wind aids transpiration, or pumping, or cell production or something. Certainly, the energy of the wind is being converted within the forest to something; I'm not quite sure what. The forest is certainly using the wind, and I, for one, never heard any adequate explanation how that happens, nor have I seen anything written on it.

The forest forces 60% of the wind up. That starts a process. Now when the wind goes up, you get a high pressure on the windward side, and decreased evaporation, and at the same the face of the forest towards the wind catches a lot more rain than the other side. That is just simply observable. So it is wetter there. When the wind goes up, it does cause an increase in rainfall. The rainfall increases between 15% and 20%. That has been measured in Holland and Sweden. When we cut the forest, the actual rainfall in the region decreases in a set of figures lying between 10% and 30%.

Then there is a secondary effect. When forest forces wind up, it goes into sidewise spiraling, that causes belts of rain across the direction of the wind. Little patches of rain go on for several tree lengths past the trees, so that at intervals of five tree lengths rain increases in a belt transverse to the wind. So you get wet, dry, wet, dry past tree belts. The descending winds past the forest are warmer, less humid and turbulent, and often cause drying out. Some people think those pressure changes in the air have the greatest effect on soil moisture. It is a fact that the low pressure belt, produces higher evaporation, and occasionally a rain shower on the leeward side of the forest. The forest has other effects on the wind about which I will not go into detail, like reducing the wind, or warming the wind, and so on.

I doubt if you go a thousand feet within the forest you will experience any wind at all. As for a tree belt, if it is to be effective, we need to have about five trees wide, although a single belt at 40% penetrability has an effect as a wind break. When only about 40% of the wind passes through a tree belt, the wind diminishes rapidly within 100 to 200 meters. It becomes negligible. Around a plant stand, to the wind itself, I wouldn't trim. If you trim, it might cause a wind tunnel below the trees, which is a little miserable for animals. The idea of a hedge row is that it does come to the ground, or starts above the stone wall or something.

The wind carries dust, and it carries humidity. Without any rain, that is, on a foggy night with air moving into the forest it will, within a hundred meters, reduce the humidity in the air by about 50%. This is called positive interception. I believe this to be a major factor in all coastal forests, and on ridges within fifty miles of the coast. If we have air coming off the sea that is very humid, and particularly night air blowing into these forests, all you see is a constant dripping of moisture within the forest, even if there is no cloud in the sky.

That occurs in an individual garden. A lady named Marjorie Spear has a garden in which it rains constantly all night, every night, when it doesn't rain anywhere else in the district, where there are no trees to intercept this humid air. I think that what happens is that the air is relatively warm and leaves relatively cold. By the time the night winds strike the tree, the leaves are sensibly cool, and the moisture precipitates out rapidly on the myriad leaf surfaces. An individual tree has many acres of leaves. Moisture doesn't precipitate out on grasslands, except as dew. Yet, within the forest there are millions of gallons that come down. In Tasmania, up to 60% of our total precipitation is put down to this effect. Only 14% of that water falls as rain–trees catch 86%. Now we are a coastal island, a small island only a couple hundred miles across. Screens put up to imitate trees create high precipitation.

When you are cutting trees down, you won't notice the rain gauges over 15%, but you only have 14% of your moisture left. Now I think that is a critical factor for all coastal mountain ranges, for the first mountain inland from the coast. So that's what the forest is doing to the wind and to the humidity in the wind.

As for particles carried by the wind–and again, I'm talking about a hundred meters of forest–they are reduced sometimes to about a quarter of their previous occurrences in the air mass. We are talking about the dust and the other particles. Now as this may represent tons of particles, particularly if the winds have blown across soils and over industrially polluted areas, this means that the forest entraps much material. That leads me to suspect, and many people to state, that there is no shortage of any mineral or any element anywhere, because it is all on the move, particularly off seacoasts. It is being netted by the forests. It might be a slow process. Mineral might be used and fixed as fast as it is netted. But this really happens.

Conversely, when we come to organic particles–I am talking about pollens, bacteria, and some oil droplets that are being released by the forest–we get a reverse effect. What's happening is that the forests absorb tons of inorganic materials and release tons of organic materials. I was reading about the early voyagers approaching this continent in the Spring. Gigantic white pine forests grew here-. Up to 80 miles out in the Atlantic, pollen coated the decks of the vessels The voyagers thought it was sulfur. They talked of gigantic sulfurous rains. The whole sea was yellow with pollen. They thought there were volcanic eruptions ahead of them; they advanced with trepidation towards these shores, into these yellow skies. Imagine the biomass on the move there!

The organic particles are far more effective precipitation nuclei than the inorganic particles. We suspect that they are the important factors in atmospheric precipitation. So that is another effect of forests–they give off nuclei upon which raindrops condense. So while forests are taking inorganic particles out of the system, they are releasing organic particles that go on in the air stream and therefore are available for condensation of rain further inland. About 60% of inland rain falls from forest clouds, not sea clouds.

Let us not deceive ourselves. Clean air contains an awful lot of stuff. Just lying on your back with a good pair of binoculars will persuade you that there is a lot of matter on the move up there. Tying nets through it will persuade you more, and putting up little traps will persuade you even more. There is a lot happening up there. Forests are a big factor.

What else is the forest doing? We will move to rainfall. Rain falls on the sea, the land, and the forest. On the sea, it simply cycles back again. I don't know what its effects are. It probably has some effect on plankton production. On the land, where it falls on the forests, the canopy absorbs almost all its energy. A big energy transaction goes on right on the canopy. The mechanical energy is almost all absorbed. Within any reasonable size forest in leaf, even a violent thunderstorm doesn't come into the forest as anything but a fine mist. I am talking about tons of water and thousands of pounds of kinetic energy. This just dissipates in the crown. This has a couple of obvious effects. This water never hits the Earth, so any erosion from that pelting rain, which is an enormous force, just doesn't happen within forests. The crown absorbs that energy. Then, if the rain is light, no water reaches the ground. It is quite possible in light rain for the top of the forest to absorb the total rainfall. That is easily seen on roads. In a reasonable light rain, under the trees the roads are dry. That water never does get to the ground, and is evaporated off the crown. That causes a profound cooling effect. Energy transactions of all sorts are taking place on the crown of trees. There is frictional slowing; there is impact absorption; the winds are being tangled and stopped; and this rain is being evaporated. So many energy transactions go on up there.

These transactions aren't going on very much below the crown; therefore the amount of energy being absorbed and dissipated on the Earth's surface is much less under forests. You get very little erosion in forest. If it rains modestly or heavily, the crown becomes saturated and water comes on down in a whole variety of ways. Some trees funnel water down the bark channels. Ten or 20 times the actual amount of rainfall will run down just around the stem. Other trees pass it down around the crown itself, as a circular rainfall. In a mixed forest, rain falls every which way–some dripping outward, some running down under the branches, some funneling down the crevices of the trees. I just went into your forest the other day when it was snowing, and every tree was intercepting snow in a totally different fashion. The crystalline structure of snow and the shape it meets interact.

Let us think for a minute about something else. Eighty-six percent of the mass of that forest is water. Ninety-six percent of its leaves and twigs are water. That is an enormous weight on the Earth. That is a lot of water. It is an Earth load of tremendous mass. Really, the forest is a whole lot of vertical tanks. Some of them are very big tanks. I believe that we can load and unload the crust of the Earth in such a way that it will cause Earth movements. We know that quite modest dams will cause local earthquakes. We failed to see the forest as the enormous water mass that it is. I think if you want the continents to rise and fall and fracture and bugger around, then you can accomplish it by unloading the land of its forests. Play around with this water mass enough, and you will get it to happen. I think we unloaded a huge weight off continents when we removed our forests. I think we are dealing with more weight here than anybody has ever acknowledged or tried to measure.

Branches will break off trees, either in fierce gales, or at other times on very dead, still, humid nights. When the trees can't transpire, the enormous weight of the leaf water just smashes the branches down. That is the time not to be in the forest–on still, misty nights. With no warning, just bang! Crash! Big branches fall on those nights. The trees can't support their own weight, any more than they can support the weight of fruit. Fruit is 96% water.

So a forest also sponges-up this water. But not always, I feel, through its roots. Much of it enters the tree through its leaves. There is a tremendous direct leaf absorption of moisture and of substances in solution. So it isn't just the roots that are at work taking in nutrient; it is also the leaves. The leaves also manufacture these nutrients as they pass inward into the tree. So the forest builds a lot of water into its mass.

The rest of the water, not absorbed by the trees, gets down to the ground. Here the litter and humus of the forest floor await it. No more water seeps down until the floor fully charges. That represents quite another mass of water. There may be six inches to a foot of water held in the landscape, but nothing moves the floor saturates. Then the water seeps into the mineral soils below the humus soils. Even down there, every foot of soil will hold an inch of rain. So if you have 30 inches of dirt, then a 3-inch rainfall won't move at all out of that forest situation. In between interception, Oabsorption, the humus absorption and three feet of dirt, no water moves. Nothing is flowing. Thirty inches is minimal. Sometimes up to 60 inches of rain will be held because we have good deep dirt. It percolates so easily because it follows old root traces. Forest soils are totally bored out by old roots that have rotted out. They form all sorts of conduits to deeper levels of soils. Within the forests we don't get any significant evaporation of this through-fall of water. We are not going to lose much of this water through evaporation.

Let us look at the soil below the forest. First, the particles absorb all they can. Then water bonds tightly with each little particle. Clay, particularly, binds water very tightly. This surface tension effect comes into operation. Now when that has happened, the spaces between the particles, in which this effect doesn't occur, also will fill with water, and that water will start to percolate down. On it goes downward. Two fates await it. It can transpire, and the trees can bring it back out of the reservoir and into the air again, thus recharging the air with humidity. That air blows onward. Now that is a very fast effect. Even a modest line of trees up on a desert causes some rain downward. Trees transpire ground water most on hot days. This heavy evaporative transpiration increases the humidity of the region. When night falls, this may reprecipitate downwind. Water is flung in all directions. It is stopped and stored.

Then, when this system is full and when there is any slope, and there is always slope, some water may start to run off. On the floor of the forest, there is no such thing as a straight run-off system. Twigs and leaves and debris accumulate in immense amounts. Therefore, water persists longer in the landscape. Run-off is very, very slow in forests. If you follow a trickle, it performs some weird convolutions getting through the forest. It meets fallen logs, trunks, leaves, leaves that bank up and turn it. These impediments repeatedly halt the water. Its time on landscape is great through a forest as compared to the open, where it just goes whist! In the forest, it is impeded and impeded and impeded. In the open, the water runs off, and the rivers rise.

If you want to increase run-off into catchment, cut the forest, and for a very short term your reservoir fills faster with every rain. So the engineers reason, "Let's cut the forest to increase the run-off." They actually diminish the rainfall, drop the total water falling on the whole area to roughly 70% of what it was before.

Evaporation does not occur from the soil surface below the forest, because it is the roots deep down below that draw the water in and take it back up. The travel direction of water entering the forest is always downwards, and only upward as pure water that releases to the atmosphere. In a forest, water never travels upward again to the surface of the soil for evaporation. We therefore get no salting, no upward migration of salts to the soil of the forest. Then the water that was further down enters shattered rock and deep leads, maybe old buried river beds, and finds its way out into the streams.

As salts come up into the trees as essential nutrients, they are fixed in the forest. After you cut the forest, even if the streams continue to run clear, they contain enormous amounts of dissolved salts. We may be getting more tonnage running off cut-over forest land as dissolved salts than we get in actual silts. We have measured that in Tasmania. Tons of essential material, particularly calcium, washes from the forest when it has been cut. The forests were holding all of these minerals. They collected them, held them, turned them round and round and round in its usage. When you cut the forest, and there is nothing to hold them, these minerals go into the runoff. They go into the streams and flow to the sea. Much work unravels there, because the forest only slowly accumulated that calcium.

Now the other thing that the forest does to precipitation is that it catches snow and brings it to rest within the forest. The difference in melt period between snow outside and inside the forest is quite large. A forest probably delays melt at least a month. So really what the forest is doing is taking all the winter's precipitation that accumulated as snow and ice, holding it, and releasing it at a much slower rate over a longer period than would be the case without that forest. If we have just pastures and open ground, that winter snow will melt extremely quickly, and cause sudden flooding.

What does the forest do to sunlight? The forest enters into energy transactions with light. We can't treat any tree, or any forest as a mass. It is a collection of individuals that do individual things to light. One obvious interaction resulting in energy exchanges occurs with sumacs. Look at the sumac. A light wind blows on a sunny day. The sumac turns from an absorber into a reflector. Suddenly its whole light-energy balance changes. It uses one energy to change its effect on another energy. It is in constant energy balancing.

I believe that trees have two or three methods by which they govern their energy intakes. One would be used by the aspen. The aspen is doing something with the wind on an energy basis, and when it's not doing it with the wind, it has an orientation basis that it is doing something with the sun. The ivy are certainly doing something with the orientation surface to sunlight all the time. They are governing to a constant. Other trees have shiny underleaves with matte-covered top leaves, and they do a trade-off, a wind trade-off.

In some forests in Tasmania, we cannot measure light in depths of the forest. There is total light interception. You don't have those forests here, but we have them. You can descend into the blackest midnight in the forests. You have to take torches down there in brilliant daylight. In Tasmania, you can go down 200 feet into some of these valleys and there is no measurable light down there. The forest totally intercepts ultra violet and passes through more of the red light, so that you have a different quality of light within the forest. Dark trees become radiators. The birches are reflectors. In the reflector species, the tree itself doesn't get much heat. In some species the tree becomes the heat store, and the heat storage system. It is 86% water heat storage. Even on very bitter nights in Tasmania, where we have thick forests above, we get a warm downdraft. What is happening is that the cold air is entering the upper parts of the forest, and there is a slow down-draft, and it is a slow down-draft through thousands of enormous water storages that have been absorbing heat all day.

Some of these mechanisms are so effective that a relatively small plant in an office deals with all the carbon dioxide problems in that office, and many of the carbon monoxide problems as well. We just need to know a lot more about this, because it is absolutely certain that, if we knew more about it, we could completely change the atmosphere of some of these buildings very favorably in terms of energy balances, and particularly in terms of health of the occupants. I suspect that we need to find out a lot more about what happens within the solar glass house, and that information is going to have a fairly beneficial effect on us.

The quality of air moving through the forests changes. The amount of negative ions increases sharply in the air stream, and most of the gases that are obnoxious to us are absorbed very efficiently. Negative ions are also excellent precipitator, which might account for the fact that much of the dust disappears in forests. There is nothing like a negative ion environment to cause clumping and precipitation. Negative ions will take cigarette smoke out of the air very efficiently in quite a large room. So will a small amount of trees.

Again, it is an error to suppose the forest stops at the soil surface. It doesn't. At least 40% of its mass is below the surface. So probably many of the figures we have thrown in here are in any case wrong because none of them are applying to the root. When a forester talks about the weight of a forest on Earth, he probably is not giving us the weight of a tree plus its roots. They estimate 5,000 cubic feet of wood in this tree, therefore 4,600 cubic feet of water. I believe they forgot the roots. Those roots are enormous storage organs. They are busy at work doing other things in the soil. We need to know what those roots are doing. We know they are on the move. They throw up whole masses towards the surface and pull them back, while they throw others down. They do it all seasonally. They live and die within the soil, leaving all sorts of channels and pathways open, which is going to greatly affect water. What's going on within those roots? Once we get below the top of the ground, we are in a whole new mystery zone. Certainly tree roots are breaking down primary rock material.

For all these reasons, and many that I haven't mentioned, because I consider them to be far too complex, forests are really worthwhile to just leave in place and really have a good look at, because mankind has never studied these forests. It wasn't until the 1950's that anybody I know of looked back through the rainfall records, and cutting record, and started to do some of the sums.

I will give you a statement that I am certain about: By the removal of ridge forests alone, we can produce deserts in any climate. By the removal of forests alone, we can remove soils. Now I am certain that the removal of the forest has been the main cause of the collapse of nations. Because when the forests go they just haven't the water, the soil, or the climate quality to sustain human life thereafter. So maybe we had better start to prize the forests a bit and to discover, not how to live without them, but how to live with them.

Before I leave, I want to say a little more about tree establishment. We have already talked a little bit about the nursery.

It may be necessary, particularly in sandy soils, to add basic nutrients. This may be necessary on acid soils and on alkaline soils. Sometimes it pays to use a little bit of superphosphate in sands and dunes. Zinc, iron, and most minerals are locked up by high calcium, and you won't get many tree species going unless you have a little bit of assistance.

I think the question of manuring trees has been taken very seriously by the forestry commissions. They are getting three and four times the growth rates from trees with one handful of superphosphate in sand. But additional superphosphate doesn't do any good at all, as usual.

**Teaspoons & Butter Knives**

Two old ladies north of Sydney evolved a system for reestablishing native forest in a national park on an area widely overrun by introduced exotic weeds and things. In short, the method they pursued was this: Given a very large area in which you want to change the nature of the forest, do it as a set of nuclei that are densely planted. Don't try to do it as a scatter of individual plants. This is really extremely important. Plant a small area, maybe half the size of this room, densely and close it out, weed out anything you don't want and turn the roots up, patch up the soil where you disturb it somehow with mulch and rally tightly established nuclei in defined areas. The placing of individual elements really isn't going to get you anywhere, or it is going to get you somewhere very, very slowly. When you put in nuclei and work from the perimeter of the nuclei, it is amazing how fast you can change the situation. What happens is your ecology, or whatever it is, helps itself, because your assembly is an entire one. I think it is more important to do this than to do anything else. That is something that if we fail to do it, we will fail.

There is one class of trees for which we need to compile a list. They are the trees that will stand alone in grassland or hostile areas. They are pioneer trees. It will pay you to just stop and look at pioneer species wherever you are, and just pop them down on your list, because they all have a set of characteristics in common. They don't mind grass competition. They are very hardy. They are drought resistant. They change the nature of the soil towards forest soils. These trees range from acacias–of which there are hundreds, and they are all nitrogen fixers–to western and eastern red cedars.

If you have good pioneer species suitable to a site that people eventually want to change into a forest, run over it with pioneers while they are thinking about it. Then they can go into whatever they want from there, cutting down the pioneer species as a manurial crop for their forest.

There is nothing wrong with western red cedar and eastern red cedar as a crop either. They are both useful as a crop while pioneering and reducing other competitors before forest establishment.

You have to do this to defeat grasslands. Then you may start your multinuclei approach. To get things back to a previous situation, on land that has been invaded, you do precisely the same. You start with the little groups of natives that remain, and get them in there to throw out exotics. Mend your holes with mulch, or with another plant that is native, and work outward from that.

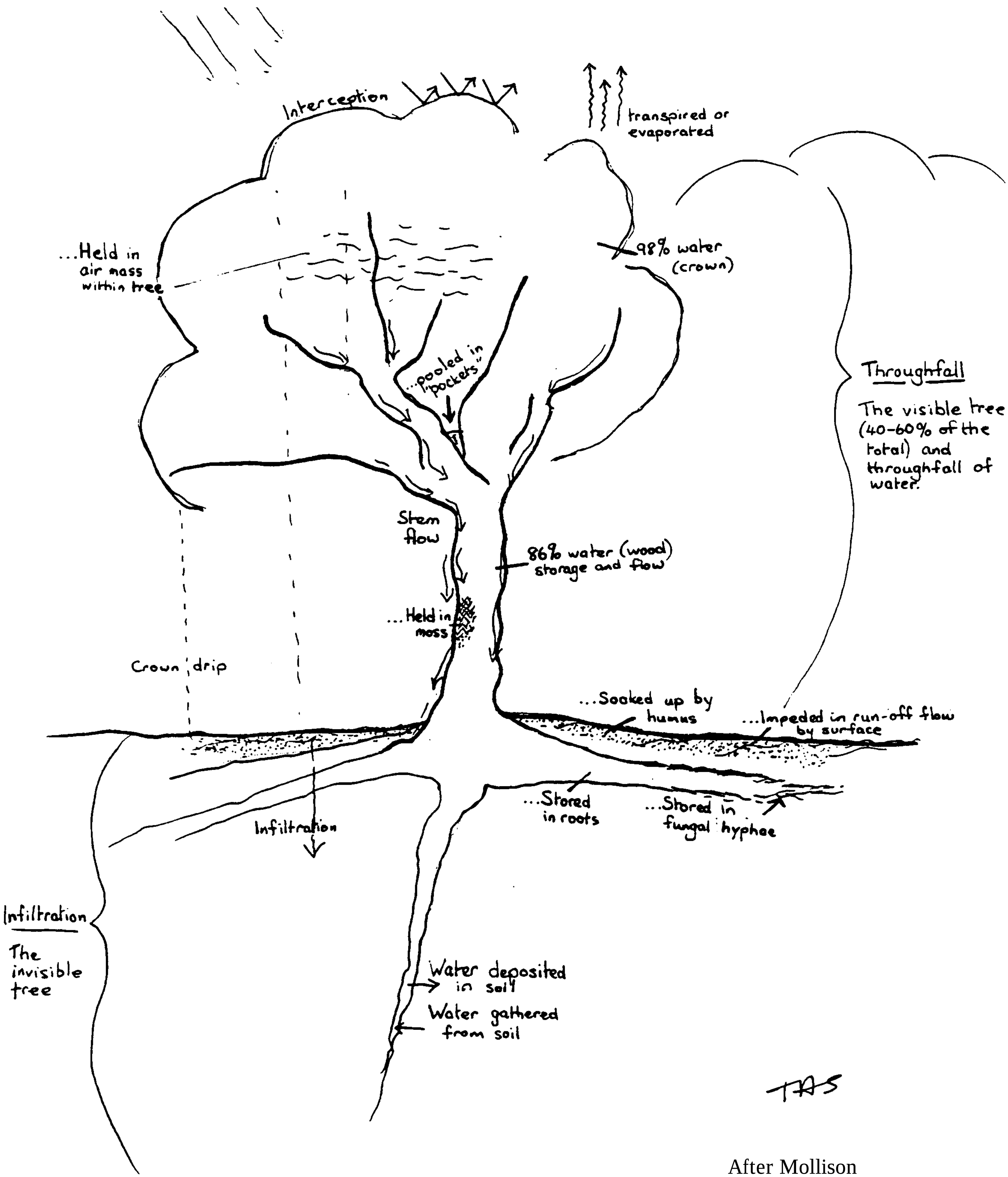
Those two old ladies, using only spoons–two spoons and a couple of blunt table knives–re-established some 1,500 acres of native Australian bush in a badly managed forest. When they started, they were about 68 years old. They finished when they were 75. They wrote a little pamphlet about what they had done. They said, "Begin where most of the things are that you want. Then go in there with little knives and spoons and take out all the strangers. Encourage the others, and just patch up the damage." They did minimal damage and just kept rolling the edges out, and I am told that it is really a remarkable area now that it is free of exotics–tall groves. It is north of Sydney in one of the parks.

Basically, this is also an approach used by Marjorie Spear, another woman past 80, though she did the opposite thing. She took a degraded and smashed-up native forest, really smashed it up, and expanded a totally exotic food forest into it in precisely the same way, by setting up a whole set of small, very densely planted nuclei, and taking the edges on out.

If you forget this particular point, you will scatter your resources, and many of your species will perish because they haven't their associates with them.

In sand wastes, we have been using the technique of burying all metallic domestic wastes, mulching, and then planting the perimeter. It seems to be working OK. You get gradual release of iron and zinc from old cans. Just fill a sand hole with this junk, layer it with humus, because it is not available unless there is humic acid, and then plant around it. I have many plants down in that sort of situation now, but I haven't been back lately. In soils, it is often a pH adjustment that is wrong, rather than an absolutely missing element, except in sands, where you are likely to have missing elements.

Righto! We have finished forests.




After Mollison