THE
PERMACULTURE ACTIVIST

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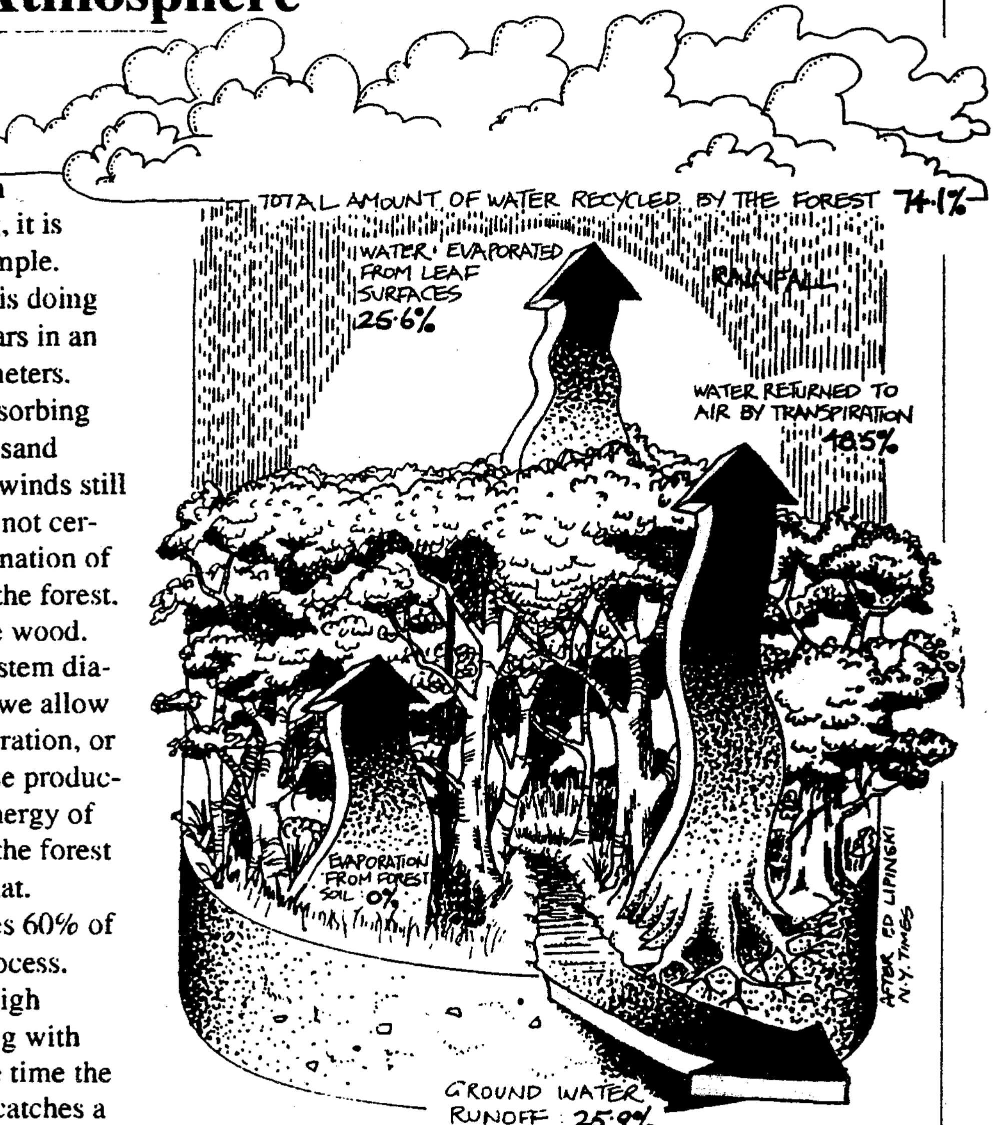
Forests and the Atmosphere

Bill Mollison



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 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 .t that energy is converted to in the forest. But I do believe it may very well be wood. Because if we anchor the trees, the stem diameter remains constant, whereas if we allow them to move, the wind aids transpiration, or pumping, or cell growth, or cellulose 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 intercepting wind forces 60% of the windstream up. That starts a process. When the wind goes up, you get a high pressure on the windward side, along with decreased evaporation. At the same time the face of the forest towards the wind catches a lot more rain than the other side. When the wind goes up, it causes an increase in rainfall of 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%. So certainly the forests result eater precipitation.

nen there is a secondary effect. When the wind is forced up by the forest, it goes into sideways spiraling, and 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 every five tree lengths you get increased rain 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. It is the opinion of some that it is pressure changes in the air which have the greatest effect on soil moisture. It is a fact that the variation

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of pressure, the high and low pressure belt, produces higher evaporation, and occasionally a rain shower on the leeward side. But we find it is a real dry place on the leeward side of the forest. The forest has other effects, like reducing the wind, or warming the wind, and so on.

Notice how the forest stops the wind. If you go a thousand feet into the forest I doubt you will experience any wind at all. A tree belt for wind shelter, if it is to be effective, must be about five rows wide, although a single belt of trees at 40% penetrability does have some effect. Passing through a proper tree belt, wind falls off very rapidly within 100 to 200 meters. It drops to a negligible amount. I wouldn't ever trim to the windward side of a tree belt. If you trim, you might create a wind tunnel below the trees, which is a little miserable for animals. The idea of a hedge row is that it comes to the ground, or starts above the stone wall, but in either case leaves no gaps.

Positive Interception

The wind carries dust, and it carries humidity. The forest influences both of these. Without any rain, but on a foggy night, as air moves into it, the forest 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. When air coming off the sea is very humid, particularly night air blowing into coastal forests, all you see is a constant dripping of moisture within the forest, even if there is no cloud in the sky.

That same effect can occur in an individual garden. A lady I know, named Marjorie Spear, has a garden with trees in which it rains constantly all night, every night, at times when it doesn't rain anywhere else in the district. Elsewhere there are no trees to intercept this humid air. I think what happens is that the air is relatively warm and the leaves relatively cold. By the time the night wind strikes the trees, their leaves are sensibly cool, and moisture then precipitates rapidly on the myriad leaf surfaces. An individual tree has many acres of leaves.

This same effect isn't occuring in other areas. Moisture doesn't precipitate on grasslands, except as dew. Yet within the forest millions of gallons come down. In Tasmania, up to 60% of our total precipitation is put down to this effect. And 14% of that water falls as rain. 86% is caught on the trees. We are a coastal island, a small island only a couple hundred miles across. But if we put up screens to imitate trees, we can create high precipitation.

When you are cutting trees down, you won't notice the rain gauges falling more than 15%, but you only have 14% of your moisture left. I think positive interception is a critical factor for all coastal mountain ranges, and for the first mountain range inland from the coast. We must remember that forests are pulling a lot of water down out of the air.

Dust and other particles carried into the forest by the wind, are reduced within 100 meters to about a quarter of their previous occurrence in the air mass. This may represent tonnages of particles, particularly if the winds have been travelling across soils and over industrially polluted areas. The forests are entrapping a lot of material, and that leads me to suspect, and a lot of people to state, that there is no shortage of any mineral or any element anywhere, because, in effect, it is all on the move, particularly off seacoasts, and it is being netted b[y] the forests. Now it might be a slow process, and it might be use[d] and fixed as fast as it is netted, b[ut] this is really happening.

Conversely, when we come to organic particles—I am talking about pollens, bacteria, and som[e] oil droplets that are being releas[ed] by the forest—we get a reverse effect. The forests are absorbin[g] tonnages of inorganic materials and releasing tonnages of organ[ic] materials. I have read of how t[he] early voyagers sailed towards t[he] continent (N. America) in the spring. At the time there were gigantic white pine forests here. Up to eighty miles out in the Atlantic, the decks of the vesse[ls] were coated with pollen, and t[hey] thought it was sulphur, and the[y] talked of gigantic sulphurous rains, and the whole sea was yellow with pollen. They thou[ght] there were volcanic eruptions ahead of them; they advanced with trepidation towards these shores, into these yellow skie[s]. Imagine the biomass on the m[ove] there!

Precipitation

We know that organic parti[cles] are far more effective precipi[tation] nuclei than inorganic particle[s]. And we suspect that they are important factors in atmosph[eric] precipitation. That points to another effect of the forests- give off organic nuclei upon which raindrops condense. while forests are taking inor[ganic] particles out of the airstrean[m] fixing them within the fores[t] system, they are releasing o[rganic] particles which go on in the airstream and therefore are [avail]able for condensation of ra[in] further inland. About 60% [of] inland rain falls from fores[t] clouds, not sea clouds.

Let us not deceive oursel[ves]

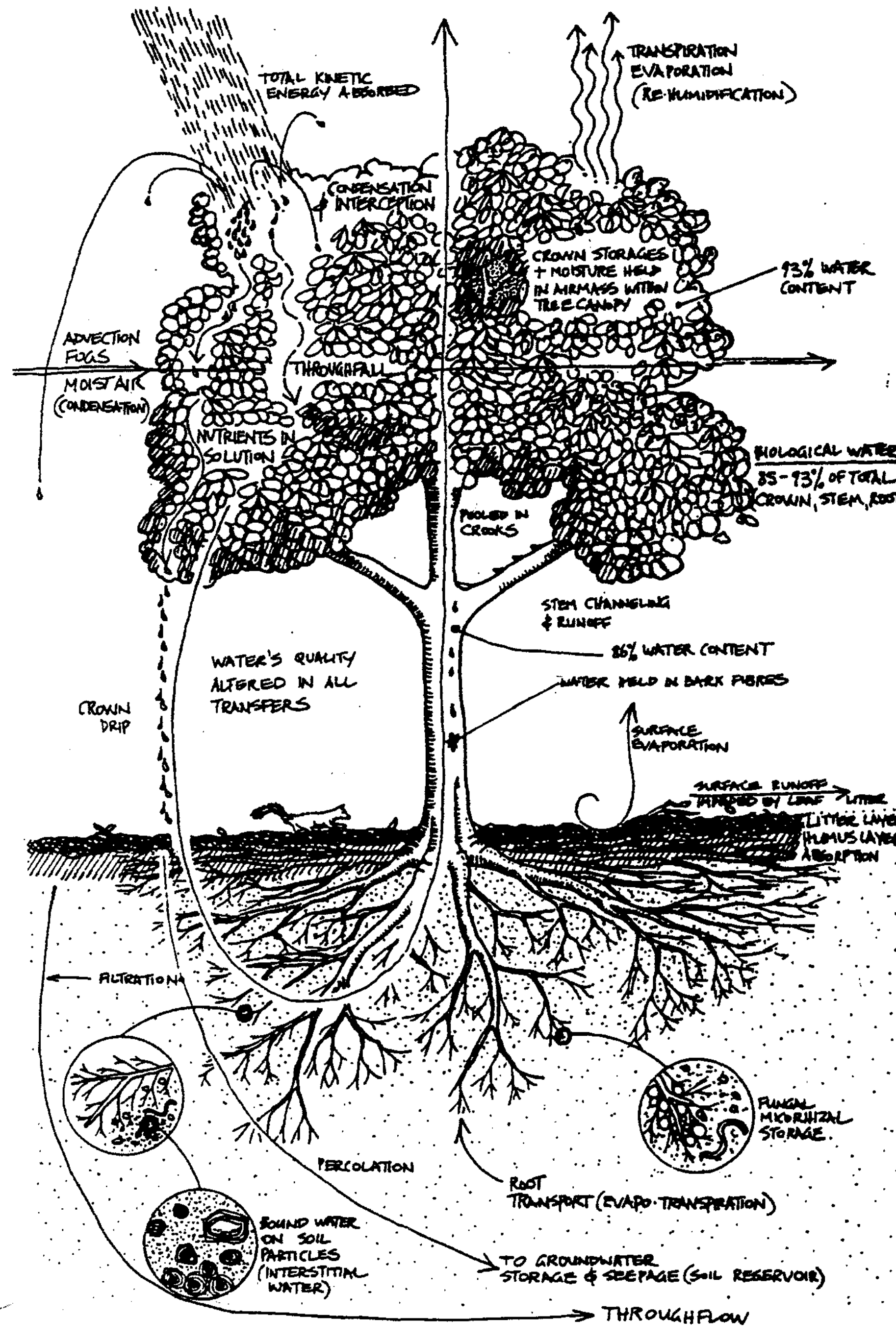
clear air contains an awful lot of stuff. Just lying on your back with a good pair of binoculars will persuade you that there is a lot of matter on the move up there. And tying nets through it will persuade you more, and putting up little traps will persuade you even more. There is a lot happening up there. Forests are a big factor.

Dispersing and Absorbing

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 surface plankton production. On the land, where it falls on the forests, almost all the mechanical energy of falling rain is absorbed on the canopy. Big 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 rain is being evaporated. Within any sizeable forest in leaf, even a violent thunderstorm won't come through as anything but a fine mist. Tons of water and thousands of pounds of kinetic energy are just dissipated in the crown.

These transactions aren't going on very much below the crown; the amount of energy being absorbed and dissipated on the earth's surface is much less under forests. Erosion from pelting rain, which is an enormous force, just doesn't happen within forests. The crown absorbs that energy. If the rain is light, no water at all may reach the ground. It is quite possible for the top of the forest to absorb the total rainfall. That is easily seen in a light rain—under trees the roads are dry. The rain never gets to the ground, but is evaporated off the crown, causing a profound cooling effect.

If it rains modestly or heavily,



HOW A TREE INTERACTS WITH RAIN

illustration by Andrew Jeeves

the crown becomes saturated and water comes down in a whole variety of ways. Some trees funnel water down the bark channels. Ten or twenty 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 is coming down every which way—some dripping outward, some running down under the branches, some funneling down the crevices of the trees.

The other thing the forest does

to precipitation is that it catches snow and brings it to rest within the forest. I have been in forests when it was snowing, and every tree was intercepting snow in a totally different fashion. There is an interaction between the crystalline structure of snow and the shapes it is encountering.

The difference in melt period between snow outside and inside the forest is quite phenomenal. A forest probably delays melt at least a month. The forest is taking all the winter's precipitation that has 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. It is the same as with rain. But the rain does come on down and enters the soil within hours. If we have just pastures and open ground, that winter snow will melt extremely quickly, and cause sudden flooding.

Water Storage

Let us look at the water stored within the forest. 86% of the mass of that forest is water. 96% of its leaves and twigs are water. Really the forest can be seen as a whole lot of vertical water tanks. That is an enormous weight on the earth. 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. But we have failed to see the forest as the enormous mass that, in fact, it is. 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 water weight, any more than they can support the weight of fruit. Fruit is 96% water.

A forest is also sponging this water up. But not, I feel, only through its roots. A lot of it is entering the tree through the leaves. Leaves absorb directly a tremendous amount of moisture and also substances in solution. It isn't just the roots that are at work taking in nutrient; it is also the leaves. And the leaves, in addition, are manufacturing and passing along nutrients to the tree. So the forest builds a lot of water into its mass.

The rest of the water, not evaporated or absorbed by the leaves, gets down to the ground. Here the litter and humus of the forest floor awaits it; no water is transmitted downward until that is fully charged. There may be six inches to a foot of water held in the forest litter, and nothing moves until it is fully charged. Then the water goes down 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 30-inch rainfall won't move at all out of that forest situation. Between interception, absorption, the humus absorption, and three feet of dirt, no water moves. Nothing is flowing. Thirty inches is minimal. Sometimes up to sixty inches of rain will be held because we have good deep dirt.

Subsoil Effects

The reason why it percolates so easily is that a lot of it is following old root traces. Forest soils are totally bored out by old roots which have rotted away. These form all sorts of conduits to deeper levels of soils.

Let us look at the soil below th forest. First, the particles absorb all they can. Then water is bonded tightly by surface tensio onto each little particle. (Clay, because of its minute particle siz binds water very tightly.) When that has happened, the spaces between the particles, in which this effect doesn't occur, also fil with water, and that water will start to percolate down. The wa that was interstitial, not bound, goes on further down and enters shattered rock and what we call deep leads, maybe old buried ri beds, and finds its way out into the streams.

As water flows down into this subsoil reservoir, two fates awa it. In the first case, the subsoil water can transpire. The trees bring it out of the soil reservoir and into the atmosphere, rechar ing the air with humidity. That a very fast effect. Even a mod line of trees up on a desert ridg causes some rain downwind. T is because ground water is bein brought up on hot days. Heavy evaporative transpiration is increasing the humidity of the region. When night falls, this re-precipitate downwind. A hu amount of action is going on there. Water is being flung in directions. Secondly, the dow flowing water is stopped and stored.

Runoff

When the soil reservoir is fu and where there is any slope, there is always slope, some w may start to run off. But on tl floor of the forest there is no s thing as a straight run-off syst There are twigs and leaves an debris in immense amounts. you follow a trickle, it perfor some weird convolutions gett through the forest. It meets u

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with fallen logs, trunks, and leaves that are banking up and turning it again. These impedances keep on halting the water, and its time on landscape is great

Run-off is very slow in forests as compared with out in 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 quicker with every rain. So the engineers reason, "Let's cut the forest to increase the runoff." What they actually do is 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 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 transpired from the leaves. 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.

Mineral Cycles

These mineral salts are instead taken up into the trees as essential nutrients; they are fixed in the forest. After you cut the forest down, what happens is that, even if the streams continue to run clear, they will contain enormous quantities of dissolved salts. We may be getting more tonnage running off cut-over forest land as dissolved salts than we get as actual silts. We have measured that in Tasmania. Just tons of essential material, particularly calcium, is being washed out of the forest when the trees are cut. The forests were holding all these minerals. They collected them, held them, and turned them round and round and round in usage. When you cut the forest, and there is nothing to hold these minerals, they run-off into the streams and flow to the sea. A lot of work is undone there, because some of that calcium was slow to accumulate in the forest.

Light

Finally, let us ask, 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 swap-offs 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 basically doing something with wind energy, and when it's not doing it with the wind, it is doing something with the sun. Ivy, on the other hand, are certainly doing something with the orientation of leaf surface to sunlight all the time. They are governing to a constant. Other trees have shiny underleaves and mat-covered top leaves, and they do a wind-light trade-off.

There are forests in Tasmania in the depths of which we cannot measure light. You can go down two hundred feet into some of these valleys and there is no measurable light because the forest is intercepting all of it. You don't have those forests here (in New England), but we have them. You can descend into the blackest midnight in those forests. You have to take torches down there in brilliant daylight. Because the forest completely intercepts ultraviolet light and passes through more of the red light, 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. But in some species the tree becomes the heat store, and what a heat storage system! It is 86% water heat storage. And even on real bitter nights in Tasmania, where we have thick forest above, we get a warm down-draft through thousands of enormous water storages which have been absorbing heat all day.

The quality of air moving through forests changes. The amount of negative ions increases sharply in the air stream, and most of the gases which are obnoxious to us are absorbed very efficiently. Negative ions are also excellent precipitators, which might account for the fact that a lot of the dust disappears in forests.

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. When a forester talks about the weight of a forest on the earth, he probably is not giving us the weight of a tree plus its roots. They say '5,000 cubic feet of wood in this tree, therefore 4,600 cubic feet of water'. And I believe they forgot about the roots. Those roots down there are enormous storage organs. And they are busy at work doing other things in the soil. We know they are on the move. They throw up whole masses towards the surface and pull them back while they throw others down. And they do it all seasonally. What they are actually doing is living and dying in the soil, leaving all sorts of channels and pathways open, which is going to have a lot of effect on 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.

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

This 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, I am certain that the removal of forests has been the main cause of the collapse of nations. Because when the forests are gone they just haven't got the water, the soil, or the climatic quality to sustain human life thereafter. 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.

Bill Mollison is the Executive Director of the Permaculture Institute at Tyalgum, N.S.W., Australia. A prolific teacher, biogeographer, and renowned storyteller, he is the author of Permaculture I (with David Holmgren), Permaculture II , and Permaculture: A Designers' Manual . This article is adapted from lectures given in 1981 at Wilton, New Hampshire. "Forests in Permaculture", is one of a series of pamphlets published by Yankee Permaculture based on the transcripts of Mollison's Permaculture Design Course. It and others in the series are available from Yankee Permaculture, PO Box 16683, Wichita, KS 67216 USA.

Managing Forests for Biomass Accumulation

Michael Pilarski

Friends of the Trees calculates that we need to double the number of trees on the planet to optimize earth climate for human habitation. This would adjust the carbon and oxygen cycles on the planet, which are now severely disrupted through worldwide deforestation and fossil fuel use and abuse. Almost everyone laments the destruction of the Amazon rainforest. Less well publicized is the fact that forest destruction rates in the Pacific Northwest and British Columbia are as severe as in Amazonia.

It is imperative that humans manage ecosystems to maximize carbon tie-up in biomass (organic material—dead and alive). We need a forestry that preserves biomass in the forest even during logging operations. Old-growth forests in the Pacific Northwest have been measured to have more tons of biomass per acre than any other ecosystem on the planet. Present clearcutting methods dramatically churns up the soil. The biggest trees are hauled away and the slash and site burnt. This effectively releases most of the carbon stored in the system into the atmosphere. We need minimum impact logging practices, uneven-aged (stands) management, selective cutting, and maintenance of productive forests for high content of down dead logs, snags, and humus. The examples of this type of forestry are rare in the Northwest, but there are some. It is possible to achieve productivity and sustainability at the same time. In fact, non-sustainable practices can never lead to long-term productivity.

Friends of the Trees Society believes that all remaining old-growth forests in the world should be allowed to evolve as they will. There is precious little left. The Pacific Northwest is fortunate to be one of the places with some old-growth left. Clearcutting as a forest practice should be banned.