WATER IN PERMACULTURE

BY BILL MOLLISON

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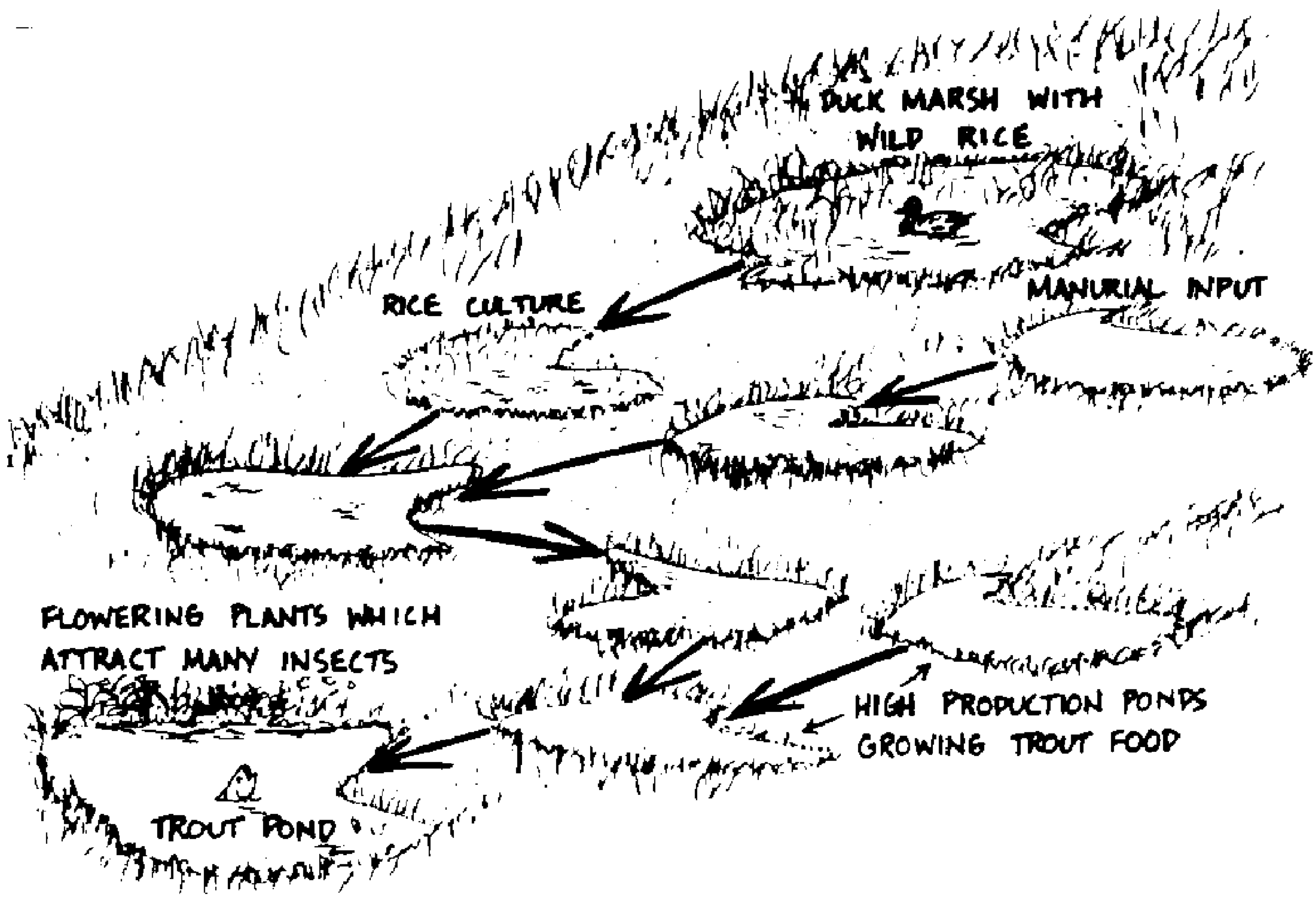


WATER IN PERMACULTURE

Almost all of the water on the earth is not moving. It is in the oceans or it is in the ice caps. I think 75% of all fresh water is unavailable. Of that fresh water in the world, there are only tiny amounts in lakes, ponds, soils, rivers and in the atmosphere. In total, less than 1% of that water moves. That's the amount that we have to work with.

The world mean average rainfall is 33.8 inches. Of the atmospheric water, 77% falls on the oceans, 23% on the land. Of the 23% falling on the land, 16 parts transpire or evaporate, leaving seven parts to run off and end in the ocean. Of the 7% runoff, 84% goes into the ocean and returns to the cycle.

The land, in addition to the rainfall, gets seven parts of its water from horizontal advection. That is where forests intervene.

This is a very simplified, generally accepted sort of model. The one real application we can make locally is in providing surface storage and soil storage of water. If we establish forests, we store a lot of water in the forests, too.

We can't do much about the rivers; and we can't do much about the atmospheric water. But, to me, it is clear that most of the world needs much more surface storage at greater heights than usual, not just in the low valleys. We need to reduce runoff. We can store water in soils that have been treated with the Wallace plow, and by constructing swales. Throughout urban areas, swales seem very appropriate.

It is the water available to us that decides what sort of plants we grow. While the average is 34 inches of rainfall, such figures are really meaningless, particularly during a plant's establishment. We must buffer extremes, particularly those drought extremes that seem to be happening more and more.

It is simply no good recommending plants to people, or designing orchards, unless you have cared for the water supply. Give them the ability to water at least twice in the summer. You must make absolutely certain that you have designed water storage so they can get water–either off site, somehow, or on the site–in the plant's establishment phases.

Seaweed and seaweed concentrates do a lot for water storage, working as jell in the soils. In the very dry soils, you can recommend the use of dried seaweed, powders and seaweed concentrates, to greatly assist water storage and plant resistance to wilt. Basically, it works on the surface film itself.

In our previous discussions of water storage, including the keyline system, we simply regarded it as reserve water supply. While in most places, ponds are made for cattle and stock watering, we design the water storages in themselves as highly productive systems.

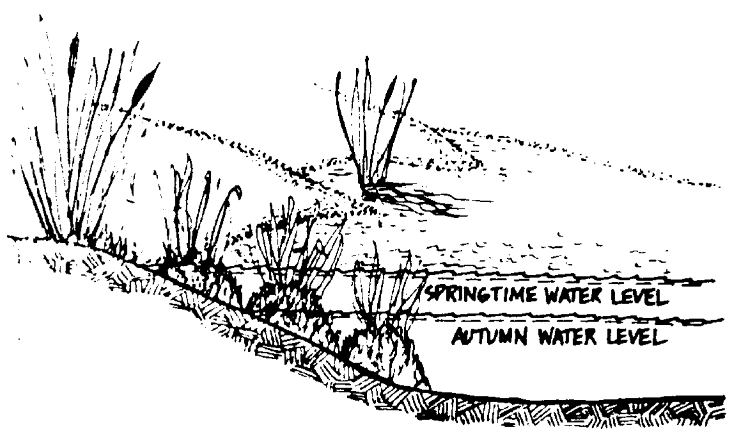
We can get books on fish culture, but there are very few, if any, books on plant aquaculture. Do you know of any? Plants that grow in water are just a neglected part of aquaculture. Yet, as on land, we are going to get more yield out of those plants than we get from animals.

The water level of lakes and ponds changes from summer to winter, furnishing a variety of sites for aquatic plants that run from the water surface to rooted vegetation to marginal vegetation. Quite a few swamp trees can live here. In fact, they must not live more than 20 feet from the edge of water, yet never in the water. One of those is bamboo. Bamboos won't take sodden conditions. They live up on fairly well-drained soil, but they will send feeder roots down to water. Many such tree species grow well in wetland margins.

Within the water there are hummocks which are either exposed or not exposed. Many plants, like the bald cypress in Florida, live on hummocks or even develop hummocks. How they develop them, nobody is quite sure. Plants on these big bogs grow in little islands, too. The weight of the trees depresses the bog so that they become moated.

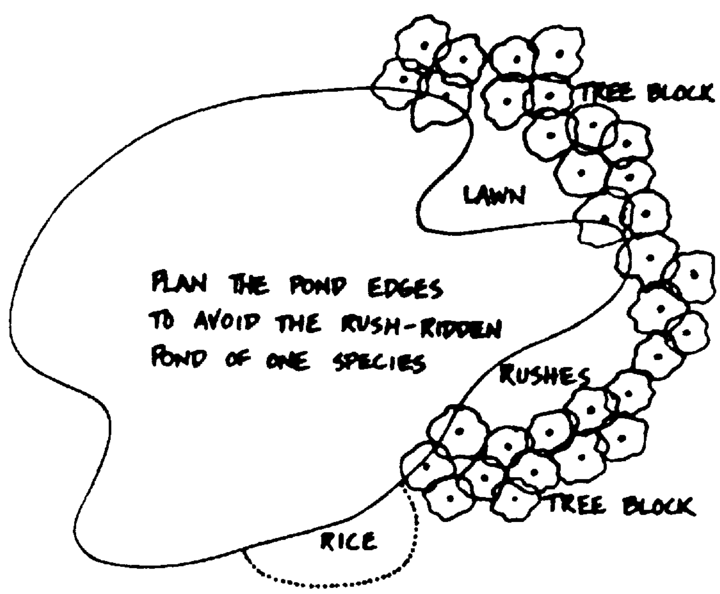
Whole sets of plants, including trees will grow out reed mats. We had a lake we called the lagoon of islands. It was just many moated islands with trees–maybe hundreds of islands. The hydro-electric commission dammed it, flooded it up. It is now a sheet of clear water. Official vandalism! That area was not meant for storage. It was a beautiful habitat.

Intertidally, or between levels, there is another set of plants. They have certain characteristics. They die down, either in summer or in winter, depending on the sort of pond. They then rest as rhizomata or tussock systems.



This is a very rich area and therefore difficult to manage. If a plant gets out of control there, there is nothing worse than to try to eradicate that plant from the situation. You want to be very careful about what edge plants you put in.

When I talk to you about this edge effect, I want to instill in you that you can maximize edges by creating islands and peninsulas. As you design a pond, decide what sort of edges you will put in it. If there are trees to be planted, plant them as a buffer, so that rushes are blocked from extension on to lawn. Decide upon your edges and put them in. If you get them in fast enough, then you won't get a completely rush-ridden pond of one species.



Different species of rushes and reeds serve varied uses. From these you get real heavy crops. That is where papyrus grows, and a whole group of things that are good for paper and fodder. That is where the reed for mats and the cattails grow.

My advice to the ordinary small homeowner is to put those cattails in the annual garden in a tiny little pond, and to cut off the tops to stop them from seeding. Keep them out of the main water storages. However, their seed can blow in at any time, and you have to pounce on them as soon as they start. Otherwise, they close off that marginal surface. Chinese water chestnuts, which are fairly hardy, grow there. They form large tubers, and so does Cyperus esculentis, the earth nut. This, again, is a rush [sedge].

Certain trees grow here where the water table is very shallow. The water table on these banks is only three or four feet down. This is a poplar spot or a willow spot.

Some swamp trees produce the most durable woods in the world, and some of them are the lightest woods in the world. I think Leiteria, the American genus, is the world's lightest wood, much lighter than balsa. They hold water in the stems. A lot of them have air cells throughout their stems and root systems. This is how they manage to live in water. They store oxygen as air in the plants themselves.

Other plants that you know very well are the arrowheads, the duck potatoes, an important wildfowl food. The Triglochin come up and lie along the surface, bearing heavy seed heads. These are eaten rather like leeks. They look like leeks, and you can treat them like leeks. Sagittaria, the duck potato, has at least 80 species and a wide climate range. It grows way up past here and way south of here.

Wild rice is a very important plant, if not for you, at least for all of your ducks. You have to put that seed into mud balls and throw it into your ponds. The seeds do not have a long air-storage life. Water plants often have seeds that are fat, squashy things, that fall from the plants, sink, and take root. Some are different, though, and will blow for miles like thistle. They bob around in the water. A few get eaten by ducks. They sink before the winter, and then take root in the bottom in springtime. Zizania (wild rice) is one of those. There are also a tropical Zizania. Zizania grows from the coast of Florida way up to central Canada. It grows in still lagoons, slow flowing rivers, oxbows–that sort of situation. It doesn't like fast water, but it likes a bit of movement through the water, either wind induced or flow induced, and it likes a depth of 18 inches to three feet. You would probably do best to choose your seed from a situation that approximates that which you are going to be planting.

I see no reason at all why, instead of thinking ponds, you shouldn't think bogs, and create a hundred square yards of bog, and go into a special crop like the distillation of Calamus for oils. Forget about the pond, just fill it up with Calamus.

Phragmites is the super, plu-perfect thatch. Thatch of Phragmites lasts 40 to 60 years. It is as good as any roof. The only one that would last longer is a turf roof. Slate roofs always crack, scale off and piddle down.

Close to the water's edge, in soaked soils, there will be fly catching plants–venus fly trap plants, pitcher plants, sundews, picking tiny little things out of the air and fastening them into the plants. When you come out into the water, you can have a few plants which root, come up, and float on top. They include all your so-called water lilies. The best way to plant those is to take a bag of manuring materials, tuck it into a good old tire, punch the tire in two or three places, and push it out with the water lily root buried in the bag inside the tire. It will come out of the tire and be out of the bag and constrained by the tire. You can always get it out again as a pond plant, and harvest it easily. That works well.[1]

Many of these deeper rooted species can be planted by putting them in clay balls containing as much nutrient as you wish to wrap with them. Just drop them in. Weight them with a stone if you want to: clay ball, stone, and a bit of horse manure with your seeds.

This is where the lotus lives. Some of the lotus have popcorn seeds. You may gather the seeds and pop them. There are many things that are good for popping, but we don't pop them. However, other people often do.

Here, which may be only three or four feet out, you also have the most important floating species, Trapa, which runs from very cool to equatorial climate. The Chinese water chestnut lives here as a mud rush. The Indian water chestnut is a floating chestnut with an anchor, anchoring the stems. The chestnut floats. It is a beautiful sight in India to see ladies floating big bronze bowls along in front of them, picking the water chestnuts. You need skilled people, because you can't walk through the rows; they have to walk rather slowly through the stems, so they don't tear them off. It is a graceful and pleasant summer occupation. But no splashing and kicking about in there, because it will knock the stems to pieces. No hanky-panky or monkey business.

Beyond that, and beyond six to nine foot depth, the only thing we are much interested in is either a continuation of our good old fern Azolla, or duck weed. on the surface. Azolla and duck weeds are both useful. The dreaded water hyacinth can be used, and used well, in restricted locations to clear up pollution. In warm climates, this plant is bad in large slow rivers. Here we want algae production, which practically ceases at 12 feet deep. The only reason we would want a space 12 to 15 feet deep in a pond is to allow fish to escape low oxygen, and high or low temperature conditions.

We are interested in algae bloom out here. When a white painted disc disappears at a depth of about two and a half feet, obliterated in a soft green water, you have a really well-manured pond. If the disk blacks out at about a foot, the pond is over-manured. If the disk can be seen at five feet, the pond is not well-manured–you need to throw in more chicken manure to increase the bloom. If we are interested in the production of shrimps, prawns, yabbies, fish, or whatever, we want a well-manured pond with a soft green bloom.

Certain fish browse algae. Even the rainbow trout has gill rakers that enable it to collect algae and zooplankton. The brown trout lacks this feature.

With trees and bee plants, we use 200 species across all climates. I have no doubt there are 2,000 species that are of great use to us, many of them not entering into any catalog of plants because it just is not our habit of recent years to go splashing around in water getting our food. I guess the reason might be that most gardening ideas come from Britain. The British never get wet. If they get wet, it is to mid-shin, their trousers rolled up. That is probably the reason we never evolved these systems.

If you want a productive pond, you might very well incorporate it as a normal part of the garden. Further, I would say that a very small area, six feet in diameter, is well worth having as a production pond, with these elements in it. These are as good vegetables as any land vegetables. Watercress and cattails are two good examples.

In Australia, we have concrete tanks anywhere from five to 25,000 gallons. You buy them off the shelf. We have stock ponds of all sorts, little concrete ponds. The most handy one only costs $40. It is a very good little production pond. I got a sheet metal mold and rolled two molds for a six foot pond, two feet deep.

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1. Because tires contain cadmium, an extremely toxic element, we usually delete Mollison's reference to various uses he finds for them. In this case, we left the reference in, assuming that the reader can find another way to do the same job.
2. In my experience in North American greenhouses, toads (*Buffo spp.*) control slugs and cut worms well as all these are nocturnal. Bull frogs were of little value, probably because they feed in daylight when those pests are not active.

I am becoming convinced that you need frogs in your glasshouse because I think they are going to deal with a lot of those slow moving things. They are plu-perfect slug eaters.[2]

I am going to repeat some things that I have been throwing out offhand. The pH in ponds is between 6 and 8, that is, it is 100 to 200 times lower in acid than most garden soils. Good garden soil will go from pH 5 to 6.5. It is common to lime ponds. Lime them when you make them. Lime the whole base of the new pond. Then, just check the pH of the pond. Most things in the pond like lime. It is quite different from land culture in that respect. So keep checking on this pH. It is good in this climate to water your plants with limey pond.

The ideal structure for a pond is a sloping floor or a step floor. You should be able to fully drain it. It is even better if you are able to drain it into another pond and take it through a dryland cycle. After a few years as a pond, it will carry dryland crops three to four years without further manuring. One reason for this is the fantastic ability of the mud and the mud surface to fix passing nutrients from the water. One of the elements in those nutrients is the diatoms, which you can't see, The other one is fresh water mussels. Mussels pump nitrogen and phosphorus into the mud. They will filter about 200 gallons of water per day per mussel. The mussel draws from the water all of the little living forms and particle and shoots them out and buries them. It lives there on the mud surface and just has it's top lip out. It injects these nutrients into the mud floor of the pond. It lowers phosphorus in the whole system. Of all other plants, animals, seeds, anything, the mussels are the superior phosphorus fixer. So I consider it a valuable part of the pond to be harvested only modestly for chicken grit.

When you drain the pond for the dry cycle, shift most of the animals into another forage pond. Don't go to dry land culture unless you have at least one other pond to transfer your old pond waters into, together with your critical species.

It is good for intensively cultivated ponds to go through a dry stage. In the dry cycle, grow the heavy feeders in the first year, then taper off and finish with a modest crop. Then roll it down and re-flood it. Once your pond is held in gley, the gley itself goes down in the soil quite a ways and perpetuates itself. You have to start that fermenting process, but you don't have to continue it. If I had a delicate pond sitting on top of a sand dune, in no way would I play on it after I had gleyed it. Just use your sense.

It is possible to go out into a perfectly stable lagoon, dig a couple of post holes, and your lagoon runs out. Just punch the gley in a sufficient number of places to a sufficient depth and the whole thing drains. Ponds do obliterate in time. The ponds that most commonly obliterate are shallow ponds, made from fairly loose fill material. There are ponds, however, that don't obliterate in a millennia. Most of the operating ponds we would put up here on this site would be there many, many years later, and the ponds in our hills would also be there.

You will never see a pond obliterate, though, in your lifetime. The only way you will see that is to make a barrier dam in the desert. As soon as you fill a watercourse in a dessert, it will percolate nicely as a sand dune. A lot of the ponds built in Arizona are barrier ponds across water courses. They simply fill up with detritus. With the sort of ponds we are making, if there is any risk of that , what you do is use your pond as your source of manure. Cut the muck out and spread it on your fields. That is often done. These ponds are great places for trapping all of those things that are good to throw on the ground. [It is also possible to build silt traps to harvest these materials before the water enters the pond, prolonging its life. - DH]

Mussels don't hurt plants nor do shrimps or prawns. We have fresh water shrimp that are very good harvesters of algae, including diatoms. They are a prime step from diatoms to fish. As you get sub-tropical, these shrimp are big enough for human food. The little arthropods that we are talking about, the phreatocids, are harmless to plants. They eat the decaying matter from the plants, and keep the stems clean. They don't chew the stems. They don't eat green plants, nor do shrimp. There are some mollusks that we don't want in there: the spiral mollusks eat plants. On the other hand, some are large enough to eat. If you want to go into snail production - God forbid! - you would go into those. Otherwise, exclude spiral mollusks. If they get on top of you, the dry land cycle and the ducks will finish them.

Don't let children bring snails into your ponds because they eat green plants, and they can wipe out a pond. The crawfishes usually don't compete with fish and don't harm them. Try to get crawfish with restricted burrowing capacity. We have one called the yabbie. He is a long tunneler. He may go 25 feet. He might start on the inside wall of your dam and come out on the outside wall! Surprise, surprise! He comes out with great speed. But we have other crawfish, and so do you.

One of them that makes a restricted burrow. In fact, the best habitat for these species is beer cans. So we throw in a clutch of the beer cans tied to a cork or a ping pong ball. Throw out the ping pong ball. Draw 20 beer cans and take out 20 large size crawfish. Then sink your beer cans again. That's a slow way to do it. A fast way to make a little trap is with a ramp and slope. They go up the ramp and hop into the trap. In Australia, the cultivation of crawfish is becoming rather common, and some hundreds of acres of flat, previously non-productive land is under aquaculture.

The crawfish is a fantastic inland resource. They have them in Chicago. You should have them here. I don't know if anybody grows them here. We worked it out. A Scotch biologist figures that 30 quarter-acre ponds in marine culture would keep a family, supplying an income of $20,000 to $30,000.[3]

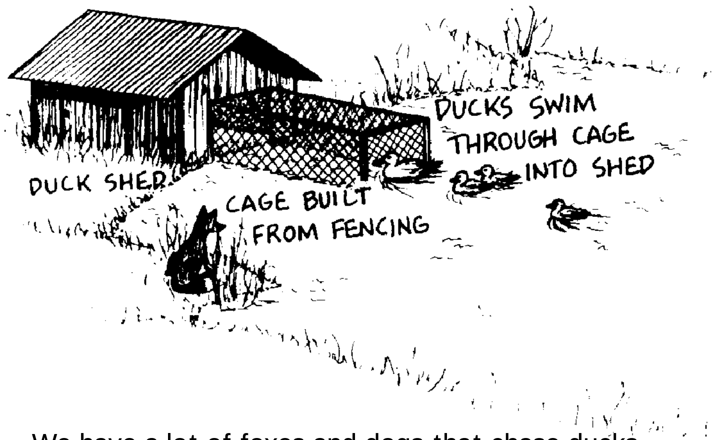
Crawfish like ponds that are about three feet deep, and they like brush piles. Piles of limbs in the water can save them from getting eaten by predators. The traditional way that the Hawaiians and the Japanese fertilize their ponds is by doing exactly what the beaver does, letting bark and limbs rot in the ponds. You don't spread it over your pond, just put it on the edge where you are not cultivating.

Another real good thing to do around ponds is to strew bales of hay around the edge, both to seal ponds and to get diatoms working. Strew it half in and half out around the edge, kick it in if it rots off. Diatoms like hay. Often you can feed little fish by having a bowl of hay and water, and dipping the water out of the bowl and feeding it to the fish. What you are actually putting in is little flagellates and diatoms. They drift around in the air. There is no need to put them in there. They are in all water. Just scatter the hay around the edge, and kick a little more in. Ducks will add manure to it.

You can figure on eight ducks to a quarter acre. But the more ducks you put on, the more manure you get. Ducks give you an additional crop, and they greatly assist the turnover of the energy in the pond. It is possible to make provision for the ducks somewhere in that food cycle. Wild rice is good in this situation because it comes up in the vegetative stage, and it grows well above the duck. You harvest what you want. It has a three week dropping period. You gather it for four or five days, and the rest of it falls. It is superb duck food.

We have a lot of foxes and dogs that chase ducks. If you haven't got a pond big enough for an island, put a fence into the water; top net it–that is essential. Put your duck shed back of that. The ducks will come out of this shed into the water and swim and browse and go back there to sleep. They know to do this from night one on. They don't want foxes either. Islands are good, though. But if it is murderous to ducks where you are, maybe you can't keep ducks.

3. 1981 dollars.



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Pond edges are good blueberry areas. Mints are invasive, but very productive. Another purpose for the pond might be to grow mints, particularly black mint. You don't need many acres of that. Two or three could bring you $70,000. You distill mint to menthol. It is good to grow mint if you are dairying and have dairy outwash. From that, you get powerful blooms of mint. So you might try a mint marsh for that black peppermint and do simple steam distillations. Mint is such a strong growing plant that it quickly exhausts even ponds. It will get pretty woody after a few years. In cold climates, it has a rest period, and you can re-manure. You can put it on edges; but because it is laterally invasive, I would put a couple of bushes on either side of where I was going to put mint–dense bushes to keep it in its little patch.

A good place for bamboo is back from your ponds. They look great.

I won't go into a discussion of the fish you might place in your pond, because you have to know your local laws about fish. Catfish look like an obviously good pond fish because they are very low on the chain feeders, way down on the trophic ladder. And they are good eating. I wouldn't go past them to trout, unless you are real keen on trout.

If you are in the happy opportunity where you spot a hundred acres with a 15-foot wide outlet, land that used to be marsh, and somebody is selling it cheap, grab it. Stock it with trout. You can retire instantly, because just by net fishing, not manuring or anything, you will have a continual trout supply.

A man bought a cattle property. That land was jumping with grasshoppers, absolutely covered with grasshoppers. He was in a grasshopper that erupts annually. He was pretty despondent about growing cattle. The grasshoppers would remove everything. He built a pond. I said, "What's in your pond?"

He said, "Let's have a look." He threw in a net and pulled out an eight pound trout.

I said, "How long have these been here?"

He said, "Twelve months."

I said, "You are nutty! You have bulldozers and this great valley, and you're going to grow cattle?"

He said, "Now I got you right!"

I said, "Hills covered with grasshoppers!"

He put over a hundred acres into a big trout pond, and he just simply retired. He doesn't have to figure around feeding those trout and adjusting them. He has a hundred acres of this trout pond.

Trout are in beaver ponds. As long as they have that escape, shaded by a few trees, they don't demand a lot. They can take it a bit warmer or a bit colder than you think. They are optimal over 60 degrees Fahrenheit, but lower than that, they are still pretty active. Trout are an extensive fish. So if you have an extensive area under water, grow trout. But intensive trout are a curse, because you have fine adjustments to make, and it is a nuisance.

As large a yield as anyone knows of for the home farm is from blueberries and mulberries on the edge of the pond. Mulberries are great feed for stock in water, as well as on land. White mulberries are used extensively throughout the ponds and paddies of Asia for their leaf and fruit as feed. We want careful adjustment of maybe 20 species of plants and small animals low on the trophic ladder. That includes the shrimps, yabbies, crayfish, catfish, edge plants, pond plants, and ducks.

You can do little pond designs at home, with perhaps ducks for their eggs, and wild rice. Always include those mussels as decomposers.

There is a whole group of American grain plants that are ideal for ponds, marsh grasses with heavy seed yield for ducks.

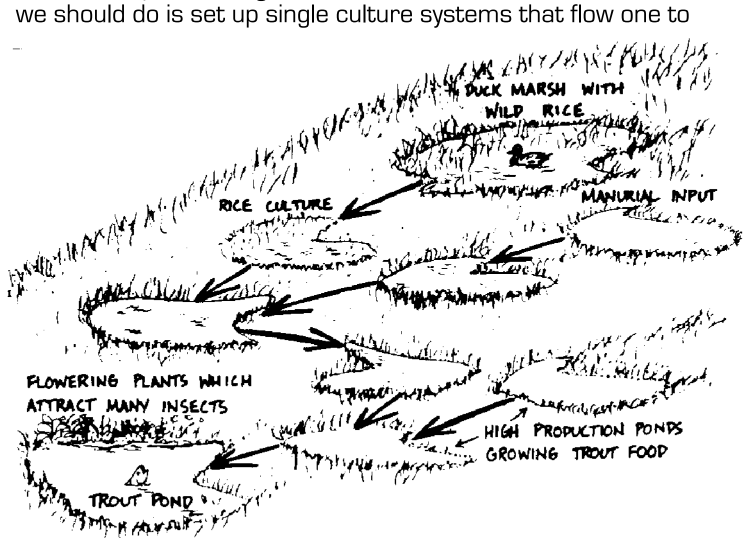
Wherever you build your pond, don't forget its other functions: barrier functions, fencing functions. Often a long pond in the valley saves you a half a mile of fences. The pond has reflection functions and fire protection functions. It's a heat store. It usually becomes a recreational area. Put a big rock by the side of a deep area where children can safely dive. The pond has water cleaning functions. It efficiently collects in its mud essential nutrients. I believe the Chinese would say that the main value of their canals and ponds is for manuring their fields.

Sewage should be turned out into a marsh, not a pond. In that marsh, grow your mints, your bog plants. They have phenomenal sewage demand. But in this climate, send your sewage into a holding pond. Then let it seep through a marsh that can grow into trees. When it has passed through that, it has no solids left at all. It still holds a lot of dissolved nutrients, mainly phosphates and nitrates. You can let that go into your pond. You need a holding pond, because in winter the marsh plants are dormant and cannot purify water.

There is a Swiss study which might interest you. One of the plants which they mention is rush, Scirpus validus. They found this to be the most efficient water cleanser. One of my designs was for a town of 8,000 people, for which I did a sewage disposal, saving $30,000 a year in engineering work, and about the equivalent amount annually for fuels. The town is pleased with it. I turned it into an industrial base for the town, an employment system, through mint and bamboo. This was originally done on 50 acres; but the town has purchased an additional 1,500 acres and turned it into further raw materials. Also, I allowed for water fowl, and put underwater shelving into it. It has been so successful, that when I last heard of it, it had vast numbers of black swans and teal. While up in Canberra, they put in a $700,000 sewage cleaning plant which produces poisonous water. They make no apologies or anything for doing this.

Just give me a bulldozer and a sloping site. As for San Francisco, I could do their whole town. As it is, all they are doing is covering the sea floor with silt. It is horrible!

If we are just dealing with water culture, I believe that what we should do is set up single culture systems that flow one to



the other, and we should design for them. Make a duck marsh with mussels, perhaps, and wild rice, an 18-inch deep flat pond. From there, we can go to ordinary rice crop, or paddy crop. From either of these, we can go to shrimp ponds that don't contain trout, or to a pond with any invertebrate that trout like. We are enriching the water, using some of it in crop, turning some of it into shrimp, and these ponds trickle to the trout pond, inevitably carrying shrimp on migration.

In Australia, there is a place that has an enormous clay base. It doesn't breed trout. Every year they stock thousands of trout and they grow well. Those trout eat a little fish called smelt. The smelt is found at one site, a quarry in which it can breed. The main food of the trout is the smelt which lives in this tiny quarry.

If we get production of tiny things that continually flow into a trout pond, we could greatly relieve the need to feed the trout, and maybe abolish it.

You have a lamp that attracts a lot of bugs, an ultraviolet lamp, the patio light. Place a lamp of this sort over the pond, with a little fan in it, so that when insects come flying to it, the down draft hits them and they go straight into the water. With that sort of setup, you could do without manure input for crops. Have a few small ponds at different pH's, which suit small forage animals, some of which, in this case can be snails. These ponds would have trickle systems into the main pond where we harvest trout. Meanwhile, from the other ponds we take wild rice, rice, duck eggs.

It is polyculture, but not in the sense that we have it all in together. Some crops may not, in fact, grow with others, because we are adjusting totally different pH's. We might find a little phreatocid, or something–a real good trout food–that will go in a low pH. Meanwhile, we might heavily lime another pond for mollusk production. With their food flowing to them, the trout are perfectly happy. Maybe a few forage ponds around fish are the way to feed fish. There is no way the trout can come up the trickles, which are through little grilles. So what is coming down, they get, but they can't get at the sources.

Some little fast breeding fish, like stickleback, breed by millions, and, given certain high algae conditions, can be converted into trout. If you put them into a total polyculture, they would short-circuit the whole system. I think we've have many skilled games to play in aquaculture, interesting games too.

There were a lot of hippies at a conference. They had colored tents all over the place. I noticed that there were a lot of grasshoppers on the yellow tent. So I figured it would be good if you could float a big yellow balloon out here in the pond, just beyond the normal grasshopper's leap. They can see yellow and they will leap for it.[4]

Now, folks, we are going to take permaculture right out into the sea. We don't stop permaculturing at the shore lines. Down we go into the tide, the rocky main shore line, the main marshland, and the tidal marsh.

Tide ranges can run from two to 27 feet. The tide range that we need is really less than one foot. In some cases tides may occur only once a day. Tides are real weird things. Around the coast of America, you will be able to determine your tide ranges, and there are also tide tables. Twenty-seven feet–something like that–for the Bay of Fundy, Darwin, and many other places.

Those mud traps, of which you find many in Tasmania, are very ancient. Nobody has any record of them ever being built. They are quite possibly aboriginal. The Maoris have many. The other Polynesians also built them. They are simple tide traps, stone walls that don't quite reach the surface at high tide. They are about six inches below the surface. Fish swim over them at high tide. The tide drops six inches, and they are still quite happy in this lagoon. When they try to swim out, they find the tide has gone out through the rocks. These traps work best at night, which is why most people think they don't work. When you go to look at them by day, there is often not much left in them, but at night they are often full of fish.

Another good thing to do is to make a pond two or three feet deep in this tidal area, because fish otherwise will strand and turn into sea gull food. You will often find a client whose land includes some salt flat, even if the government has struck off a hundred foot tide reserve, above the high tide mark, as they frequently do. You will often find that back from that, for hundreds of yards, you have salt marsh. You can put a simple channel through that reserve area, if a channel doesn't already exist, just by driving backwards and forwards with your tractor for a while. The tide runs into these salt marshes in any case. It is possible, between tides, to dig inland ponds. There are only a few rules. They must have about a three-to-one side slope, a real gentle side slope. Then the rocks fall, and you can throw them up on the tide side to stop the sea winds coming in. Put some salt-resistant shrubs around your pond, and lead your water in through the channel. You could fill a pond with the next tide, if you wish. Then, depending on how deep that channel is–and you can regulate it by shifting a board up or down–you can give it a three inch, or six inch, or one foot tide range twice daily over that pond. It is the cheapest swimming pool you can build anybody, and self-flushing. It is always warm. It is inland. You can shelter it. The tide brings only a few inches of water over the warm water.

A variety of organisms, particularly oysters and mussels, grow best when their location is at 60% air exposure. For any kind of oyster, your local fisheries guide will tell you what air to water exposure is ideal. Broadly speaking, above that exposure you get much less meats, while below it, immersed, you get much more shell. But at the ideal exposure you get a modest amount of shell with a lot of meat. So if you have an oyster enthusiast, you can actually set him up with a situation in which he can raft or support oysters inland, which is much easier than having them out in the tide land, and which is self-governed to give them all ideal exposure. It is possible for a client to make a lot of money breeding oysters, selling off the spat.

If he has access to a lot of broken pot, he can set up a lobster city. Lobsters will not tolerate another lobster in the same hole. They will lose legs and things. Often you find that there is some fish processing somewhere, usually with waste product that you can feed to lobsters in these stacks. It amounts to the growing of a marine animal inland.

Another thing you can grow there is sponges. You can also grow flounder, if you can feed them. Lobsters and oysters are pretty immune from predation. But with the flounder and other fish, you might strike cormorant problems. Cormorants can be converted to fish food by hanging a five and a half inch net well off the bottom. It will drown them and fish will eat them. But you only do this when you are into intense fish production. Ponds in these areas offer no protection for fish. If you have any shelter, as soon as a cormorant hits the water, the fish takes for shelter. The cormorant might get one, but he doesn't get many. But in an open pond situation, he will murder a lot. You can bring the growth of lobsters to a standstill in dense populations, so that none will exceed three and a quarter inch carapace, simply because the density of lobsters is enormous.

Let's look at the inlet. You can bring the tide in, maybe with banks supported by concrete. You can slide boards in, adjusting your tide range. You can also have funnels leading in so the sea comes in through funnels at night. A lot of small fish enter. Small round fish can't get back out again. You can bring a lot of fish into your ponds continually, with every tide. If you have a predator fish or lobsters in there, you can just keep them in food. Now I'll give a couple of instances of the human brain at

4. Not all yellows are created equal. Insects use prismatic eyes to see colors, including yellow, as bands of the spectrum. People do see this "spectral yellow" as yellow. We also see mixtures of the red and green portions of the spectrum as yellow, whereas insects would see red plus green, not a composite color. For insect traps, use either a known "spectral yellow" or perform tests with insects. Seeing the trap as yellow is inconclusive.

work. They want a sea pond for the breeding of oyster spat. So what do they do? They go 50 feet above sea level, dig out dams, and pump sea water up 50 feet. They are doing that in Tasmania. Or they go into the sea and build a wall out at tremendous maintenance cost.

If you get hold of these saltings, and there are thousands of acres of them, you have the best goose grazing areas you ever saw.

Now what do you have in the way of plants for here? For salt flat tidal range, you have front line plants, the mangroves, if you are in a hot enough climate. On these salt marshes, you have various little fat plants at your grass roots. Salicornia is a great goose fodder. This is real goose country, where I think a lot of our domestic geese breeds come from. If you want to go into a very small industry, you can make Salicornia pickles, which sell well in England. A host of little plants out here are quite useful. You can plant here salt marsh honey plants. Sea lavender is a very good honey plant. There is an interesting plant, Spartina. It is called cord grass, used for weaving those fancy seat chairs. The old timers made cord from it. But it is far more important than that. Spartina is a heavy seed producer, and it is also a great forage crop for geese, and the base food for most of the cool water fish. No Spartina, no bluefish. It is a nurse ground for the young and their food. The bluefish industry depends on the Spartina and the Spartina depends on there never being an oil spill. So I advise you to collect some Spartina seed and send it down to me as rapidly as possible. After the next oil spill, I will send you back some Spartina seed, at a very minimal cost. It is a northern hemisphere plant. That environment is totally unoccupied in the southern hemisphere. It doesn't have a plant in it. Without Spartina, you don't have quahaugs either, because your quahog zone comes in here. We don't have quahaugs because we don't have Spartina.

When we come down into the sea grasses, it is very interesting. They are the Zostera and the Posidonia, the eel grasses. These are basic sea foods. They absorb nutrients quickly. I think it has been calculated that if you put a bag of super-phosphate out to them, in three days they will have absorbed all of it. When composted for about 10 days, they are the best insulation material you can get. They shed all their upper part, which comes ashore by the tons, either in autumn or early summer, depending on what variety they are. They heat up like fury when you pile them on your carts. The composting process burns out a lot of things that are on sea grasses that otherwise stink, while it leaves the frame of the sea grass. It is a chocolate color, fibrous stuff. As an insulation material, it doesn't have any of the risks of the mineral fibers. And they last forever. You can use that for garden mulch, but not where there are cattle, because they eat it. Put it straight on and forget about salt, unless you are in a location with below 20 inch rainfall. Put it on sopping wet.

Possibly, in this whole estuary the eelgrass will only blow ashore at one place. This is probable. But it is easily caught on fences.

It will be necessary to investigate your client's title. Ancient grant titles extend to low tide. There are still some in the United States. Titles which are not grants, but freehold–they are not Crown charters–will go to high tide. Modern titles may be set back 100 or so feet from the beach which has been converted into beach reserve. At the same time you can get, under lease, access to the intertidal zone. It is not difficult, and is very cheap. At least in Australia, everybody has the right, no matter who leases the area, to take a single eelgrass load. It is real good stuff and it is free to you. If you don't collect it, it either blows inland or wisps out, a silica skeleton that just helps to build up the beach plants a bit, while the rest of it breaks up and returns as mud into the channels and goes back to the sea. It probably fertilizes the sea further out. We have enough of this stuff in the world to insulate the world, safely. When you convert it to insulation you have put it to permanent use, at a big energy savings.

Another thing about these little sub-tidal fences and screens for collecting long-shore drift is that other things arrive here: broken up shell, sometimes by tons.

I was on an island recently that was originally very low pH and has an acidic soil. They have been carting limestone onto it by boat for I don't know how long. They built a jetty with stone base, and they are still carting limestone in on this jetty. Yet I looked over the side of this jetty, and by my best estimate, there might be 1,100 tons of broken shell there, which is just limestone. Shell, itself, is salable in 50 pound bags to any responsible chicken keeper. It is quite expensive. It is a continually renewable resource of good lime for fields.

These little longshore drift traps can collect many things. If you look closely at natural things in this tide range, like a log that washed ashore, or an old wreck, or an old boat moldering away there, and you walk around and study it, you find that the tide comes in and out, and the longshore drift builds up. A deep and permanent pond forms there, and a shallow permanent pond in front of it. Nobody had to dig those, and nobody has to maintain them. All you have to do is to direct the tide into these scour-hole situations. They are excellent growing ponds.

Again, if you have the right title, or lease title, you can put in simple barrier systems, which may be fences or logs, or anything you can drag there. You can produce permanent ponds. You don't have to dig or maintain them. One thing that grows in there is octopus. If you simply provide the pots for them, they are occupied. At low tide they are ponds; at high tide, they are slightly flooded. Octopus have no place to rest in this whole situation, and it is full of little mollusks. They can't dig caves in there. They would like to be there because they eat mollusks. When you give them a pond, they have a place to breed. If you put pots in there–ordinary clay pots–each pot has an octopus in it. When the tide comes in, these hundreds of octopus come out of their pots and go out and eat shellfish. They come home and go back into the pot at low tide.

They will do this as soon as you provide pots. I don't know where they come from. They apparently have just been swimming all over those browsing lands, looking for somewhere to live. It is a good octopus growing situation. It is also a very good place for growing sponges.

Now you can start to play around. There can be barrier fences, drift fences, pond scour holes. We can design for ourselves a complicated system which scours water and is self-maintaining, and brings in broken shells. You just combine a series of fairly natural drift events into a complex of fish trap, scour hole and growing situation.

It is enjoyable working around down there. We do a lot of it in miniature to start with, taking little logs down and watching the effect, building little fences. Then when you feel as though you are getting it right, scale them up. Always be looking along the shoreline at what is really happening. Observe when something happens–where a reef runs out, or a log strands–because there are lots of forces at work, and lots of material on the move all the way along here. You can bring it to where you want it.

I believe also that it would be very productive to run the same thing that we would run in large dams, what I call sub-surface dams. This would permit some of the waters, just for a while, to remain as quite water. I believe we could create large Zostera fields intertidally. The condition required for Zostera is a period of still water, not too much run of tide. I think that we could greatly increase the productivity of intertidal sand flows by installing shallow still-water systems. This I do know: in a tidal river that fills at high tide, where a natural barrier occurs in it, like a stone dike, that area will be full of Zostera and full of fish. It is very simple to duplicate that system by constructing leaky walls, just rubble walls. These are not dams. On open coastlines, you don't find Zostera. When the Zostera get mussels attached to them, and shrimp move into there, a whole series of events start to take place. It is a fascinating area to play with, that salt marsh to low tide.

We don't stop there; and we don't stop at this intertidal place, because certainly the Hawaiians kept on gardening right out into the reefs. So did the Irish. The Irish set out what they call fields. The fields are simply rows of stone across hard bottom. You can handle very large boulders in the sea. You come in along side of them, draw them on to boats, float them out, and roll them off. You can place them easily in the sea. They grow enormous quantities of desirable seaweeds on those fields. Many of those Irish fields are not harvested any more; but some are. They are visible from air, enormous acreages under water.

I went to Donegal and poked around on the barrens. I saw some very interesting things there. They make tiny little stone-walled fields. I said, "Why don't you enlarge these fields?"

They answered, "Because the smaller field produces more than the larger one."

I said, "Why?"

They said, "It is warmer."

You could feel the radiant heat from those walls.

They deliberately made their fields smaller and increased their productivity.

They also used the tide a lot. They cut the kelp, tie a big rope around it and pull it up, 10 or 12 tons of kelp on the move. They bring it in on the tide, right into the bog channels. When the tide goes out, there it is, right on the shore. They load donkeys and and away they go with the kelp. They can handle great weights in the water. All over the coast, you will see little hollow mounds. They fill these with kelp stems, which they stack and dry like firewood. They fire them with peat, and get the potash from the kelp stems for their fields. The fronds they lay down as mulch. It is a marginal existence, the only way they can exist, but it is quite enjoyable actually. They eat a lot of dulse and other seaweeds chopped in their porridge.

You can extend your aquaculture systems into estuaries. You can do beautiful swap-offs in estuaries, too. You can take cold water, fresh water, warm salt water from them. In estuaries, in adjoining ponds with totally different salinity grading, you can grow everything from trout to grey mullet to eels, because you have an intake of fresh water up there, as well as twice daily intake of warm salt water. So we can continue to design even onward and outward.

Another thing that I have seen working very well is very large raft culture. When the Irish salmon runs were good, they didn't worry about culturing salmon. Now two things have happened. Their authorities "improved" their rivers. Their idea of improving rivers was to get a bulldozer down the bed of the river. That destroyed all the old salmon weirs. Now salmon weirs are little log and rock constructions across the river. They oxygenated the water. The engineers did away with them, and the oxygen levels dropped. The salmon were wiped out. The Japanese got efficient with their gill nets at sea. They would catch nearly all the salmon bred in Ireland. So the Irish, not to be outdone, bring the salmon inshore and release them into giant floating rafts, moored in quiet tidal areas behind islands. They produce an amazing amount of salmon there in big flooded nets.

So you can go into rafting. I should mention at this point that rafts are applicable across the whole of the aquatic systems: tiny little ones on tiny little ponds for insect attractants; larger ones to grow plants at a fixed root level, including pot plants. Water culture is highly developed in southwest Asia. A raft remains constant and level, and you can set pots in rafts so that your plants are at the same depth at all times. One thing you can grow well on rafts is daffodils. You can set them out on chicken wire. Each little space holds a daffodil bulb,and its roots are just in the water. If it is a high nutrient water, you get a lot of daffodils. Vegetable crops could be grown on rafts, and they can grow rock cultures, mussels, oysters, and algae. It would be a good way to grow algae. You can make a ring, and a big net, and grow fish within the sea in that net system. The Irish had very large rings, and they walk boards around them, with four foot fences so the salmon couldn't jump out.

You can do large scale transfer of sea birds in nesting cycle, by keeping adults until the nesting cycle begins on part of the coast. A mutton-bird is a critically important food of the Tasmanians. You can keep the adults like chickens until they nest. When you release them, they return to the nest, and then you start a whole new colony. To some degree, you can do the same with seals. You have to kidnap the young seal, before they can swim, when they are not being fed, and they all start a new seal colony, too. So it is possible to colonize an abandoned area. Seal are critically important to inshore fisheries. The loss of seal dropped the inshore fisheries right down. What apparently happened was that the seals ate mainly spiny and whitefish, which have a high manurial turnover on the Zostera bed which, in turn, supports high quality food fish. When you kill off the seals, you kill off your manurial system. There are connections there that nobody ever made. They simply killed the seals for fur, and destroyed the inshore fisheries.

Another thing that nobody has made much use of except one man I know is the sea as a source of phosphate. Phosphate is carried by birds. Sea birds like islands, and specific roosting places. Look at a flock of gulls and cormorants roosting on an old bridgework. You will see quite species-specific roosts. You can make very attractive roosting systems by creating roosts on platforms in the sea or on islands. Well, this man built a platform with multiple roosts on a desert coast off west Africa. The platform was the size of a football field, with concrete pylons. He spent a lot of money doing it. And he was the subject of great laughter. He's gathered so much phosphate off that area that he's annually a millionaire, and he's laughing. He gathers it both as a liquid when rain falls, which he pipes ashore and evaporates on the shoreline, and as a solid which is shoveled into bags. Basically, he has reconstituted a phosphate island.

There are many phosphate islands in the world that are being mined, but very few that are being created. The potential for creating a small phosphate island serving a small village is a very simple affair, providing you look at your roosting situation. Two hundred terns always roosting in the right place will entirely supply maybe an island or a village. Phosphate is one of the critically lacking minerals in the Third World. Wherever you can get that organized, in a lake, or by the sea, or on the land, it is a good thing to have done. The Dutch build specific bat roosts throughout their fields, which control mosquitoes and give them a critical manure. You will see those bat roosts in the flatlands in Holland, slatted like racks for drying towels. These are ideal bat roosts. The insectivors hang from them. Their manure is carefully collected and carefully distributed. So the sea and lakes are good places for collecting phosphates. If you can achieve something like that, you will be making a better strike than anybody else for local self-sufficiency.

You know now about Spirulina, the hippie food additive. Spirulina is an algae. It can be simply produced in tanks under continuous production system. Spirulina desalinate water. A modest plant will desalinate 10,000 gallons of water a day, producing that much fresh water from salt or brackish water. Once it starts to produce fresh water, you can mix it with hyper-saline water coming in and put it back again through the tanks. It has a higher BTU than coal, if you want to use it as a fuel. It is about 86% total protein, of which 68% is a complete protein. It has no cellulose, so it is almost entirely digestible. In summer, it will give three crops a day. It is presently greatly over-priced, selling for about $30 a pound, dried. It should cost one and a half cents.

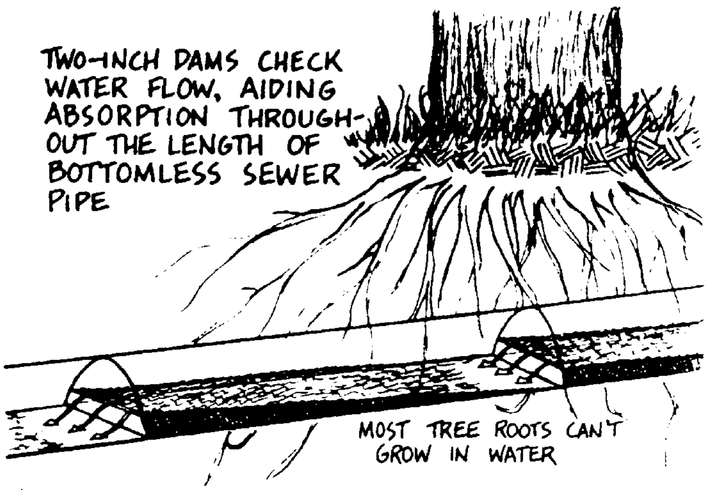
It will clean up sewage water; it will clean up grey water. You can feed it to your ducks and pigs, or turn it into a powder and eat it yourself. There is no need to eat the stuff. I merely propose this as part of aquaculture. It is very promising, I think. But I'm not going to do it. It is not my style of garden.

In places where you will be designing in arid lands, perhaps just summer arid lands, you will find people who are short of garden water and who have showers and sinks going into underground drains. Shunting systems can be installed, using a simple standard double mouth fitting, and gray water can then be run directly into mulch. This has been done successfully in dozens of places with summer arid areas where I have designed. Shower water is immediately taken up by plants.

Grey water can be recycled through glass houses. It releases its heat in there. A sensible thing to do is to put your shower in the glass house. You can shunt this relatively clean water directly to the gardens.

I previously described for you that half-pipe open on one side, designed to lead water from toilets directly to tree crop, and which won't become blocked by roots. I think this is really a sane and safe way to dispose of sewage. While I think there is nothing at all wrong with the flush toilet, I do think there is something awfully wrong with Los Angeles–a crazy excess of everything, including the flush toilet.

This tile drains useful where we can get sufficient domestic water from uphill to run a flush toilet, and where we can grow trees on the outrun. I think it is an extraordinarily safe system. It has been on a long trial. It is now produced from standard plastic material. What size? If you use a lot of water, make a big drain. It falls at the normal drain-fall. About every four feet it has a two inch piece that fastens the bottom of the sections together. These act like little dams that slow the water, so that little ponds form continually behind them. This half pipe is placed upside down in an earth trench. It is buried in earth, but it is open on the bottom. It doesn't have stone on it or under it. It can even be laid in clay. You then plant trees beside it, even invasive trees, and away they grow. The man who made it originally made it out of half pipe and molded those little dams in it. Put it down below the frost line. It holds the water up as it goes along until absorption takes it out.



It works. Round pipes don't work, because they get invaded by roots. They will fill up with poplars and eucalyptus root. Leach fields work for a while, but these devices seem to work indefinitely.

The more you play with water, or walk on landscape where you can play with water, the more fascinating things you'll see that you can do. I do believe that if we really studied what the beavers are doing, we would already see some very smart work, just on flatlands. They are not building just one dam, they are building several dams, for all different reasons, and they are building little canals and bog places, and they are doing water control–pretty good little fellows!

Here is something we have done on flood plains. If you have a row of trees along a river bank, which you often do have–willows and poplars, you will notice that there is seldom more than four trees tilted over, until the next one is upright. I have not seen many flood plains that would push more than four trees down in a row. And they go on growing. The fifth tree usually has the full upright height of the tree. Casuarinas, willows, poplars, all withstand flood.

You can plant in two ways. In both cases, you start at right angles to the bank and do a nice taper towards the river. That way, you will create a scourhole lagoon in the river, which is a very handy thing, providing a low water area for fish. If you can pick a place where it is not rocky, you can create a permanent lagoon. You can bring in detritus, collect firewood, also collect a substantial amount of mulch. You can have a place that doesn't collect anything, but which does give some silt. So floods can provide you with a lot of wood, a lot of mulch, and a lot of silt.

This silt is a good place for a crop like asparagus. It likes an annual dressing of silt. In Australia, it is a channel weed–it grows in the irrigation channels. It is four feet down with its roots.

In Australia, poplars grow to 90 feet high. Saw them off at the butt, dig an eight foot hole and lay them straight in position. A 90-foot hedge. It works. You grow your willows to sort of 30 feet high, saw them off, and plunk them in a hole. As long as you have them anchored, they'll grow. There are nurseries that will sell them to you at about 60 or 80 feet. Canadians would be transplanting at least 50 foot poplars, wouldn't they? No roots, just saw them off. Then you get another one that comes from the roots. That's why you run that nursery. You can take a 90 foot poplar and make two 45-foot poplars. You could take a 90 foot poplar and make three 30-foot poplars.

Now a word on very large dams such as the Aswan or any of those dams. They are mostly negative in their effect. All studies show that they reduce the fertility of the river below them by trapping the silt. They often sharply increase disease, and particularly in tropical lands, because the country is not scoured by floods. They always change the fisheries below. In Australia, for instance, they completely wipe out some species of fish for miles downstream because of the cold water released from the base of these dams. They have a very low biological use. They give rise to centralized power systems and, inevitably, to polluting industries at the other end of the usage chain. Generally speaking, they are a disaster.

So we are mainly in favor of reasonably small impoundments.

There is always a nuisance damming the waterways. You have to pay a lot of attention to your spillway systems, and those dams may flood. But they have their uses. However, it is the last place to go for a dam.