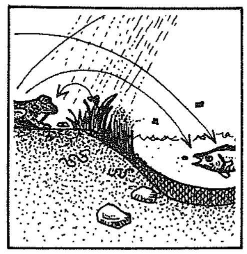


Chapter 2

CONCEPTS AND THEMES IN DESIGN

The world teeters on the threshold of revolution. If it is a bloody revolution it is all over. The alternative is a design science revolution... Design science produces so much performance per unit of resource invested as to take care of all human needs.

(Buckminster Fuller)

All living organisms... are 'open systems'; that is to say, they maintain their complex forms and functions through continuous exchanges of energies and materials with their environment. Instead of 'running down' like a mechanical clock that dissipates its energy through friction, the living organism is constantly 'building up' more complex substances from the substance it feeds on, more complex forms of energies from the energies it absorbs, and more complex patterns of information... perceptions, feelings, thoughts... form the input of its receptor organs.

(Arthur Koestler, 1967, *The Ghost in the Machine*)

Most **thermodynamic** problems concern 'closed' systems, where the reactions take place in confinement, and can be reversed; an example is the expansion and compression of gas in a cylinder. But in an open system, energy is gained or lost irreversibly, and the system, its environment, or both are changed by the interaction... the second law of thermodynamics [states that] energy tends to dissipate and organized systems drift inevitably towards **entropy**, or chaos. In seeming violation of that law, biological systems tend to become increasingly complex and efficient.

(*Newsweek*, October 24, 1977, on the Nobel Prize awarded to Ilya Prigogine.)

Lovelock shows that the biosphere, or Gaia as he calls it, actually created those conditions that are required for its support... and systematically builds up the stock of materials that it requires to move... towards increasng complexity, diversity, and stability.

(Edward Goldsmith, 1981, "Thermodynamics or Ecodynamics", *The Ecologist.)*

Man did not weave the web of life, he is merely a strand in it. Whatever he does to the web, he does to himself... to harm the earth is to heap contempt upon the creator... contaminate your bed, and you will one night suffocate in your own waste.

(Chief Seattle, 1854, responding to a U. S. government offer to buy Indian land.)

2.1 INTRODUCTION

It is alarming that in western society no popular body of directives has arisen to replace the injunctions of tribal taboo and myth. When we left tribal life we left with it all guides to sensible behaviour in the natural world, of which we are part and in which we live and die. More to the point, by never having the time or commonsense to evolve new or current guiding directives, we have forgotten how to evolve self–regulating systems. Hence, the call for a society in which we are all designers, based on an ethical and applied education, with a clear concept of life ethics.

The Gaia hypothesis, as formulated by James Lovelock, is that the earth less and less appears to behave like a material assembly, and more and more appears to act as a thought process. Even in the inanimate world we are dealing with a life force, and our acts are of great effect. The reaction of the earth is to restore equilibrium and balance. If we maltreat, overload, deform, or deflect natural systems and processes, then we will get a reaction, and this reaction may have long–term consequences. Don't do anything unless you've thought out all its consequences and advantages.

Aboriginal cultures used *myth* to show how unnecessary acts and unthinking destruction of elements brings about catastrophe and suffering. The usual structure of myth has these sequences:

1. A willful act of an individual or group.
2. A transmutation (animate to inanimate or the reverse, e.g. Lot's wife turns into a pillar of salt). This is by way of a warning.
3. Invocation of an elemental force (fire, storm, earthquake, flood, tidal wave, plague) as a result of any set of willful acts.
4. Necessary atonement by suffering, isolation, migration, or death.

So the act of a child or individual is given a meaning which relates to the whole of nature, and rebounds on the society. Reared on such myths, we go carefully in the world, aware that every unthinking act can have awful consequences.

Because we have replaced nature–based myth with a set of fixed prohibitions relating only to other people, and unrelated to nature, we have developed destructive and people–centred civilisations and religions.

In life and in design, we must accept that *immutable rules will not apply*, and instead be prepared to be guided on our continuing exploration by *flexible principles and directives.*

Thus, this book emphasises self–reliance, responsibility, and the functions of living things. Within a self–regulated system on earth, energy from the sun can be trapped and stored in any number of ways. While the sun burns, we are in an open system. If we don't destroy the earth, open–system energy saving will see us evolve as conscious beings in a conscious universe.

A Policy of Responsibility (to relinquish power)
The role of beneficial authority is to return function and responsibility to life and to people; if successful, no further authority is needed. The role of successful design is to create a self–managed system.

2.2
SCIENCE AND THE THOUSAND NAMES OF GOD

Although we can observe nature, living systems do not lend themselves to strict scientific definition for two reasons. Firstly, life is always in process of change, and secondly, life systems *react* to investigation or experiments. We must always accept, therefore, that there will never be "laws" in the area of biology.

"Hard" science, such as we apply to material systems (physics, mathematics, inorganic chemistry), studiously avoids life systems, regarding as not quite respectable those sciences (botany, zoology, psychology) which try to deal with life. Rigorous scientific method deals with the necessity of rigorous control of variables, and in a life system (or indeed any system), this presumes two things that are impossible:

1. That you know all variables (in order to control some of them and measure others) before you start; or
2. That you can in fact control all or indeed any variables without creating disorder in the life system.

Every experiment is carried out by people, and the results are imparted to people. Thus living things conduct and impart knowledge. To ignore life in the system studied, one has to ignore oneself. Life exists in conditions of flux, not imposed control, and responds to any form of control in a new fashion. Living things respond to strict control (either by removal of stimuli or by constant input of stimuli) by becoming *uncontrolled,* or (in the case of people and rats at least) by dysfunction, or by going mad.

Experiments, therefore, are not decisive, rigid, or true findings but an eternal search for the variables that have *not* been accounted for previously. This is the equivalent of true believers, in their empirical approach to the knowledge of God's name. They simply keep chanting variables of all possible names until (perhaps) they hit on the right one. Thus does science proceed in biological experiments.

Scientists who "know" and observe, don't usually apply their knowledge in the world. Those who "act", often don't know or observe. This has resulted in several tragic conditions, where productive natural ecosystems have been destroyed to create unproductive cultivated systems, breaking every sane environmental principle to do so. Energy–efficient animals (deer, kangaroo, fish) have been displaced by inefficient animal systems (sheep, cattle). Every widespread modern agricultural system needs great energy inputs; most agriculture destroys basic resources and denies future yields.

As Edward Goldsmith makes clear ("Thermodynamics or Ecodynamics", *The Ecologist*, 1981), many scientists refuse to consider the function of life in such systems. Natural systems disintegrate and decay, producing more and more helpless plants, animals, and people, and the State or the farmer takes over the function of natural processes. (The State becomes the father of the orphaned child, the farmer the father of the orphaned chicken.) It is only by returning self–regulating function and responsibility to living things (such as people) that a stable life system can evolve.

Scientific method is one of the ways to know about the real world, the world we are part of and live in. Observation and contemplative understanding is another. We can find out about many things, both living and inorganic, by timing, measuring, and observing them; enough to make calendars, computers, clocks, meters, and rulers, but not ever enough to understand the complex actions in even a simple living system. You can hit a nail on the head, or cause a machine to do so, and get a fairly predictable result. Hit a dog on the head, and it will either dodge, bite back, or die, but it will never again react in the same way. We can predict only those things we set up to be predictable, not what we encounter in the real world of living and reactive processes.

Ecologists and "whole systems" people struggle to understand open and complex systems, even though they realise that they too are a part of the system they study. In fact, given enough limnologists (those who study freshwater lakes and lake organisms), these become the most important factor in the spread of lake organisms via their boats, boots, and nets! (It is also time, I feel, for students of communities to form a *community* of students of communities and keep out of everybody else's hair!)

Overseas aid is perilously close to being a very good reason for overseas aid to be necessary, as spies need counterspies. I shudder to think that if we train more brain surgeons, they must cut open more brains in order to support themselves... imagine! I think it fair to say that if you submit to poverty, you equip yourself to know about poverty, and the same goes for lobotomy.

There are several ways not to face life: by taking drugs, watching television, becoming a fakir in a cave, or reading in pure science. All are an abdication of personal responsibility for life on earth (including, of course, one's own life). Value- and ethic-free lifestyles are as aberrant in science as in society.

> It is the quantifiability of many... scientific concepts that have led to their adoption by scientists often regardless of the fact that, as they are defined, they correspond to nothing whatsoever in the world of living things.
>
> (E. Goldsmith, 1981 "Thermodynamics or Ecodynamics", *The Ecologist.)*

Perverse planning is everywhere obvious: houses face not the sun, but rather the road, lawns replace gardens, and trees are planted to be pruned and tended. Make-work is the rule, and I suspect that most theoretical scientists inhabit demented domestic environments, just as many psychiatrists are inhabitants of mental institutions.

Scientific (and non-scientific) groups or individuals can make progress in finding solutions to specific problems. The following approaches do very well (designers please note):

1. IMPROVING TOOLS, or inventing new tools for specific jobs.
2. COLLECTING A LARGE SET OF OBSERVATIONS on occurrences, or samples of a set of phenomena, and sorting them on the basis of likeness–unlikeness (by establishing systems and system boundaries, categories, and keys to systems). This process often reveals common characteristics of diverse elements, and leads to an understanding of common traits, suggesting (by analogy) strategies in design.
3. INSIGHT : the "Aha!" or "Eureka!" response to observation. This, as is well recorded, comes to the individual as though by special gift or providence. In fact, it is quite probably the end point of 2.
4. TRIALS: "give it a try and see if it works". This empirical approach simply eliminates those things that don't work. It does not necessarily establish how or why something works, or even if it works in the long run.
5. GUESSING: the best guesses are based on trials that are already known to work.
6. OBSERVING UNIQUE EVENTS and taking note of them (the "discovery" of penicillin).
7. ACCIDENT: trials set up for one reason work in a way not predicted or foreseen; compounds made for one purpose are applied to another.
8. IMITATION: by testing already-known effects (discovered by others).
9. PATTERNING: by seeing a pattern to events of often very different natures, and thus producing insights into underlying effects. Often preceded by 2 above, but rare in science.
10. COMMONSENSE: often called "management" in business and natural systems control. This consists of staying with and steering a system or enterprise through constant adjustment to a successful conclusion or result. It also suits evolving systems, and is the basis of continuous change and adjustment.

2.3
APPLYING LAWS AND PRINCIPLES TO DESIGN

Principles differ from dogmas in that there are no penalties for error, but only learning from error, which leads to a new evolution. Dogmas are rules which are intended to force centralised control (often by guilt), and it is obvious that every such rule or law represents a failure of the social system. It is too late to fail, but never too late to adopt sensible principles for our guidance, and to throw away the rule book.

<u>Life Intervention Principle</u>
In chaos lies unparalleled opportunity for imposing creative order.

Just join with one or two friends to make your way in the confusion. Others will follow and learn.

There is only one law that is offered to us by such education as we derive from nature, and that is the law of return, which can be stated in many ways:

<u>Law of Return</u>
"Whatever we take, we must return", or

"Nature demands a return for every gift received," or "The user must pay."

We should examine, and act on, the forms of this law. It is the reason why this book carries a tree tax: that we may be able to continue in the use of books. It is why we must never buy books or newspapers that do *not* tax, nor goods where the manufacturer does not recycle or replant the materials of the manufacture. It is why we must carefully study how to use our wastes, and this includes our body wastes. Put in the form of a directive or policy statement, this law would read:

Every object must responsibly provide for its replacement; society must, *as a condition of use*, replace an equal or greater resource than that used.

Inherent in such a law are the concepts of replanting, recycling, durability, and the correct or beneficial disposal of wastes. Nature has extreme penalties for those who break such laws, and for their descendants and neighbours.

Nor can we deny immanence; if a landscape delights us, we should not insult it with castles on peaks, roadways, and clear–cuts. We should return the pleasure we get from natural prospects, and maintain their integrity. It would be pleasant indeed were the land around us always to appear welcoming or non–threatening. This effect, too, can be created or destroyed. There is no reason not to bury our necessary constructs in earth, or clothe them with vegetation. If we want pleasure in life, then we should preserve the life around us.

Energies enter a system, and either remain or escape. Our work as permaculture designers is to prevent energy leaving before the basic needs of the whole system are satisfied, so that growth, reproduction, and maintenance continue in our living components.

All permaculture designers should be aware of the fundamental principles that govern natural systems. These are not immutable rules, but can be used as a set of directives, taking each case as unique but gaining confidence and inspiration from a set of findings and solutions in other places and other times. We can use the guiding principles and laws of natural systems, as formulated by such people as Watt, Odum, and Birch, and apply some of them to our consciously–designed ecologies.

One such law is the basic law of thermodynamics, as restated by Watt[13]:

> All energy entering an organism, population or ecosystem can be accounted for as energy which is stored or leaves. Energy can be transferred from one form to another, but it cannot disappear, or be destroyed, or created. No energy conversion system is ever completely efficient.

As stated by Asimov (1970):

> The total energy of the universe is constant and the total entropy is increasing.

Entropy is bound or dissipated energy; it becomes unavailable for work, or not useful to the system. It is the waters of a mountain stream that have reached the sea. It is the heat, noise, and exhaust smoke that an automobile emits while travelling. It is the energy of food used to keep an animal warm, alive, and mobile. Thus, ambient and useful energy storages are degraded into less useful forms until they are no longer of any use to our system.

The question for the designer becomes, "How can I best use energy before it passes from my site, or system?" Our strategy is to set up an interception net from "source to sink". This net is a compound web of life and technologies, and is designed to catch and store as much energy as possible on its way to increasing entropy (as in **Figure 2.1**).

Therefore, we design to catch and store as much water as possible from the hills before it ends up at its "sink" in the quiet valley lake. If we made no attempt to store or use it as it passes through our system, we would suffer drought, have to import it from outside our system, or use energy to pump it back uphill.

Although the material world can perhaps be predictably measured (at least over a wide range of phenomena), by applications of the laws of thermodynamics, these relate mainly to non–living or experimentally "closed systems". The concept of entropy is not necessarily applicable to those living, open earth systems with which we are involved and in which we are immersed. Such laws are more useful in finding an effective path through material technologies than through a life–complexed world. The key word in open systems is "exchange". For example, on the local level, cities *appear* to be "open", but as they return little energy to the systems that supply them, and pass on their wastes as pollutants to the sea, they are *not* in exchange but in a localised one–way trade with respect to their food resource. All cities break the basic "law of return".

Life systems constantly organise and create complex storages from diffuse energy and materials, accumulating, decomposing, building, and transforming them for further use. We can use these effects in the design process by finding pathways or routes by which life systems convert diffuse materials into those of most use. For example, if we have a "waste" such as manure, we can leave it on a field. Although this is of productive use, we have only achieved one function. Alternatively, we can route it through a series of transformations that give us a variety of resources.

First we can ferment it, and distill it to alcohol, and secondly route the waste through a biogas digester, where anaerobic organisms convert it to methane, of use as a cooking or heating gas, or as fuel for vehicles. Thirdly, the liquid effluent can be sent to fields, and the

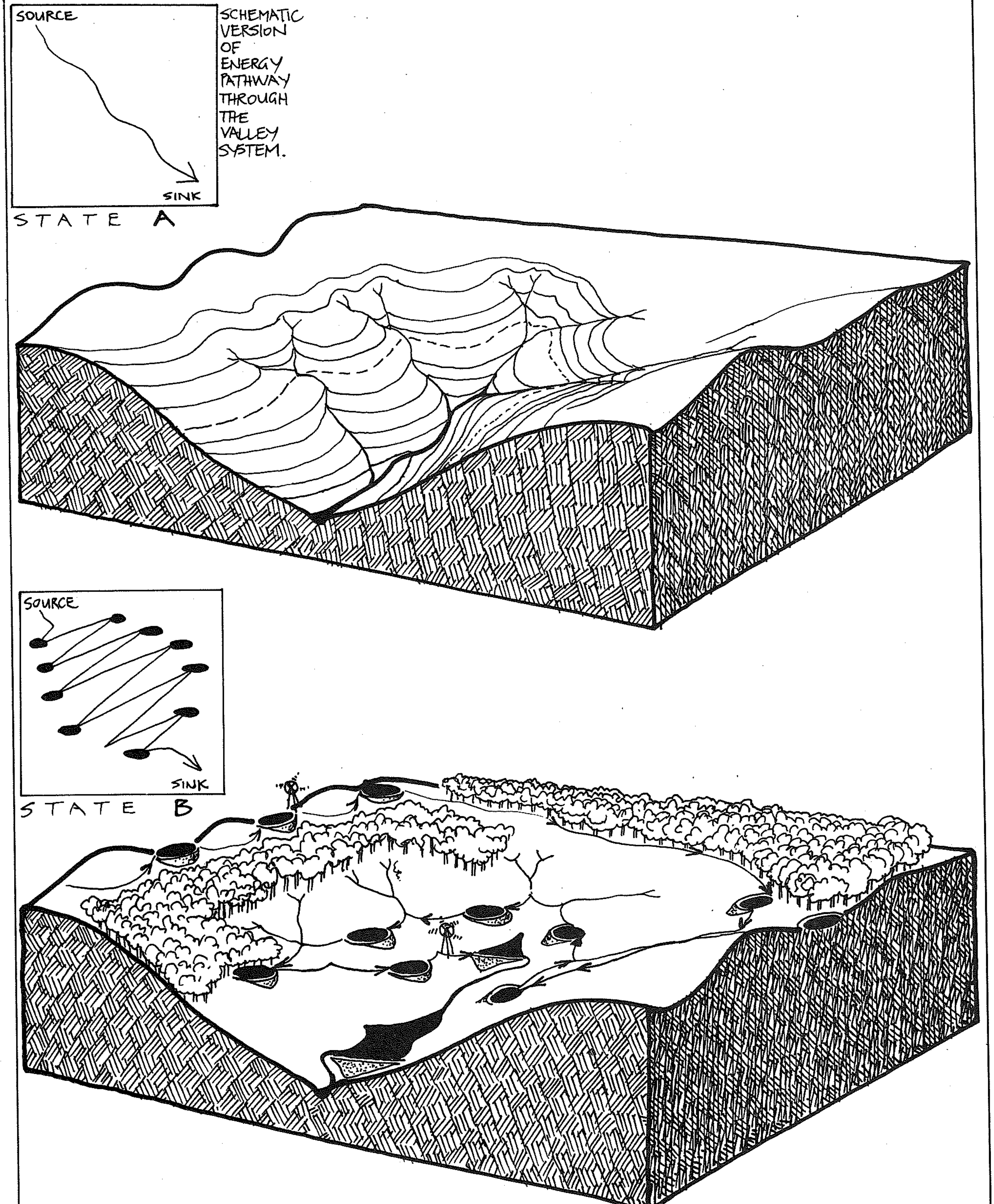


FIGURE 2.1
DESIGNING TO CATCH AND STORE ENERGY.
The designer's work is to set up useful energy storages in a landscape or building (proceeding from State A to State B). Such storages, available for increasing yields, are called resources.

solid sludge fed to worms, which convert it to rich horticultural soil. Fourthly, the worms themselves can be used to feed fish or poultry.

Birch states six principles of natural systems:

1. "Nothing in nature grows forever."
   (There is a constant cycle of decay and rebirth.)
2. "Continuation of life depends on the maintenance of the global bio-geochemical cycles of essential elements, in particular carbon, oxygen, nitrogen, sulphur, and phosphorus."
   (Thus, we need to cycle these and other minor nutrients to stimulate growth, and to keep the atmosphere and waters of earth unpolluted.)
3. "The probability of extinction of populations or a species is greatest when the density is very high or very low."
   (Both crowding and too few individuals of a species may result in reaching thresholds of extinction.)
4. "The chance that species have to survive and reproduce is dependent primarily upon one or two key factors in the complex web of relations of the organism to its environment."
   (If we can determine what these critical factors are, we can exclude, by design, some limiting factors, e.g. frost, and increase others, e.g. shelter, nest sites).
5. "Our ability to change the face of the earth increases at a faster rate than our ability to foresee the consequence of such change."
   (Hence the folly of destroying life systems for short-term profit.)
6. "Living organisms are not only means but ends. In addition to their instrumental value to humans and other living organisms, they have an intrinsic worth."
   (This is the *life ethic* thesis so often missing from otherwise ethical systems.)

Although these principles are basic and inescapable, what we as designers have to deal with is survival on a particular site, here and now. Thus, we must study whether the resources and energy consumed can be derived from renewable or non-renewable resources, and how non-renewable resources can best be used to conserve and generate energy in living (renewable) systems. Fortunately for us, the long-term energy derived from the sun is available on earth, and can be used to renew our resources if life systems are carefully constructed and preserved.

There are thus several practical design considerations to observe:

- The systems we construct should last as long as possible, and take least maintenance.
- These systems, fueled by the sun, should produce not only their own needs, but the needs of the people creating or controlling them. Thus, they are sustainable, as they sustain both themselves and those who construct them.
- We can use energy to construct these systems, providing that in their lifetime, they store or conserve more energy than we use to construct them or to maintain them.

The following are some design principles that have been distilled for use in permaculture:

1. WORK WITH NATURE, RATHER THAN AGAINST IT. We can assist rather than impede natural elements, forces, pressures, processes, agencies, and evolutions. In natural successions, grasses slowly give way to shrubs, which eventually give way to trees. We can actively assist this natural succession not by slashing out weeds and pioneers, but by using them to provide microclimate, nutrients, and wind protection for the exotic or native species we want to establish.

"If we throw nature out the window, she comes back in the door with a pitchfork" (Masanobu Fukuoka). For example, if we spray for pest infestations, we end up destroying both pests and the predators that feed on them, so the following year we get an explosion of pests because there are no predators to control them. Consequently, we spray more heavily, putting things further out of balance. Unfortunately, all the pests are never killed, and the survivors breed more resistent progeny (nature's pitchfork!)

2. THE PROBLEM IS THE SOLUTION. Everything works both ways. It is only how we see things that makes them advantageous or not. If the wind blows cold, let us use both its strength and its coolness to advantage (for example, funneling wind to a wind generator, or directing cold winter wind to a cool cupboard in a heated house). A corollary of this principle is that everything is a positive resource; it is up to us to work out *how* we may use it as such. A designer may recognise a specific site characteristic as either a problem or as a unique feature capable of several uses, e.g. jagged rock outcrops. Such features can only become "problems" when we have already decided on imposing a specific site pattern that the rock outcrop interferes with. It is not a problem, and may be an asset if we accept it for the many values it possesses. "The problem is the solution" is a Mollisonism implying that only our fixed attitudes are problems when dealing with things like rock outcrops! A friend has included several natural boulders in her home, with excellent physical, aesthetic, and economic benefit; the builder would have removed them as "problems", at great expense.

3. MAKE THE LEAST CHANGE FOR THE GREATEST POSSIBLE EFFECT. For example, when choosing a dam site, select the area where you get the most water for the least amount of earth moved.

4. THE YIELD OF A SYSTEM IS THEORETICALLY UNLIMITED. The only limit on the number of uses of a resource possible within a system is in the limit of the information and the imagination of the designer. If you think you have fully planted an area, almost any other innovative designer can see ways to add a vine, a fungus, a beneficial insect, or can see a yield potential that has been ignored. Gahan Gilfedder at the Garden of Eden in Australia found an unsuspected market for cherimoya seed, required by nurseries as seed stock for

grafting. This made a resource from a "waste" product derived from damaged fruit.

5. EVERYTHING GARDENS. A Mollisonian principle is that "everything makes it own garden", or everything has an effect on its environment. Rabbits make burrows and defecation mounds, scratch out roots, create short swards or lawns, and also creates the conditions favourable for weeds such as thistles. People build houses, dispose of sewage, dig up soils for gardens, and maintain annual vegetable patches. We can "use" the rabbit directly as food, to help in fire control, to prepare soil for "thistles" (cardoons and globe artichokes), and to shelter many native animal species in their abandoned burrows. Rabbits maintain species–rich moorland swards suited to many orchids and other small plants. It is a matter of careful consideration as to where this rabbit, and ourselves, belong in any system, and if we should control or manage their effects or tolerate them. When we examine how plants and animals change ecosystems, we may find many allies in our efforts to sustain ourselves and other species. (See **Figure 2.2**).

2.4 RESOURCES

The energies coming into our system are such natural forces as sun, wind, and rain. Living components and some technological or non–living units built into the system translate the incoming energies into useful reserves, which we can call *resources*. Some of these resources have to be used by the system for its own purposes (stocks of fish must be maintained to produce more fish). An ideal technology should at the very least fuel itself.

The surplus, over and above these system needs, is our *yield*. Yield, then, is any useful resource surplus to the needs of the local system and thus available for use, export or trade. The way to obtain yield is to be conservative in resource use, for energy, like money, is much more easily saved than generated. Resource saving involves recycling waste, insulating against heat loss, etc. Then, we can work out paths or routes to send resources on to their next "use point".

If the aim of functional design is to obtain yields, or to provide a surplus of resources, it is as well to be clear about just what it is that we call a resource, and what categories of resource there are, as these latter may affect our strategies of use. In short, we cannot use all resources in the same way and to the same ends. Ethics of resource use are evolved by knowing about the results of resource exploitation. Forests, soils, air, water, sunlight, and seeds are resources that we all regard as part of a common heritage.

A second category of resource is that which belong to us as group, family, or person: those fabricated, ordered, or otherwise developed resources that people create by their work, and of which a presence or absence does not apparently affect the common resource. What we create, however, is *always made from the common resource*, so that it is impossible to draw a line between these categories.

What other ways can we look at resources? Let us try a use–and–results approach. What happens if we use some resources, if we look upon them as a yield? We then find that a response or result follows. Resources are:

1. THOSE WHICH INCREASE BY MODEST USE. Green browse is an example: if deer do not browse shrubs, the latter may become woody and unpalatable. Also, a browsed biennial, unable to flower, may tiller out and become perennial (e.g. the fireweed *Erechthites* nibbled by wallaby in Tasmania). Seedling trees can be maintained at browse height, but if ungrazed, "escape" to unbrowsable height and shade out other palatable plants. *Overgrazing* may (by damage) cause extinction of palatable selected browse and browsers, but underbrowsing may cause similar effects. *Information* is another resource that can increase with use. It withers or is outdated if not used. Too little impoverishes a system, but when freely used and exchanged, it flourishes and increases.

2. THOSE UNAFFECTED BY USE. In impalpable terms, a view or a good climate is unaffected by use. In palpable terms the diversion of a part of a river to hydroelectric generation or irrigation (the water returned to the stream after use), is also unaffected, as is a stone pile as mulch, heat store, or water run–off collector. A well–managed ecosystem is an example of resources unaffected by use.

3. THOSE WHICH DISAPPEAR OR DEGRADE IF NOT USED. For example an unharvested crop of an annual, or a grass which could be stored for the winter, irruptions of oceanic fish, swarms of bees or grasshoppers, ripe fruit, and water run–off during rains.

4. THOSE REDUCED BY USE. For example a fish or game stock unwisely used, clay deposits, mature forests, and coal and oil.

5. THOSE WHICH POLLUTE OR DESTROY OTHER RESOURCES IF USED. Such as residual poisons in an ecosystem, radioactives, super-highways, large buildings or areas of concrete, and sewers running pollutants to the sea.

Categories 1 to 3 are those most commonly produced in natural systems and rural living situations, and are the only sustainable basis of society. Categories 4 and 5 are as a result of urban and industrial development, and if not used to produce permanent beneficial changes to the ecosystem, become pollutants (some are permanent pollutants in terms of the lifetimes of people).

It follows that a sane society manages resources categories 1 to 4 wisely, bans the use of resource category 5, and regulates all uses to produce sustainable yield. This is called resource management, and has been successfully applied to some fish and animal populations, but seldom to our own lives. Investment priorities can be decided on the same criteria, at both the national and household level.

Policy of Resource Management

A responsible human society bans the use of resources which permanently reduce yields of sustainable resources, e.g. pollutants, persistent poisons, radioactives, large areas of concrete and highways, sewers from city to sea.

Failure to do this will cause the society itself to fail, so that programmes of highway building and city expansion, the release of persistent biocides, and loss of soil will bring any society down more surely and permanently than war itself. Immoral governments tolerate desertification and land salting, concreted highways and city sprawl, which take more good land permanently out of life production than the loss of territory to a conqueror. Immorality of this nature is termed "progress" and "growth" to confuse the ignorant and to supplant local self-reliance for the temporary ends of centralised power.

The key principle to wise resource use is the principle of "enough". This is basic to understanding

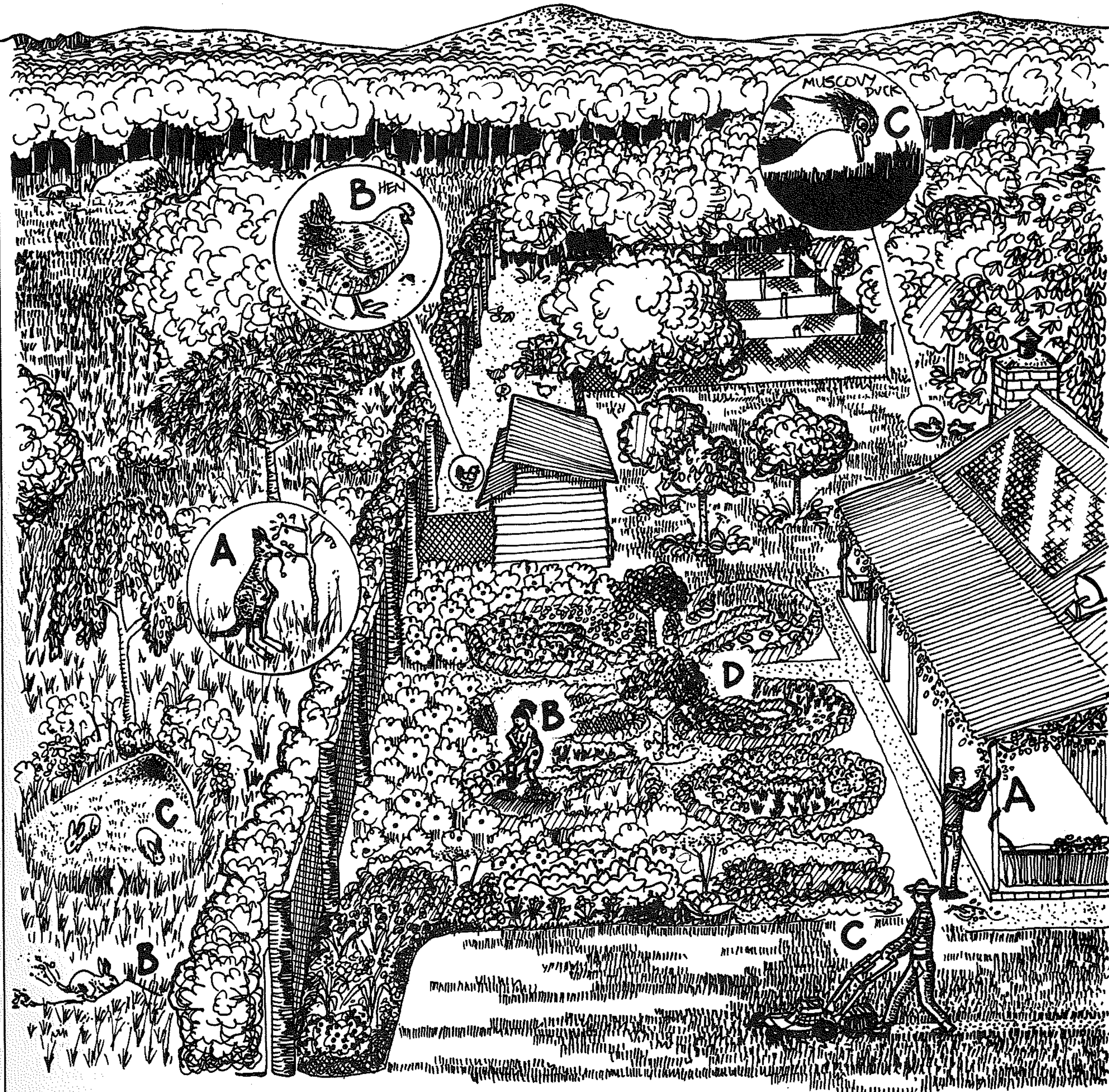


FIGURE 2.2

EVERYTHING GARDENS.

A – Pruning, B – Digging, C – Mowing, D – Typical plant assembly for species. Some species (*Oryctolagus, Cuniculus, Macropus, Gallus, Cairina*, and *Homo sapiens*) at work in their fields. Plants developed by each species are maintained in similar deflection states as lawns, pruned trees, flat weeds, and characteristic herbage around dwellings.

societies in chaos or systems in disorder. Today superhighways and overpasses in Massachusetts alone need some 400 billion dollars to repair, and the collapsing sewer systems of London and New York some 80 billions. Neither Massachusetts, London, nor New York can raise this money, which shows that an unthinking historical development strategy can cripple a future society. Today's luxuries are tomorrow's disasters.

Principle of Disorder
Any system or organism can accept only that quantity of a resource which can be used productively. Any resource input beyond that point throws the system or organism into disorder; oversupply of a resource is a form of chronic pollution.

Both an over– and undersupply of resources have much the same effect, except that oversupply has more grotesque results in life systems than undersupply. To a degree, undersupply can be coped with by reduced growth and a wider spacing or dispersal of organisms, but oversupply of a resource can cause inflated growth, crowding, and sociopathy in social organisms. In people, both gross over– and under–nutrition are common. Ethical resource management is needed to balance out the pathologies of famine and obesity.

2.5 YIELDS

Yields can be thought of in immediate, palpable, and material ways, and are fairly easily measured as:

1. PRODUCT YIELD: The sum of primary and derived products available from, or surplus to, the system. Some of these are intrinsic (or precede design), others are created by design.

2. ENERGY YIELD: The sum of conserved, stored, and generated energy surplus to the system, again both intrinsic and those created by design.

Impalpable yields are those related to health and nutrition, security, and a satisfactory social context and lifestyle. Not surprisingly, it is the search for these invisible yields that most often drives people to seek good design or to take up life on the land, for "what does it benefit a man if he gains the whole world and loses his soul?" Thus, we see the invisible yields in terms of values and ethics. This governs our concept of needs and sets the limits of "enough". Here, we see an ethical basis as a vital component of yield.

Although all systems have a natural or base yield depending on their productivity, our concern in permaculture is that this essential base yield is sustainable. Several factors now operate to reduce the yield of natural systems. In the simplest form, this is the overuse of energy in degenerative systems due to the unwise application of fossil fuel energy. "Poisoning by unproductive use" is observable and widespread. Thus we must concentrate on productive use, which implies that the energy used is turned into biological growth and held as basic living material in the global ecosystem. Unused, wasted, or frivolously used resources are energies running wild, which creates chaos, destroys basic resources, and eventually abolishes all yield or surplus.

In design terms, we can find yields from those living populations or resources which are the stocks of the biologist (the so–called standing crop) or from non–living systems such as the climatic elements, chemical energy, and machine technology. There is energy stored by extinct life as coal, oil, and gas; energy left over from the formation of the earth as geothermal energy; tides; and electromagnetic and gravitational forces. Cosmic and solar energies impinge on the earth, and life intercepts these flows to make them available for life forms.

In our small part of the system (the design site) our work is to store, direct, conserve, and convert to useful forms those energies that exist on, or pass through, the site. The total sum of our strategy, in terms of surplus energy usefully stored, is the *system yield* of design.

Definition of System Yield
System yield is the sum total of surplus energy produced by, stored, conserved, reused, or converted by the design. Energy is in surplus once the system itself has available all its needs for growth, reproduction, and maintenance.

Some biologists may define yield or production in more narrow terms, accepting that a forest, lake, or crop has a finite upper limit of surplus due to substrate conditions and available energy. We do not have to accept this, as it is a passive approach, inapplicable to active and conscious design or active management using, for example, fertilisers, windbreaks, or selected species.

Even more narrowly defined is the yield of agricultural economists, who regard a single product (peaches/ha) as the yield. It may be this approach itself itself which is the true limit to yield!

A true accounting of yield takes into consideration both upstream costs (energy) and downstream costs (health). The "product yield" may create problems of pollution and soil mineral loss, and cost more than it can replace.

The very concept of surplus yield supposes either flow through or growth within our system. Coal and rock do not have yield in this sense; they have a finite or limited product. Only life and flow can yield continually, or as long as they persist. Thus the energy stocks of any system are the flows and lives within it. The flow may exist without life (as on the moon), where only technology can intervene to obtain a yield, but on earth at least, life is the intervening strategy for capturing flow and producing yield. And technology depends on the continuation of life, not the opposite.

The Role of Life in Yield

Living things, including people, are the only effective intervening systems to capture resources on this planet, and to produce a yield. Thus, it is the sum and capacity of life forms which decide total system yield and surplus.

We have long been devising houses, farms, and cities which are energy–demanding, despite a known set of strategies and techniques (all well tried) which could make these systems energy–producing. It has long been apparent that this condition is deliberately and artificially maintained by utilities, bureaucracies, and governments who are composed of those so dependent on the consumption and sale of energy resources that without this continuing exploitation they themselves would perish.

In permaculture, we have abundant strategies under the following broad categories which can create yields instead of incurring costly inputs or energy supply.

STRATEGIES THAT CREATE YIELDS.

Physical–Environmental:

- The creation of a niche in space; the provision of a critical resource.
- The rehabilitation and creation of soils.
- The diversion of water, and water recycling.
- The integration of structures and landscape.

Biological:

- The selection of low–maintenance cultivars and species for a particular site.
- Investigation of other species for usable yields.
- Supplying key nutrients; biological waste recycling (mulch, manure).
- The assembly of beneficial and cooperative **guilds** of plants and animals.

Spatial and Configurational:

- **Annidation** of units, functions, and species (annidation is a design or pattern strategy of "nesting" or stacking one thing within another, like a bowl in a bowl, or a vine in a tree).
- **Tessellation** of units, functions, and species (tessellation is the forming or arranging of a mosaic of parts).
- Innovative spatial geometry of designs as **edge** and **harmonics**.
- Routing of materials or energy to next best use.
- Zone, sector, slope, orientation, and site strategies (Chapter 3).
- Use of special patterns to suit irrigation, crop systems, or energy conservation.

Temporal:

- Sequential annidation (interplant, intercrop).
- Increasing cyclic frequency.
- Tessellation of cycles and successions, as in browsing sequences.

Technical:

- Use of appropriate and rehabilitative technology.
- Design of energy–efficient structures.

Conservation:

- Routing of resources to next best use
- Recycling at the highest level.
- Safe storage of food product.
- **No–tillage** or low–tillage cropping.
- Creation of very durable systems and objects.
- Storage of run–off water for extended use.

Cultural:

- Removing cultural barriers to resource use.
- Making unusual resources acceptable.
- Expanding choices in a culture.

Legal/Administrative:

- Removing socio–legal impediments to resource use.
- Creating effective structures to aid resource management.
- Costing and adjusting systems for *all* energy inputs and outputs.

Social:

- Cooperative endeavours, pooling of resources, sharing.
- Financial recycling within the community.
- Positive action to remove and replace impeding systems.

Design:

- Making harmonious connections between components and sub–systems.
- Making choices as to where we place things or how we live.
- Observing, managing, and directing systems.
- Applying information.

This approach to potential production is beyond that of product yield alone. It is theoretically unlimited in its potential, for system yield results from the number of strategies applied, what connections are made, and what information is applied to a particular design.

Now we see that yield in design is not some external, fixed, immutable quantity limited by circumstances that previously existed, but results from our behaviour, knowledge, and the application of our intellect, skill, and comprehension. These can either limit or liberate the concept of yield. Thus, the profound difference between permaculture design and nature, is that in permaculture we actively intervene to supply missing elements and to guide system evolution.

Limits to Yield

Yield is not a fixed sum in any design system. It is the measure of the comprehension, understanding, and ability of the designers and managers of that design.

Defined in this way, yield has no known limits, as we cannot know all ways to conserve, store, and save energy, nor can we fail to improve any system we build and observe. There is always room for another plant, another cycle, another route, another arrangement, another technique or structure. We can thus continually shrink the area we need to survive. The critical yield strategy is in governing our own appetites!

Just as we can increase yield, so we can decrease it. The perverse aims of some politicians, developers, and even religious dogmatists limit yield by disallowing certain products as a yield. Just as one's neighbours may refuse the snail and eat the lettuce, refuse the blackbird and eat the strawberry, so we may only "allow" certain types of toilets, or certain plants in gardens or parks. And thus people are the main impediment to using their potential yields.

FARM STRATEGIES:
CATEGORIES AND EXAMPLES.

If we take as a condition the "fencepost-to-fencepost" grasslands or crops now developing in the western world, and apply the strategies given, then yields will increase. How these systems interact raises yield even more, but on their own they are sufficiently impressive.

Water Storage:
(12–20% of landscape).

1. Product increase, e.g. animal protein production (water is more productive per unit area than land; fish more efficient at food conversion than cattle).
2. Product increase on land remaining due to:
   - irrigation; and
   - water nutrient quality from, e.g. fish manure.
3. Interaction, e.g. ducks on water to increase yields in and around ponds (e.g. pest and weed control, manure).
4. **Microclimatic** buffering due to water bodies (see Chapter 5, Climatic Factors).

Land Forming:

1. Product increase due to even irrigation (no dry areas or waterlogging).
2. Land stability due to reduction of soil loss from water run-off or salting.
3. Gravity flow replaces pumped water (depends on site).
4. Recycling of water possible.

Soil Reconditioning:

1. Product increase due to deeper root penetration.
2. Water infiltration (zero run-off) due to absorption.
3. Buffering of soil microclimate (see Chapter 8, Soils).
4. Supply of essential nutrients.

Establishing of Windbreak and Forage Forest:
(20–30% of landscape)

1. Shelter effects, e.g. increase in plant yields, animal protein, and microclimate buffering both above and below ground.
2. Increase in carrying capacity due to shrub and tree forage.
3. Savings on nutrients recycled via legumes and trees.
4. Intrinsic products of the forest, e.g. nectar for honey, seeds, firewood from fallen timber).
5. Insect and bird escapement, and **pest predator** habitat.
6. **Wildlife corridors.**

Selective Farm Reafforestation:
(*not* industrial forestry)

1. Increase precipitation due to night condensation, water penetration (see Chapter 6, Trees and Their Energy Transactions).
2. Product increase due to superiority of perennials over annuals in bulk, energy savings, and length of yield (**Figure: 1.1**).
3. Increase in rainfall due to trees cross-wind (see Chapter 6).
4. Reduced cost and increased capacity due to selected self-forage browse, e.g. drought-proof stockfeed, medicinal qualities of some perennial plants.
5. Reduced cost due to on-farm durable timber, e.g. fence posts, construction material.
6. Reduced carcass loss due to shivering, sweating, exposure.
7. Increased crop production in sheltered areas.
8. Increased carcass weight due to increased food intake in sheltered conditions (not the same as 6. above), i.e. on hot days cattle will graze all day when they are on shaded pasture, instead of sheltering from the sun.
9. Reduced evaporation from ponds due to less wind over water surfaces (see Chapter 5).

Market and Process Strategies:

1. Selected crop for specialty market for price/ha increase, e.g. fresh herbs near a concentration of restaurants.
2. Marketing by self-pick, mail order, direct dispatch, way-side sale.
3. Processing to a higher order of product (e.g. seed to oil).
4. Processing to refined order (e.g. crude eucalyptus oil to fractions).
5. Money saved by processing fuels on farm; plus sale of surplus fuel.

Social/Financial:

1. Market stability gained by farm-link strategy, where an urban group contracts to buy specific produce from the farmer.
2. Income from field days and educational courses.
3. Rental or income from urban visitors e.g. a guest house or holiday farm.
4. Direct investment by city people in a particular farm.
5. Formation of a local credit union and bank for the district, thus recycling money locally.
6. Vehicle and implement pool with neighbours; schedules of sowing and reaping worked out (capital saved 90%).
7. Labour exchange with neighbours.
8. Produce and marketing cooperatives.

Crop techniques:

1. Low or no-tillage farming saves:
   - energy in reduced tillage;
   - soil;
   - water and reduces evaporation; and
   - time between crops.

To put these into practical terms, I have culled from an interview with a farmer (Norm Sims, *Weekly Times*, 5 Jan. 1983) statements on savings due to some site strategies applied. On land–forming: "We expect to double production over the next few years, using half the irrigation waters" (4 times benefit); "Salinity is reduced". In severe drought: "Pasture production has never looked better and water is available". "It took us six days to irrigate what we now do in two..." and, "Rather than restricting watering intervals we are restricting the area" (aiming to milk 185 cows on 24 ha. On grazing rotation and electric fencing: "26 paddocks are grazed in a 21 day rotation" (average field of 1.6 ha each with a trough water–point for cattle).

Here, there are these specific strategies in use:

- laser levelling of fields for even irrigation;
- water reticulation;
- water storage and recycling;
- grazing rotation of 21 days;
- central access road;
- crop for concentrated rations grown; and
- pasture area reduced to give best watering regime.

It seems obvious from the foregoing that the *primary* and *certain* increases in crop yield do not just come from varietal selections (a fiction promulgated by agricultural companies, seed patent holders, agricultural researchers, or extension officers), but from attention to site design and development, followed by wise enterprise selection to suit the (modified) site, concurrently with a marketing and processing strategy.

As these are often permanent or durable strategies, it is not in the commercial interest to encourage them, as the continuous benefit is to the farmer alone, and the role of middlemen and traders is reduced. But, in the western world, the 4–6% of us in essential production are in fact enslaved, while the remaining 96% are deriving secondary or tertiary benefits without adequate return to the primary producers. This can only result in a weak economy, waste, and irresponsibility for life existence based on the expectation that the world owes politicians, students, and middlemen a living.

Benefits, like wastes, must be *returned* or recycled to keep any system going. Accumulations of unused benefits are predictive of a collapse at production level; thence, throughout all tiers of the system.

EXTENDING YIELDS

The concentration of yields into one short period is a fiscal, not an environmental or subsistence strategy, and has resulted in a "feast and famine" regime in markets and fields, and consequent high storage costs. Our aim should be to disperse food yield over time, so that many products are available at any season. This aim is achieved, in permaculture, in a variety of ways:

- By selection of early, mid and late season varieties.
- By planting the same variety in early or late–ripening situations.
- By selection of varieties that yield over a long season.
- By a general increase in diversity in the system, so that:
- Leaf, fruit, seed and root are all product yields.
- By using self–storing species such as tubers, hard seeds, fuelwood, or rhizomes which can be cropped on demand.
- By techniques such as preserving, drying, pitting, and cool storage.
- By regional trade between communities, or by the utilisation of land at different altitudes or latitudes.

YIELDS AND STORAGE

How yields endure is important, for there are unlimited opportunities to use durable yields in terms of season or lifetime.

By a series of preservation strategies, food can be stored for days, weeks, or years. Water not open to evaporation and pollution, or with natural cleansing organisms, will keep indefinitely. Shelters may outlast the forests that build them, or can be made of living or durable materials such as ivy, concrete, or stone. Energy alone (like the food which is part of energy) is difficult to store. Batteries leak or decay, heat escapes, and insulation breaks down. Only living things, like forests, increase their energy store.

Because of seasonal or diurnal cycles, we should pay close attention to storage strategies. Very little famine would occur could grains, fish, and fruit available in good times be stored for lean times. The strategies of food storage are critical. I believe that people should therefore mulch their recipe books, which often specify out–of–season or not–in–garden foods, and replace them with books that stress either low–energy methods of food preservation, or how to live easily from your garden in season.

CULTURAL IMPEDIMENTS TO YIELD.

I confess to a rare problem—gynekinetophobia, or the fear of women falling on me—but this is a rather mild illness compared with many affluent suburbanites, who have developed an almost total zoophobia, or fear of anything that moves. It is, as any traveller can confirm, a complaint best developed in the affluent North American, and seems to be part of blue toilet dyes, air fresheners, lots of paper tissues, and two showers a day.

It is very difficult, almost taboo, to talk of using rabbits, quail, pigs, poultry, or cows in city farms or urban gardens in the United States. They are common-place city farm animals in England, and are ordinary village animals in Asia. Australians feel no repulsion towards them, and the edible guinea–pig lives comfortably in the homes of South Americans. But in the USA, no!

Useful animals are effectively abolished from American cities, leaving the field wide open for a host of others: pigeons forage the streets, thousands of gulls defecate in New York City reservoirs (fresh from the garbage piles); gigantic garbage bins are tipped over by large, flea–ridden dogs in Los Angeles; rats half the size of dogs (and also flea–ridden) are waiting for the garbage left by the dogs, and have tunnelled under the bus stops in their millions in Washington, D.C. (not far from the White House). They in turn are stalked by mangy cats, who also keep a desultory eye on the billions of cockroaches crawling in most houses. Not to mention the flies.

We will omit the legendary albino alligators of the sewers, and the rejected boa constrictors that pop up in the blue–rinse toilets. So much wasted food breeds its own population of pests. A sensible re–routing of edible garbage through a herd of pigs or a legion of guinea–pigs would abolish much of this nuisance, and a few good Asian restaurants could deal with the cats and dogs. The gulls would starve if chickens were fed on household wastes, and the besieged American might add a very large range of foods to those now available in cities. I mention this only to show that cultural prejudices can grossly reduce the available food resources, and that if we refuse to take sensible actions, some gross results can follow, with the biomass of useful foragers such as domesticated animals replaced by an equivalent biomass of pests.

MAXIMUM PRODUCT YIELD CONCEPT: THE "BIG PUMPKIN" FALLACY.

In a fluctuating climatic and market environment, the concept of forcing a *maximum product yield* is courting disaster. This is, however, the whole impetus of selling (e.g., the "big pumpkin" and "giant new variety" advertisements in seed catalogues), or in prizes awarded at agricultural shows. Better by far are more crop mixes and fail–safe systems that can produce in most conditions (wet or dry, cold or hot), or that hold constant value as subsistence (potato, taro, arrowroot) or have special value (vanilla, quinine, bamboo), or high food value per volume (fish, chicken).

The factors which can increase product yield are these:

- Genetic selection;
- Increased fertiliser (to a limited extent);
- Increased water (to a limited extent);
- Decreased competition from other non–beneficial species; and
- Better management in utilisation of yield and of harvest, timing, and integration.

They are the same factors which cause imbalance, as the selection of types for a particular yield need not be the factor that enables it to produce consistently in field field conditions (whether it be feathering to a "standard" in a chicken, redness in a rose, or weight in a fish). High–producing hens need biennial replacement (thus a constant breeding program) and may not even set their own eggs, thus needing artificial aids. A water and fertiliser–dependent crop is liable to collapse when it is water or nutrient stressed, or becomes too expensive to maintain in any market downturn. To go for one such crop, and so decrease diversity, is to decrease insurance for yield if one species or variety fails or is susceptible to change. Peasant farmers rightly reject advice based on maximum yield fallacies, and even more so if they share crops with a landlord, for they also value their spare time.

In the case of livestock, forced production is eventually limited by insoluble or intractable illnesses, so that in high–producing New Zealand herds, veterinary costs reach $120 per stock unit (for chronic illnesses such as facial eczema and white muscle disease). On less stressed pastures and farms, veterinary costs drop away to $20 or so per unit, top–dressing of pasture is reduced, and healthier herds give healthier yields. In the end, the forcing of product yields creates unique and inflexible health problems in plants, soils, and animals. Such yields become economically and ecologically unsustainable, and a danger to public health. 93% of chickens in battery cages develop cancers. If we eat cancer, we must risk cancer, for "we are what we eat" in a very real sense.

Insurance of some yield on a sustainable basis is better than expensive "feast and famine" regimes. The home garden is one such secure approach, where it is rare for all crops to fail, because of the innate diversity of such a mixed system. In fact, it is commonplace for gardeners to find a garden plant or some varieties fail in any one season, but no great harm results, as many other crops or varieties are available. Thus, species and and variety diversity are what people really need. Plant Variety Rights legislation, plant patenting, and multinational seed resource ownership has had a disastrous effect on the availability of hardy, adapted local varieties of plants, especially in Europe, where some 85% of locally–adapted seed crops have become "illegal", or have disappeared from seed company catalogues.

There are several paths open to us in design, and the least energy path is the one we seek, or evolve towards. There are two ways of producing an egg: the first has become the normal way in the western world (**Figure 2.3**), and the second is the way proposed by permaculture systems (**Figure 2.4**).

Some ridiculous systems have been evolved in which people, machines, time, and energy are expended in vast quantities on the chicken, perhaps with the aim of maximum product yield, regardless of costs. We can short–cut these systems with great gains in personal and planetary health, and with a far greater variety of yields available for local ecologies. These illustrations also bring home the commonsense nature of self–regulated systems.

2.6

CYCLES: A NICHE IN TIME

Cycles are any recurring events or phenomena. They have another implication, which is one of diversion. A cycle is, if you like, an interruption or eddy in the straight–line progression towards entropy. It is the special provenance of life to cycle materials. So efficiently does this happen that in a tropical forest almost all material nutrients are in cycle in life forms. It is this very complex cycling in the tropics which opened up so many opportunities for yield that thousands of species have evolved to take advantage of these.

If NICHES are opportunities in space, CYCLES are opportunities in time (a time–slot) and both together give harbour to many events and species. Geese eat grass, digest it, moult, produce waste products, add parasites, digestive enzymes, acids and alkalis, and defecate. The ground receives the rejecta, the sun shines, and rain may fall. Fungi, bacteria, grass roots and foliage work on feathers and faeces, and re–metabolise them into life. If we reorganise and encourage such cycles, our opportunities to obtain yields multiply. Every peasant farmer who keeps pigeons (as they still do in the Mediterranean borders) knows this truth. Here, every thinking farmer builds his own phosphate factory, as a pigeon loft.

Each such cycle is a *unique event*; diet, choice, selection, season, weather, digestion, decomposition, and regeneration differ each time it happens. Thus, it is the number of such cycles, great and small, that decide the potential for diversity. We should feel ourselves privileged to be part of such eternal renewal. Just by living we have achieved immortality—as grass, grasshoppers, gulls, geese, and other people. We are *of* the diversity we experience in every real sense.

If, as physical scientists assure us, we all contain a few molecules of Einstein, and if the atomic particles of our physical body reach to the outermost bounds of the universe, then we are all *de facto* components of all things. There is nowhere left for us to go if we are already everywhere, and this is, in truth, all we will ever have or need. If we love ourselves at all, we should respect all things equally, and not claim any superiority over what are, in effect, our other parts. Is the hand superior to the eye? The bishop to the goose? The son to the mother?

<u>Principle of Cyclic Opportunity</u>
Every cyclic event increases the opportunity for yield. To increase cycling is to increase yield.

People are built up molecule by molecule, cycling through themselves the materials of their environment: its air, soils, foods, minerals, and pathogens. Over time, people create their own local ecology (as do wombats and all sedentary animals); their wastes, exudae, and rejecta eventually create the very soils in which they garden. "Garbage in, garbage out" applies equally to computers and people. We gardeners are constantly cycling ourselves, and by a generational pattern of adjustment become "eco–compatible" with our landscape and climate. We are not the end point of evolution but a step on the way, and part of a whole sequence of cycles.

It is the number of such degenerative–regenerative cycles, unknowable to us, which determine the number of *opportunities* in the system, and its potential to change, mutate, diversify, and reintegrate. Not only can we never cross the same river twice, we can never see the same view twice, nor know the same system twice. Every cycle is a new opportunity. In nature, it is our right to die and make way for our successors, who are ourselves re–expressed in different forms.

It is our tolerance of the proliferation of life which permits such cycles. Deprived systems, like those blasted by biocides, lose most or all opportunity to transcend their prior state, and the egg of life is broken, degrades, and assumes a lower potential.

Tribal peoples are very much aware of, and tied to, their soil and landscapes, so that their mental and physical health depend on these ties being maintained. The rest of us have suffered forcible, historic dislocations from home sites, and many no longer know where home is, although there are new and conscious moves to reinhabit the earth and to identify with a **bioregion** as "home."

Travel itself causes stress and morbidity. Travellers both carry and acquire pathogens and spread them to other cultures. New settlers bring new species, new timetables, and new concepts. Local systems have to readjust, or fail. These processes are analagous to the disturbance of old ecosystems by new ecological or climatic forces. The post–invasion evolution contains part of the old and part of the new system, so is itself a new assembly with new potentials. Too often, however, we have destroyed very productive local ecologies, only to replace them with energy–consuming "improvements" of our own making. We have assumed the role of the creator, and destroyed the creation to do so.

Cycling of nutrients is continuous in the tropics, but is interrupted wherever drought, cold, or low nutrient status reduces the "base opportunity", just as the killing of fish stocks reduces the yield. Such cycles are slowed or even stopped by climatic factors or by our interference.

Cycles in nature are diversion routes away from entropic ends—life itself cycles nutrients—giving opportunities for yield, and thus opportunities for species to occupy time niches.

Cycles, like comets, have schedules or times to occur. Some are frequent and obvious like day and night, others long–term like sunspot cycles. Both short and long cycles are used in phenomenological reckoning by aborigines, who use cycle–indicators as time maps.

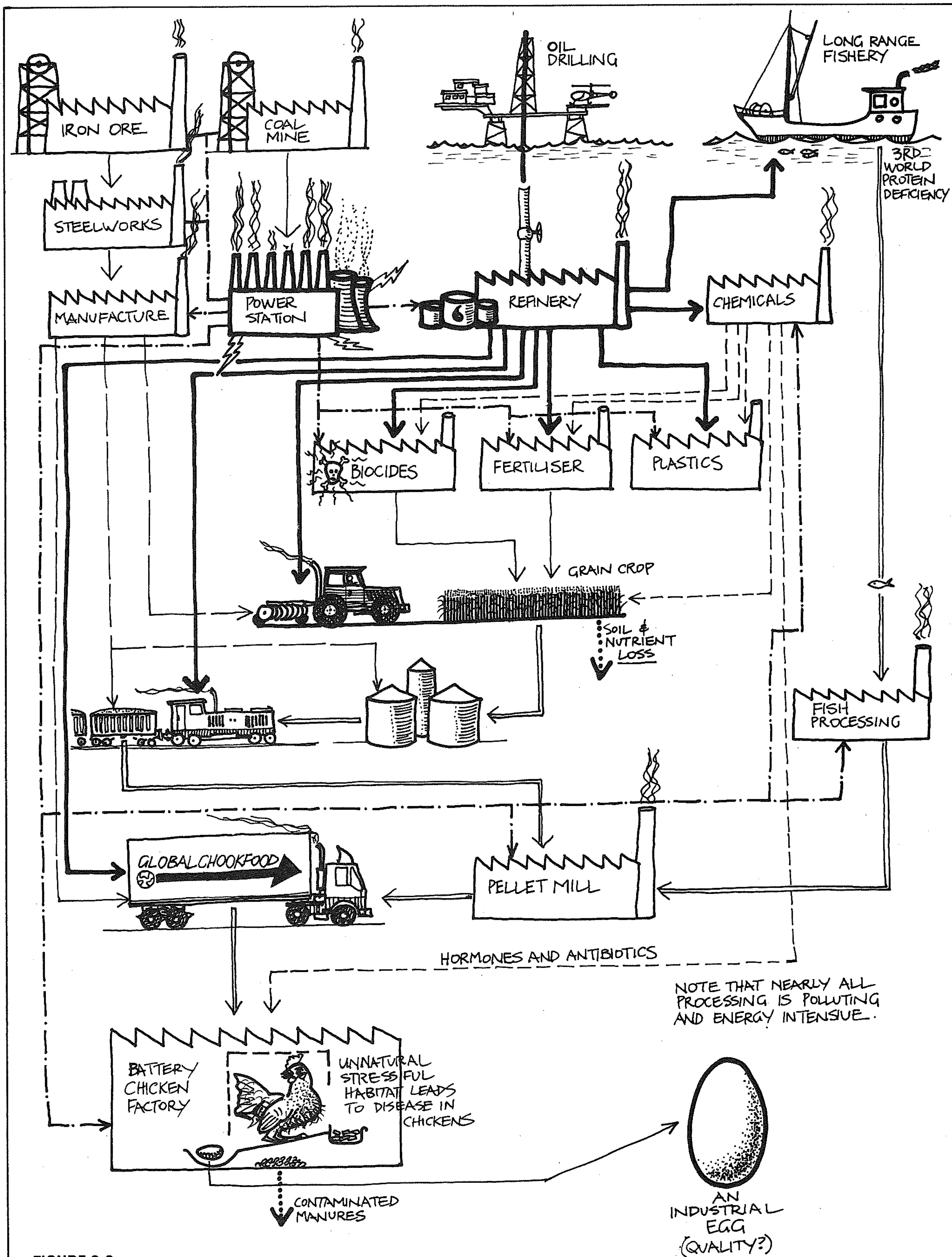


FIGURE 2.3
INDUSTRIAL METHODS OF PRODUCING AN EGG.

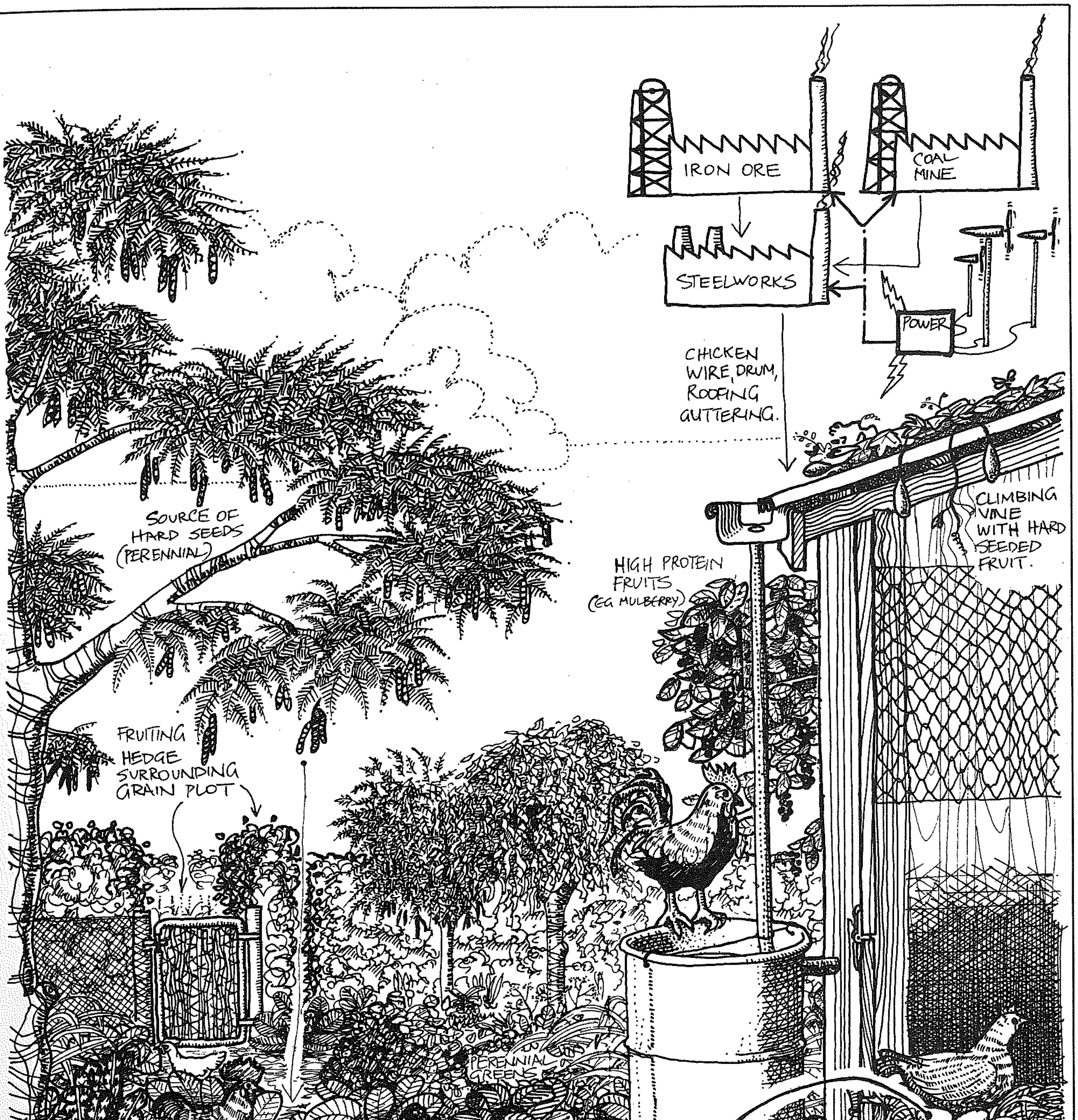


FIGURE 2.4
PERMACULTURE METHODS OF PRODUCING AN EGG.

ASPECTS OF THE TIME RESOURCE.

Time is a resource which can accumulate in ecosystems. It can be "lost" to an evolving or evolved system by setback (adverse disturbance), just about the same way as we can set back the hands of a clock. Such setbacks are termed *deflection states* by ecologists.

Ecosystems, especially those we are in process of constructing or destroying, are always proceding to some other state of evolution. Left alone, they may evolve at their own pace to some unknowable (or imaginary) endpoint, which we once called a climax state. However, forest climax states are temporary events in the long span of geological time.

Australian studies show that old dune forests lose the battle to mobilise nutrients, and begin to show a net nutrient loss, aided by rainfall and occasional fire, until they begin to recede to a less vigorous shrubbery system. Most other (disturbed) forests appear to be building, but (if disturbed too often) never reach the previous vigour, height, or yield. This is obvious to many of us who have seen original, regrowth, and second regrowth tree stands. These show signs of decay at progressively lower heights, and no doubt these too are losing vitality with age. I can sympathise.

Time can work as a rehabilitative resource, for active intervention in such successions enables us to analyse and to supply key nutrients and soil treatments, if needed, to assist maximum forest rejuvenation.

A second time concept is that of life–time, or the "quality time" that we have to enjoy, examine, and understand our world. To the interested observer, it would seem that life–time is very short indeed for those mobile, power–using, bombarded, employed, make–work, and busy humans who make up non–tribal societies, while many tribal peoples still manage to preserve a high quota of the celebrations, discussions, contemplations, mutual preening, and creative artwork on which many of us "wish we had time to spend..."

This erosion of the lifetimes of people, exacerbated by the media and messages of the consumer society, is perhaps the most serious effect of that society.

> Life is too much with us, late and soon
> Getting and gaining, we lay waste our years...
> (W. B. Yeats)

People so harried that they have "no time for anything else", may find that time has run out to save themselves, their lives, or those of their children.

A NICHE IN TIME AND SPACE.

Niche is a place to be, to fit in and find food, shelter, and room to operate. Many such niches are unfilled due to chance factors. Many are wiped out by agriculture or urban sprawl. Many can be created. But in pursuit of a simple food product, most farmers give no place for wildlife, no nesting sites or unbrowsed grass for quail or pheasant (both industrious insect eaters), and often no time for any intelligent assessment of the potential benefits of other species.

Existence is not only a matter of product yield, but a question of appreciating variety in landscape. Evolving plant systems and existing animals provide niches for new species: the cattle egret follows cattle; the burrows of rabbits are occupied by possum, bandicoot, snakes, frogs, and feral cats; and the growing tree becomes a trellis, shade spot, and a host to fungus and epiphytes.

Every large tree is a universe in itself. A tree offers many specialty–forage niches to bird, mammal, and invertebrate species. For instance, yellow–throated honeyeaters (in Tasmania) search the knot–holes for insects, treecreepers the bark fissures, strongbilled honeyeaters the rolls of branch bark and hanging strips of bark, and blackheaded honeyeaters the foliage, where pardalotes specify the scale insects as *their* field. As for time–sharing, the yellow–throats are permanent and territory–holding residents, the treecreepers migrants, the strongbills and blackheads roving flock species, and all of them scatter as breeding pairs in the spring and summer, so that it is rare to find any one tree fully occupied at any one time. There is also a pronounced post–breeding tendency for several bird species to form **consociations** for foraging and travelling in autumn and winter. Five to eight species travel together, some (e.g. fly-catchers) gathering insects disturbed by the others, with all species reacting to the alarm calls of any one species, but some species (mynahs for example) acting as sentinels for the whole mixed company.

Here, we see time, space, and functions all used in a complex and non–competitive way, and glimpse something of the potential for designers to enrich human societies *providing that no individual or group claims a right to sole use at all times* for an area. The failure of a monoculture to produce, sustain, or persist is thus easily explained, as many species are invading or trying to use more efficiently the complex resources of time and space.

A combined space–time factor is called a **schedule**: a time to be in that place. Any observer of public park use sees the usage change hour by hour. Morning joggers give way to lunch–time office workers, who are succeeded by older, retired people playing draughts, later displaced by evening entertainment crowds, and late at night, the people on the edge of time: the semi–legal, the unemployed, and the lonely. Towards dawn, only the lame and isolated strollers, often with dogs for companions, remain on the streets.

Many mammals, forced to develop tracks and resting places, do not control "areas", but rather time–slots in space. My own studies of wild wallaby, urban people, and possum show this to be the case. Fighting occurs when one is *out of schedule*, and ceases when that place is vacated for use.

Schedules may run on long cycles, tuned to the level of browse or succession of vegetation, e.g. a sequence of grazing has been observed for African herds, so that

FIGURE 2.5

NICHES IN SPACE AND TIME; SCHEDULES.

Not only can we fit species into various levels of plant structure, and broad ecotones of vegetation and soils, but also season, time of day, migration, and scheduling of SPACE–TIME relationships allows a complex use of vegetative resources by a great variety of animal species, such as we see in the natural world.

In this landscape, plant and animal species can find innumerable niches:

a) In the vertical structure of vegetation (I – IV) including a root zone;

b) Across the aspects, zones, or soil catena variations with slope, and with soil water depth;

c) In the different orders of flow in streams;

d) Within the different species that occupy specific sites or assemblies;

e) At the edges or boundaries of any system.

All of the above are independent "dimensions" of the total SPATIAL system. As well:

f) As seasonal migrants through the system;

g) As opportunistic or irruptive visitors in floods, plagues, or after fires;

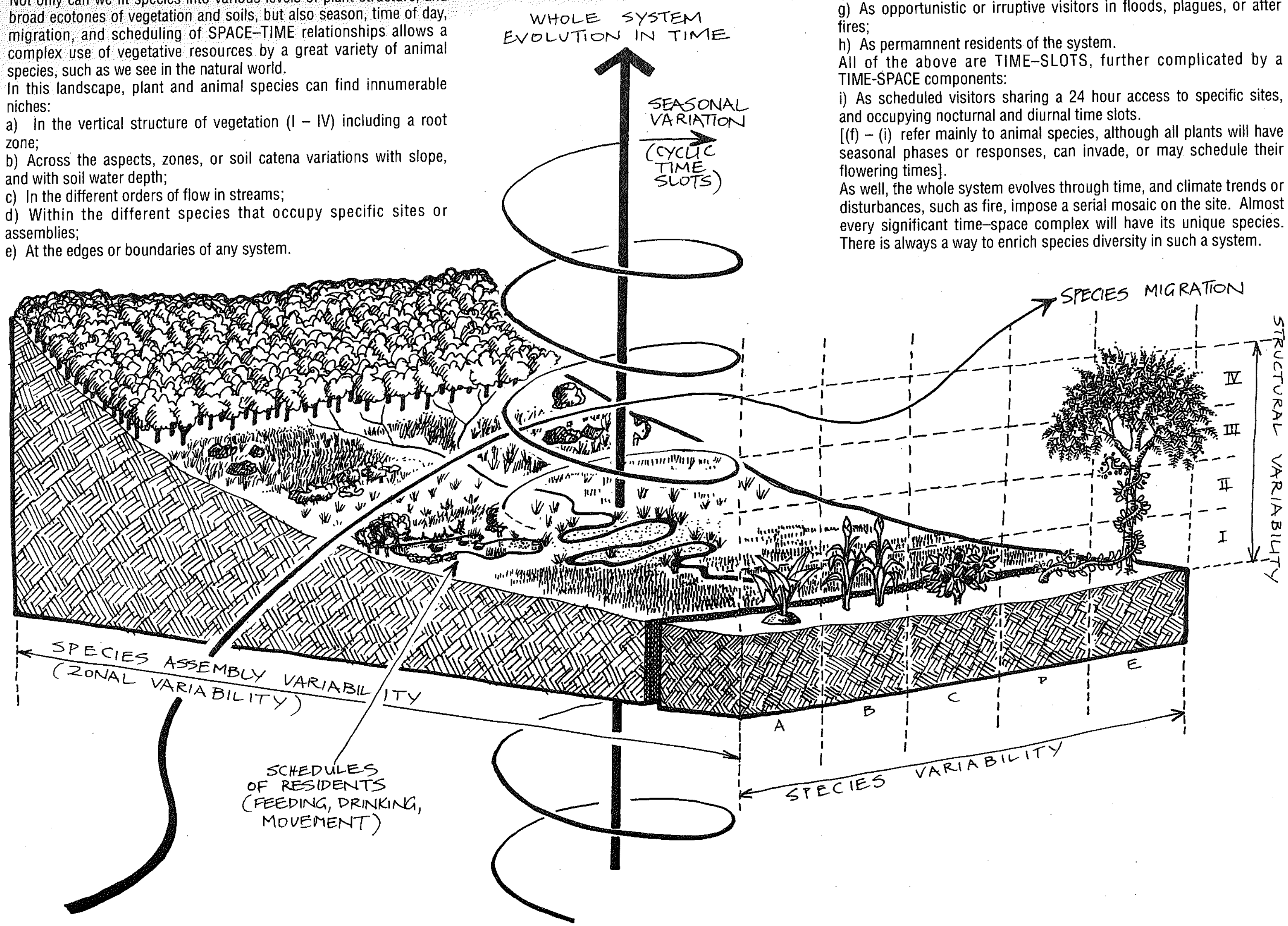
h) As permamnent residents of the system.

All of the above are TIME–SLOTS, further complicated by a TIME-SPACE components:

i) As scheduled visitors sharing a 24 hour access to specific sites, and occupying nocturnal and diurnal time slots.

[(f) – (i) refer mainly to animal species, although all plants will have seasonal phases or responses, can invade, or may schedule their flowering times].

As well, the whole system evolves through time, and climate trends or disturbances, such as fire, impose a serial mosaic on the site. Almost every significant time–space complex will have its unique species. There is always a way to enrich species diversity in such a system.



antelope follow wildebeest follow elephant (or some such sequence) for many herd species.

This suggests that informed graziers, knowing the preferences of different species (sheep follow cattle follow horses follow goats) can make much better use of the basic browse resource by scheduling rotation (not to keep one level of browse constant, but to dynamically balance levels by species succession).

Scheduling (the "right" to use a particular space at a specific time) occurs within species, where dominant animals use prime grazing land at prime time, and sub–dominants are pushed to the edge of time and space, or between species, so that sequences of different species use the same area of vegetation at different seasons or stages of growth. No individual "owns" the area, just a time–space slot (like a chair in a family kitchen at dinnertime). In Tasmania, there are two prime time activity peaks for wallaby over 24 hours, both at night: the main one is crepuscular (just after sundown), and the secondary one is auroral (just before dawn). This permits digestive and recuperative rest periods, denied to weaker animals who cannot compete for preferred periods. Within this framework, any possum can, by aggression, displace a wallaby at a feeding–place. Any individual holds a place only for a short time, moving on to contest another area until satiated. Thus, the sharing of resources is a complex dynamic, but no species or individual has sole rights.

A human analogy would be that of a sports–ground used by different sports groups at times, by gulls or rodents whenever sports are not being played, and by worms at all times.

To summarise, we have:

- Niche in space, or "territory" (nest and forage sites);
- Niche in time (cycles of opportunity); and
- Niche in space–time (schedules).

Between these, there is always space or time available to increase turnover. Niches enable better utilisation and greater diversity, hence more yield. Of all of these niches, schedules are the best strategy for fitting in new species of mammals, providing these are not territorial species (which try to hold their own space at all times), but are chosen from cooperative species which yield space when the time is right (see **Figure 2.5**). There are lessons here for people: those who try to hold on to all things at all times prevent their use by others.

2.7
PYRAMIDS, FOOD WEBS, GROWTH, AND VEGETARIANISM

A figure often used to explain how much of a food or forage is needed to grow another animal is the *trophic pyramid*. While the pyramid is a useful concept, it is very simplistic, and in all but laboratory conditions or feed–lot situations, it is unrelated to field reality, and may only apply where we actually provide simple food to captive species. The field condition is very different (**Figure 2.6**).

The pyramid is often used to support claims that we should all become vegetarians, or herbivores. This is perhaps not so far from the truth, but there are real–world factors to consider. I have shown the pyramid and also a direct path (herbage to human) to illustrate how we would support more people if we ate vegetation. But we need to re–examine this concept for people who return their wastes to gardens. There are the following factors to consider:

1. NATURE IS MUCH MORE COMPLEX than is shown in a pyramid. Instead of simple "trophic levels", we have a complex interaction of the same species, largely governed not by food habits, but by pasture management practices. Such a complex diagram is called a *food web*, and is the normality in field conditions.

2. PYRAMIDS IGNORE FEEDBACK. In a very real sense vegetation eventually "eats" grasshoppers, frogs, fish, and people. Not only that, but as an animal grows, it returns nutrient to the soil via excreted, moulted, or discarded body wastes, and even if the frog eats 10 kg of grasshoppers to make one kilo of frog, it doesn't (obviously) keep the 10 kg in a bag, but excretes 9 kg or more back to earth as manures. This causes more vegetation to grow, thus producing more grasshoppers. The manure from insect "pests" may be the basis of a regenerative future evolution.

With these obvious feedbacks, the web itself becomes much more complex, and it starts to resemble less of a one–way staircase (the pyramid) than a series of cyclic events; less of a ziggurat and more like a spider's web. So that the real position is that waste recycling to herbage is the main producer of that herbage.

3. WHAT OF MATURITY? If our fish (level 4) was a carp, and that carp was more than a year or two old, then it would probably have reached full size, although it may then continue to live for another 80–100 years.

So now, the carp (at 80 years old and 10 kg weight) has eaten 100 x 10 kg = 1000 kg of frogs and insects, and has returned 990 kg of digested material per year to the pond, to grow more herbage. Thus, in order to keep the system in growth, we must be able to efficiently crop *any* level just before maturity is reached. We can see that old or mature systems no longer use food for growth, but for *maintenance*. So it is with mature fish, frogs, forests, and people.

Old organisms thus become constant recyclers (food in, waste out) and cease to grow, or they even begin to lose weight. This is why we try to use only young and growing plants and animals for food, if food is scarce. An exception is a fruit or nut tree, where we consume seed or fruit (seed is an immature tree).

4. ARE FOOD CHAINS SO SIMPLE? We know that people normally eat vegetation, and that many people eat grasshoppers, frogs, fish, and (at times) other people. Even a cow eats grasshoppers as it eats grass, and of course every eater ingests large quantities of

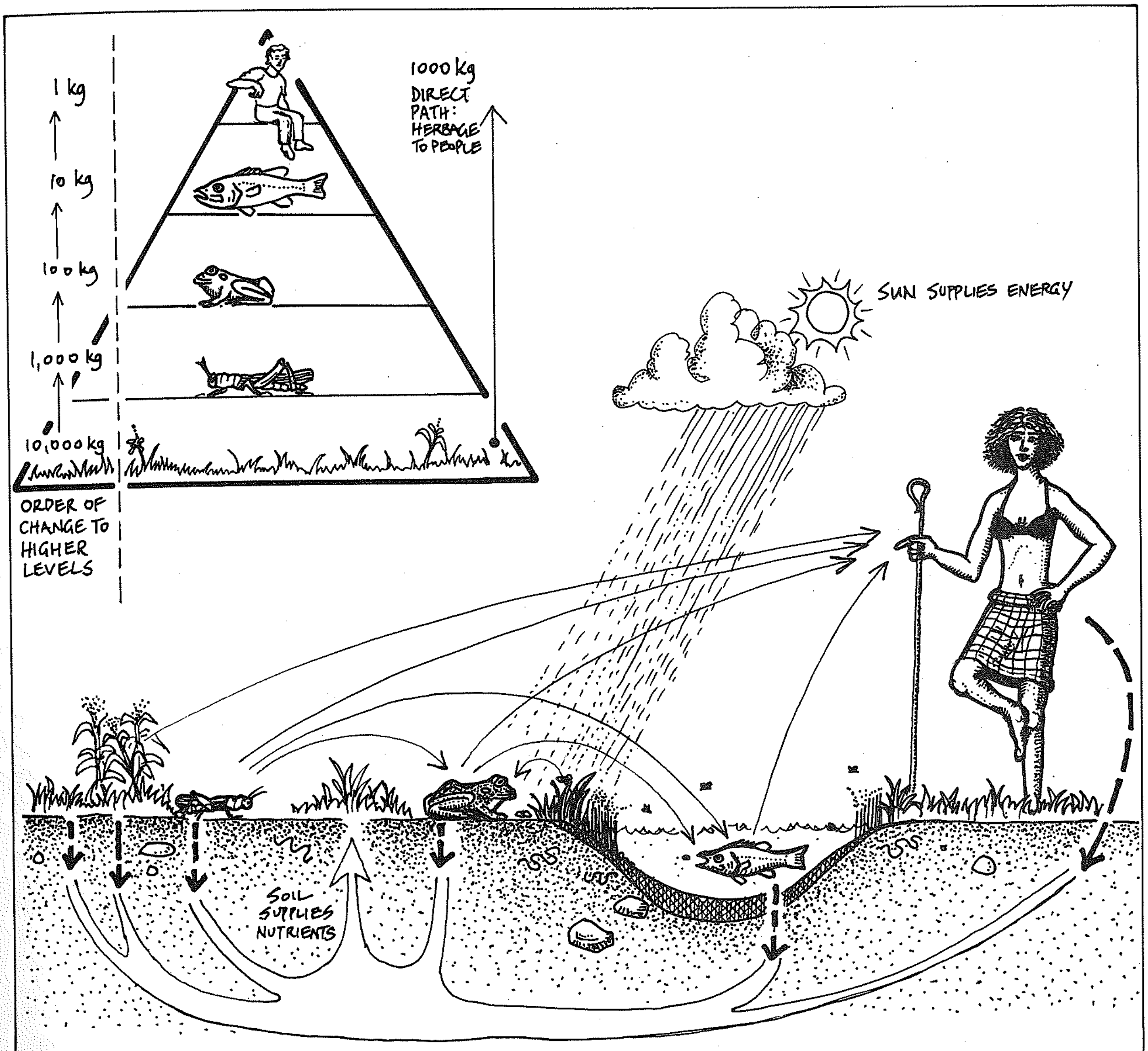


FIGURE 2.6
TROPHIC PYRAMID.
Life systems are rarely strictly hierachical as in the pyramid structure. Most species are omnivorous and *all* species recycle valuable waste products to lower levels of the trophic ladder. Thus, life systems are a web or cyclic systems rather than a pyramid.

bacteria and small animals living on vegetation. "Man cannot live by bread alone", unless in a sterile laboratory condition!

As our one–way pyramid is very suspect, so is the argument that we should become vegetarians to ameliorate the world food shortage problem. Only in home gardens is most of the vegetation edible for people; much of the earth is occupied by inedible vegetation. Deer, rabbits, sheep, and herbivorous fish are very useful to us, in that they convert this otherwise unusable herbage to acceptable human food. Animals represent a valid method of storing inedible vegetation as food. If we convert all vegetation to edible species, we assume a human priority that is unsustainable, and must destroy other plants and animals to do so.

In the urban western world, vegetarianism relies heavily on grains and grain legumes (e.g. the soya bean). Even to cook these foods, we need to use up very large quantities of wood and fossil fuels. Worse, soya beans are one of the foods owned (100% of patent rights) by a few multinationals. They are grown on rich bottomland soils, in large monocultural operations, and in 1980–82 caused more deforestation in the USA and Brazil than any other crop. Worse still, about 70% of the beans were either fed to pigs, or used in industry as a base for paint used on motor vehicles!

Much worse again, grains and grain legumes account for most of the erosion of soils in every agricultural region, and moreover, very few home gardeners in the developed world ever grow grains or grain legumes, so that much of what is eaten in the West is grown in areas where real famine threatens (mung beans from India, chick peas from Ethiopia, soya beans from Africa and India).

Old farmers and my own great-grandfather had a saying that bears some consideration. This was: "We will sell nothing from our farm that will not walk or fly off." In effect, the farmer was concerned to sell *only* animals, never crops or vegetation, because if the farm was to survive without massive energy inputs, animals were the only traditional recycling strategy for a sustainable export market.

What does all this mean to concerned and responsible people in terms of their diet and food habits, with respect to a sustainable natural system?

1. Vegetarian diets *are* very efficient, providing:
   - They are based on easily cooked or easily processed crop grown in *home gardens;*
   - That wastes, especially body wastes, are returned to the soil of that garden; and
   - That we eat from where we live, and do not exploit others or incur large transport costs.
2. Omnivorous diets (any sort of food) make the best use of *complex natural systems;* that we should eat from what is edible, at any level (except for other people in most circumstances, and under most laws!)
3. Primarily carnivorous diets have a valid place in special ecologies, such as areas of cold, where gardening cannot be a sufficient food base; in areas where people gather from the sea; where harsh conditions mean reliance on animals as gatherers; and where animals can use otherwise-waste products, such as vegetable trimmings, scraps, or rejected or spoilt vegetation.
4. We should always do our energy budgets. Whatever we eat, if we do not grow any of our own food, and over-use a flush toilet (sending our wastes to sea) we have lost the essential soil and nutrients needed for a sustainable life cycle.

While a tropical gardener can be very efficient and responsible by developing fruit and vegetable crop which needs very little cooking, sensible omnivorism is a good choice for those with access to semi-natural systems. City people using sewers would be better advised to adopt a free-range meat diet than to eat grain and grain legumes. Better still, all city waste should be returned to the soils of their supply farms.

Even in our garden, we need to concentrate on cycles and routes rather than think in pyramids. Simplistic analysis of trophic levels fails to note that some food resources are unusable by people, either because the energy needed in processing is too much (since some products of nature are poisonous or unpalatable foods), or because the resources are too scattered to repay our collection. Such resources are often harvested into useful packages by other species. Herons, themselves edible, eat poisonous toadfish, and goats will browse thorny and bitter shrubs. Thus we can specify these useful conversions before blindly eliminating a life element *of any type* from our diets.

While it is manifestly immoral to feed edible Peruvian fish to hogs in the USA, it may be of great value to convert forest acorns (unharvested in the USA) to hogs, and let the pilchards and anchovies feed the hungry of Peru (which includes the pelicans!)

The trophic pyramid is valid enough as a conceptual model, for we can see that poisons at the base concentrate at the top. In fact, the highest level of some radioactives and DDT measured are found in mothers' milk. We can see that the generalised or omnivorous (non-selective) feeder is buffered from catastrophic famine by a complex web of trophic connections, so that some losses and some gains accrue to people, being generally omnivorous.

In short, people need to discard fixed ideas, examine their kitchen cupboards, and try to reduce food imports, waste, and energy loss. A responsible diet is not easy to achieve, but the solutions lie very close to home. Viva the home gardener!

2.8
COMPLEXITY AND CONNECTIONS

There are ecologies on very flat and somewhat invariant sites that in the end simplify, or are originally simple because that condition itself is not typical of the earth's crust, just as a field, levelled, drained, and fertilised for a specific crop will not support the species that it once did when it varied in micro-elevation, drainage, and plant complexities. Other simple natural ecologies occur where rapid change can occur (sea coasts), or where we deliberately fire or plough on a regular basis, so that there is never enough time for a diverse system to establish.

Marshes, swamps, tidal flats, salt-pans, and level deserts support less diversity than adjoining hill and valley systems, but nevertheless in sum (if species are assembled from global environments or from similar climatic areas) are still very rich, and, in the case of mangrove and tidal marsh, extremely productive ecologies.

It is not that a single stand of one mangrove species is itself so diverse, it is the mobile species working at different stages of decomposition of the mangrove leaf. Each of these species in turn feeds others.

Thus, very simple plant associations may support very productive and complex animal associations. Mobile species are capable of occupying a great variety of niches in one mangrove tree or swamp stand, from underground to canopy, and of schedules from low to high tide. Time and space are needed for tree species to evolve a complex stand in such situations, and as they are often obliterated and re-established by a world-wide change due to a sea level fluctuation, relatively little time can be allowed for mangrove species to themselves develop and colonise the new, and potentially short–term, shoreline.

Old deserts, like that of Central Australia, may exhibit some 3000 species of woody plants, while recently desertified areas, like those of southwest Asia, may have as few as 150 plants surviving the recent changes from forest. We can, in these cases, act as the agents of constructive change, bringing species to assist local re–colonisation from the world's arid lands. Such species will assist in pioneering natural reafforestation. This has not generally been our aim, and we annually destroy such invaluable species complexes to grow a single crop such as wheat, thus laying waste to the future.

The number of elements in an aggregate or system certainly affects its potential complexity, if complexity is taken to be the number of functional connections between elements. In fact, as Waddington (1977) points out, in the case of a single interaction (a conversation) between elements, complexity goes up roughly as the square of the number of elements: "Two's company, three's a crowd"...and five or six is getting to be a shambles!

This is bad enough, but if we consider the number of possible connections to and from an element such as a chicken (**Figure 3.1**), we can see that these potential connections depend on the information we have about the chicken, so that the complexity of a system depends on the information we have about its components, always providing that such information is used in design. As we cannot know everything, or even know more than the approximate categories and quantity of things which are (for example) eaten by chickens, thus in permaculture we always suppose that the chicken is busy *making connections itself*, about which we could not know and, of course, for which we could not design. We must simply trust the chicken.

Thus, in commonsense, we can design for what we believe to be essentials, and let the chicken attend to all the details, checking at later stages to see that yields (our ultimate products) are satisfactory, the chickens healthy and happy, and the system holding up fairly well.

It is important to concentrate on the nature or value of *connections between elements*. In nature, we can rarely connect components as easily as a wire or piece of pipe can be fixed into place. We do not "connect" the legume to the orange tree, the chicken to the seed, or the hedgerow to the wind; we have to understand how they function, and then place them where we trust they will work. They then proceed to do additional tasks and to provide other connections themselves. They do not confine their functions to our design concepts!

Evolving complex species assemblies in isolated sites, like the Galapagos Islands, may depend more on a species–swarm arising from pioneer or survivor species than on invaders adapting from borderlands. Only when many niches are empty is a species able to differentiate and survive without competition; so the dodo and Darwin's finches arose. Having arisen, they may then well prove to be very useful to other systems. Unique island species often have functions not easily found in continental and crowded ecologies; frequently, hardy travelers like reptiles and crustaceans take up those niches that, on continents, are occupied by species of mammals and birds.

It is not enough to merely specify the *number* of connections, and not note their value in the system as a whole; it may be possible that complex social situations and cultivated or chance complexity may occur in natural systems by introductions or migrations. These new events, although increasing complexity, may reduce stability with respect to a desirable local yield. Thus, where the *benign* complexity of cooperative organisms is useful, competitive or inharmonious complexity is potentially destructive. Again, it is a question of matching needs with products, and of the values given to connections.

2.9
ORDER OR CHAOS

It follows that order and disorder arise not from some remote and abstract energy theory but from actual ground conditions or contexts, both in natural and designed systems. Entropy is the result of the framework, not the complexity. A jumble of diverse elements is disordered. An element running wild or in an active destructive mode (bull in a china shop) is disordered, and too few or too many forced connections lead to disorder.

Order is found in things *working beneficially together*. It is not the forced condition of neatness, tidiness, and straightness all of which are, in design or energy terms, disordered. True order may lie in apparent confusion; it is the acid test of entropic order to test the system for yield. If it consumes energy beyond product, it is in disorder. If it produces energy to or beyond consumption, it is ordered.

Thus the seemingly–wild and naturally–functioning garden of a New Guinea villager is beautifully ordered and in harmony, while the clipped lawns and pruned roses of the pseudo–aristocrat are nature in wild disarray.

<u>Principle of Disorder</u>
Order and harmony produce energy for other uses. Disorder consumes energy to no useful end.

Neatness, tidiness, uniformity, and straightness signify an energy–maintained disorder in natural systems.

2.10
PERMITTED AND FORCED FUNCTIONS

All key living elements may supply many functions in a system, but if we try to force too many work functions on an element, it collapses. One cannot reasonably expect a cow to give milk, raise a calf, forage its own food, plough, haul water, and tread a corn mill. *Forcing* an element to function, however, is a very different proposition from putting it in position where its natural or everyday behaviours permit benefits to other parts of the system.

Placed correctly, a tree or chicken experiences no stress not common to all trees and chickens about their daily business. Further, if we place any of the other elements needed close by, the tree or chicken has less stress than normal. It is the design approach itself that permits components to provide many functions without forcing functions (that are not in any case inherent) upon that element. The chicken may be busy, but not overworked.

People, too, like to be where their very different and complementary capabilities are used rather than being forced to either a single function (like a 300–egg–a–year chicken or a typist confined to a computer operation in an office), or so many functions that they suffer deprivation or overload (like our cow above).

Principle of Stress and Harmony

Stress here may be defined as either prevention of natural function, or of forced function. Harmony may be defined as the integration of chosen and natural functions, and the supply of essential needs.

2.11 DIVERSITY

Diversity is the number of different components or constructs in the system; an enumeration of elements and of parts. It has no relationship to connections between components, and little to the function or the self–regulating capacity of any real system (within the boundaries of too few or too many components). Thus diversity either of components or assemblies does not of itself guarantee either stability or yield. Where we *maintain* such diversity, as in our gardens, then this may guarantee yield, but if we leave our gardens, they will simplify, or simply be obliterated by non–maintained and hardy species adapted to that site (as is evident in any abandoned garden).

Thus, our own efforts are an integral part of maintaining diversity in a permaculture system. Few species grown by people persist beyond the lifetime of those species if we leave the situation alone. Australia is a country where towns may arise and be abandoned to serve a mining or port operation. Where these were built in forested areas, they are obliterated by forest in 30–80 years, with perhaps a few trees such as dates, mulberries, and figs persisting in savannah or isolated dryland locations. These "survivor" trees are important to note in planning longer–term stability for that region.

Great diversity may create chaos or confusion, whereas multiple function brings order and develops resources. I believe that a happy medium is to include as much diversity in a cultivated ecosystem as it can maintain itself, and to let it simplify or complicate further if that is its nature.

Very diverse things, especially such abstract systems as competing beliefs, are difficult to make compatible with any natural system, or knowledge, so that some sorts of dogmatic diversity are as incompatible as a chicken and a fox. Although true incompatibility may be rare, one should be prepared for it to exist, and an intervening neutral component can be introduced, as is the case when growing those "bad neighbours" apples and walnuts, where it is necessary to intervene with a mulberry, which gets along with them both.

Principle of Stability

It is not the number of diverse things in a design that leads to stabilty, it is the number of beneficial connections between these components.

It follows that adding in a technology or living species "just to have it there" has no sense to it. Adding it in to supply a need or consume an otherwise wasted resource—*to do something useful*—makes a great deal of sense. Often, however, we lack functional information on components and may therefore leave out technologies or species in designs which would have been useful had we known. Thus,

Information is the critical potential resource. It becomes a resource only when obtained and acted upon.

In the real world, resources are energy storages; in the abstract world, useful information or time. Watt[13], in his categories of resources, includes time and diversity. Diversity *of itself* is now not seen as a resource, but a diversity of *beneficial functional connections* certainly is a resource. *Complexity*, in the sense of some powerful interconnections between species, is what we are really seeking in food systems. Such complexity has its own rules, and we are slowly evolving those rules as recommendations for polycultures (dealt with elsewhere in this book under their climatic characteristics), or as "guilds" of plants and animals that assist each other.

Peter Moon (*New Sientist*, 28 Feb. '85) differentiates between *richness* (the number of species per unit area), *diversity* (the relative abundance of species), and *evenness* (how species contribute to the biomass total). He notes that richness may decrease in plants as systems age, when shade and competition reduce annuals or weaker species, but that richness may then increase in animals such as decomposers, due to the development of a greater range of niches and microclimate (more animals live in ungrazed or uncut grasslands, but less plant species survive).

Richness of tree species has very recently been correlated to the energy use of that plant community, as measured by evapotranspiration (*New Scientist*, 22

Oct '87) . Thus species–rich regions are not so much correlated to latitude, allied to richness in birds and mammals, or as result of prior events such as glaciation or fire, but are essentially linked to the basic productivity of the region. Within this broader framework, local niches or a range of altitudes can create more diversity; such measures refer to present, not past, climate.

Some disturbance or "moderate stress" such as we achieve in gardens provides the richest environment. We can actively design to allow some undisturbed (low stress) islands of vegetation, while mowing or digging in other areas (high stress), thus getting the best of both worlds in terms of a stress **mosaic**. We can also be active in plant and animal maintenance, increasing or decreasing grazing pressures, thus managing species abundance locally.

2.12
STABILITY

The short meaning of stability in an ecosystem is *self–regulation* rather than a climax (end–point) stability. Nothing in nature remains forever, not soil or hills or forests. For our foreseeable future we can have dynamic life–support systems, as tribal people have demonstrated to us all over the world, sometimes for thousands of years of constructive regulation.

Thus, stability in ecosystems or gardens is not the stability of a concrete pylon; it is the process of constant feedback and response that characterises such endeavours as riding a bike. We are also in an area of uncertainty about the concept of end states or climax in systems—the state to which they tend to evolve. It is doubtful if any such state ever existed, as inexorable climatic change, fire, nutrient leaching, and invasion deflect systems from their apparent endpoints.

Moreover, it is probable that very old systems are also fragile, having been long in a state of maintenance, and we may see sudden or slow collapse in such evolved states. John Seymour (*Ecos*, Summer '81–82), notes the slow loss of nutrients in an old stable dune system at Cooloola in Australia. Here, climax is a passing phase as the virgin dunes lose nutrient status to fire and water filtration to great depths, where nutrients become unavailable to trees. Thus, the study of very old systems shows a retreat from the "most evolved" (greatest biomas) condition unless some new factor is introduced (ash from a volcano, fertiliser applied by people).

Daniel Goodman [*Quartertly Review Biology*, 50(3)] notes that "wild fluctuations" may occur in tropical forests, or in savannah grasslands. Epidemics of pathogens may affect a plant or animal species and sadly decrease its numbers. Although these natural fluctuations pale beside our own effects on ecosystems, such disturbances, providing they affect only a few species, are not as severe as persistent nutrient loss (or acid rain).

All these effects are under some human control in a developed ecosystem. Protection from fire, positive nutrient supply to plants, and long–term evolutions are possible *in terms of human occupancy*. In the longer term, however, we too will be gone, and other species will arise to replace us (unless we take the earth with us, as megalomaniacs would do if we give them that chance: "If I can't take it with me, I'm not going....!") Just as it was the habit of kings to be buried with their riches, horses, and slaves, so modern warlords threaten to bury all humanity as they depart.

2.13
TIME AND YIELD

Old systems store up their energy in bulky unproductive forms, e.g. an old forest has large trunks, roots and limbs, and old fish are "on maintenance". Such ancient systems composed of large individuals (trees or animals) need energy just to maintain their health, and thus they can use less of the available sun energy, so that flow of energy *through* the system is less. Therefore the yield, or turnover of matter, is less. This too is a function of time (ageing). Matter is used up in system maintenance, and is not available as yield, or as increasing size or weight in life components.

Against this factor, species diversity (richness) works to make the most of incoming energy.

> Carlander has shown that the standing crop of fish in different reservoirs is an increasing function of the number of species present.
>
> (Watt[13])

This is also true of studies in most "wild" systems, where the complexity and standing crop are both much more than the simple cultivated ecology which replaces them. Thus, the clearing of an African veld or an Australian savannah of their web of species, and their replacement with a few perennial pasture plants and beef cattle, or with a single–species pine forest not only takes enormous energy but also grossly decreases total yields.

We would do better to try to understand how to manage natural yields, and modify such systems by management than to replace them with "economic" (here economic means monetary rather than energy return) systems which impoverish the yield and encourage disaster via pests and soil loss. Economics in future will inevitably be tied to yield judged on energy rather than on monetary return. In the present economy, we waste energy to make money. But in the very near future, any system which wastes energy must fail.

Pond and hedgerows both slowly gain species as they age, probably as a function of natural dispersal plus new niche evolution created by other species. This continues until the system begins to be overshadowed by a few large dominants or hyper-predators whose biomass represents an end storage of energy, and a decreasing yield in the total system.

Only local disturbance (fire, flood, death) renews the flow of energy through old systems. The time of cycling of natural systems may be a very long period, but in annual cropping it may be reduced to just one season or less. Permaculture thus uses the time resource much better than does annual gardening alone, and so uses sun energy to better effect. The mixed ecology of annuals and perennials maximises not only product yield, but also the resourcefulness of the men and women who establish, control, and harvest, it. It is only in a thoughtless, monetary, and doomed economy that we can evolve the concept of unemployed and unwanted human beings.

Death in over–mature systems is thus seen as the essential renewal of life, not in the negativistic sense of the fatalist, but in a positivistic and natural way. It is better that elements die, and are renewed by other species, than the system simplifies to extinction. It is better for the tribe if its components change than if it turns in on itself, ages, and decays as a whole. Life is then seen as a preparation for succession and renewal, rather than a journey to extinction.

Time as Watt notes is a resource. Like all resources, too much of it becomes counterproductive, and a system in which too much time is accumulated becomes chronically polluted, as a system in which not enough time has accumulated is below peak yield. A strawberry seedling and an old strawberry bush are equally unproductive, as are the very young and the very old in society. As there are age–specific diseases in people (whooping cough, prostate hypertrophy) so there are age–specific diseases in whole systems, and a mixed–age stand is the best insurance against complete failure or epidemic disease of this nature. As individuals, we have a right to live a responsible life, and a right to die. If our efforts to prevent ageing succeed, we may produce a crowded, unstable, and unproductive society subject to gerontocratic peevishness!

2.14 PRINCIPLE SUMMARY

The Prime Directive of Permaculture: The only ethical decision is to take responsibility for our own existence and that of our children's.

Principle of Cooperation: Cooperation, not competition, is the very basis of future survival and of existing life systems.

The Ethical Basis of Permaculture:

1. CARE OF THE EARTH: Provision for all life systems to continue and increase.

2. CARE OF PEOPLE: Provision for people to access those resources necessary to their existence.

3. SETTING LIMITS TO POPULATION AND CONSUMPTION: By governing our own needs, we can set resources aside to further the above principles.

Rules of Use of Natural Resources:

- Reduce waste, hence pollution;
- Thoroughly replace lost minerals;
- Do a careful energy accounting; and
- Make a biosocial impact assessment for long term effects on society, and act to buffer or eliminate any negative impacts.

Life Intervention Principle: In chaos lies unparalleled opportunity for imposing creative order.

Law of Return: Whatever we take, we must return, or
Nature demands a return for every gift received, or
The user must pay.

Directive of Return: Every object must responsibly provide for its replacement. Society must, *as a conditions of use*, replace an equal or greater resource than that used.

Set of Ethics on Natural Systems:

- Implacable and uncompromising opposition to further disturbance of any remaining natural forests;
- Vigorous rehabilitation of degraded and damaged natural systems to a stable state;
- Establishment of plant systems for our own use on the *least* amount of land we can use for our existence; and
- Establishment of plant and animal refuges for rare or threatened species.

The Basic Law of Thermodynamics [as restated by Watt[13]]:

"All energy entering an organism, population or ecosystem can be accounted for as energy which is stored or leaves. Energy can be transferred from one form to another, but it cannot disappear, or be destroyed, or created. No energy conversion system is ever completely efficient."

[As stated by Asimov (1970)]: "The total energy of the universe is constant and the total entropy is increasing."

Birch's Six Principles of Natural Systems:

1. Nothing in nature grows forever. There is a constant cycle of decay and rebirth.

2. Continuation of life depends on the maintenance of the global bio–geochemical cycles of essential elements, in particular carbon, oxygen, nitrogen, sulphur, and phosphorus.

3. The probability of extinction of populations or a species is greatest when the density is very high or very low. Both crowding and too few individuals of a species may reach thresholds of extinction.

4. The chance that a species has to survive and reproduce is dependent primarily upon one or two key factors in the complex web of relations of the organism to its environment.

5. Our ability to change the face of the earth increases at a faster rate than our ability to foresee the consequence of change.

6. Living organisms are not only means but ends. In addition to their instrumental value to humans and other living organisms, they have an intrinsic worth.

Practical Design Considerations:

• The systems we construct should last as long as possible, and take least maintenance.

• These systems, fueled by the sun, should produce not only their own needs, but the needs of the people creating or controlling them. Thus, they are sustainable, as they sustain both themselves and those who construct them.

• We can use energy to construct these systems, providing that in their lifetime, they store or conserve more energy than we use to construct them or to maintain them.

Mollisonian Permaculture Principles:

1. Work with nature, rather than against the natural elements, forces, pressures, processes, agencies, and evolutions, so that we assist rather than impede natural developments.

2. The problem is the solution; everything works both ways. It is only how we see things that makes them advantageous or not (if the wind blows cold, let us use both its strength and its coolness to advantage). A corollary of this principle is that everything is a positive resource; it is just up to us to work out *how* we may use it as such.

3. Make the least change for the greatest possible effect.

4. The yield of a system is theoretically unlimited. The only limit on the number of uses of a resource possible within a system is in the limit of the information and the imagination of the designer.

5. Everything gardens, or has an effect on its environment.

A Policy of Responsibility (to relinquish power): The role of beneficial authority is to return function and responsibility to life and to people; if successful, no further authority is needed. The role of successful design is to create a self–managed system.

Categories of Resources:

1. Those which increase by modest use.
2. Those unaffected by use.
3. Those which disappear or degrade if not used.
4. Those reduced by use.
5. Those which pollute or destroy other resources if used.

Policy of Resource Management: A responsible human society bans the use of resources which permanently reduce yields of sustainable resources, e.g. pollutants, persistent poisons, radioactives, large areas of concrete and highways, sewers from city to sea.

Principle of Disorder: Any system or organism can accept only that quantity of a resource which can be used productively. Any resource input beyond that point throws the system or organism into disorder; oversupply of a resource is a form of chronic pollution.

Definition of System Yield: System yield is the sum total of surplus energy produced by, stored, conserved, reused, or converted by the design. Energy is in surplus once the system itself has available all its needs for growth, reproduction, and maintenance.

The Role of Life in Yield: Living things, including people, are the only effective intervening systems to capture resources on this planet, and to produce a yield. Thus, it is the sum and capacity of life forms which decide total system yield and surplus.

Limits to Yield: Yield is not a fixed sum in any design system. It is the measure of the comprehension, understanding, and ability of the designers and managers of that design.

Dispersal of Food Yield Over Time:

• By selection of early, mid and late season varieties.

• By planting the same variety in early or late-ripening situations.

• By selection of long–yielding varieties.

• By a general increase in diversity in the system, so that:

• Leaf, fruit, seed and root are all product yields.

• By using self–storing species such as tubers, hard seeds, fuelwood, or rhizomes which can be "cropped on demand".

• By techniques such as preserving, drying, pitting, and cool storage.

• By regional trade between communities, or by the utilisation of land at different altitudes or latitudes.

Principle of Cyclic Opportunity: Every cyclic event increases the opportunity for yield. To increase cycling is to increase yield.

Cycles in nature are diversion routes away from entropic ends—life itself cycles nutrients—giving opportunities for yield, and thus opportunities for species to occupy time niches.

Types of Niches:

• Niche in space, or "territory" (nest and forage sites).

• Niche in time (cycles of opportunity).

• Niche in space–time (schedules)

Principle of Disorder: Order and harmony produce energy for other uses. Disorder consumes energy to no useful end.

Neatness, tidiness, uniformity, and straightness signify an energy–maintained disorder in natural systems.

Principle of Stress and Harmony

Stress may be defined as either prevention of natural function, or of forced function; and (conversely) harmony as the permission of chosen and natural functions and the supply of essential needs.

Principle of Stability: It is not the number of diverse things in a design that leads to stability, it is the number of beneficial connections between these components.

Information as a Resource: Information is *the* critical potential resource. It *becomes* a resource only when obtained and acted upon.

2.15
REFERENCES

Waddington, C. H., *Tools for Thought*, Paladin, UK, 1977.