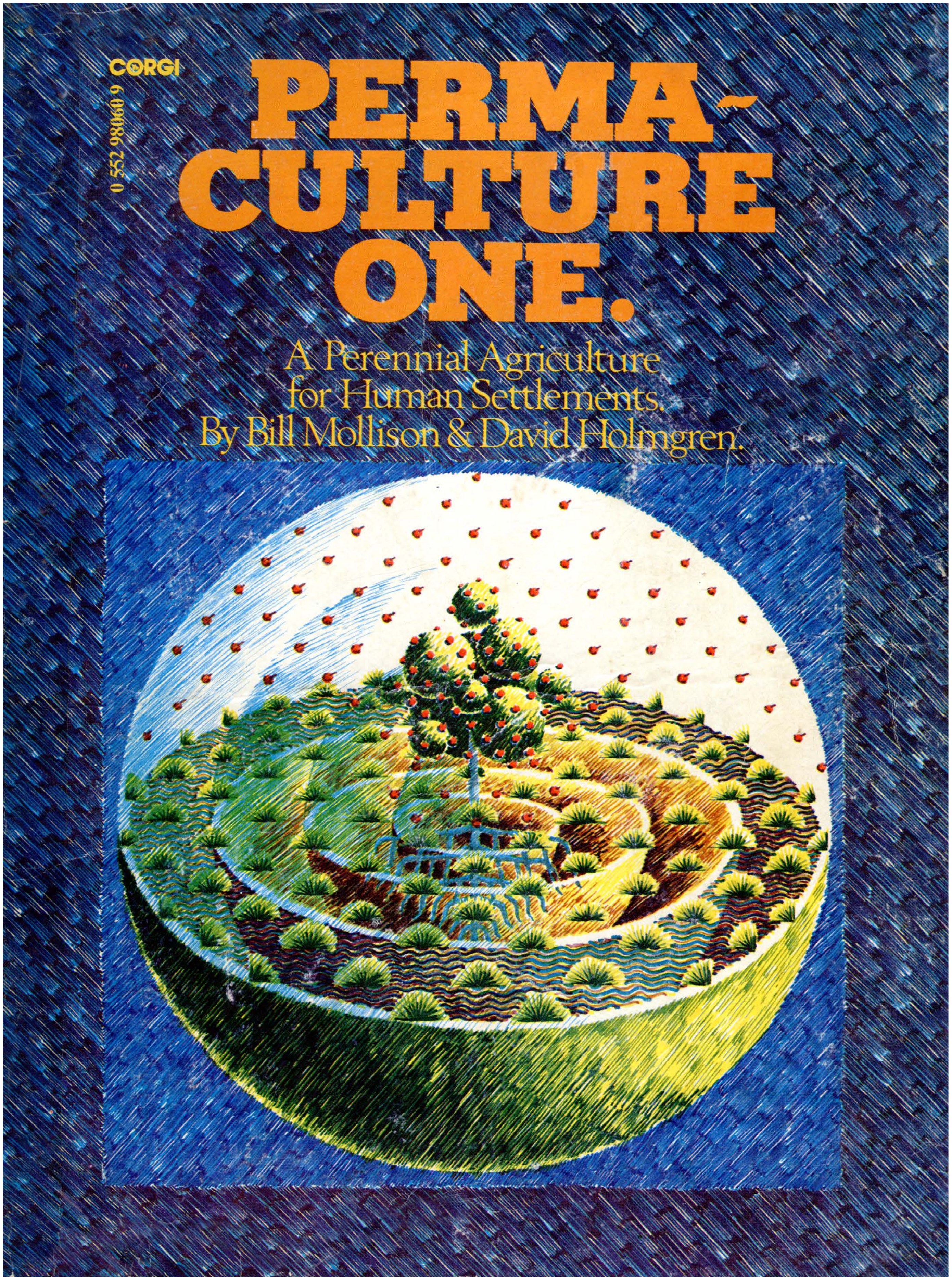

Facsimile Edition

with new preface by co-author David Holmgren

This facsimile edition of Bill Mollison and David Holmgren's
Permaculture One: A perennial agriculture for human settlements
is created from a scan of the original first edition published in 1978.
This copy has not only both authors' signatures, but also the sticker
showing it was purchased from Rellim Books, David Holmgren's
parents' bookshop.

It is now fully searchable and contains a new preface written
by David Holmgren after his more than 40 years of practicing
permaculture and watching the movement grow and develop.

Facsimile edition published by Melliodora Publishing Sept 2021

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Preface to Facsimile Edition of Permaculture One

By David Holmgren

It has been over 40 years since the publication of *Permaculture One: A perennial agriculture for human settlements* launched the permaculture concept. This facsimile edition makes this seminal work available again after almost 30 years out of print.

As the younger surviving co-originator of the concept, and persistent practitioner, designer and teacher of permaculture, I find it a difficult but important task to provide some perspective on the significance of this book, given the spread and influence of the permaculture concept around the world. In this extended introduction I am also taking the opportunity to share some of the story behind the book's creation.

Despite the great number of permaculture publications since it was originally published, there is still substantial interest in *Permaculture One* as the seminal work of the concept and the only book co-authored by the permaculture co-originators.

This co-authorship has often been a subject of speculation. As I have always maintained, it was Bill Mollison's energy that led to the publication of our modest manuscript – if it wasn't for his efforts, it might never have seen the light of day. As a yarn-spinning, charismatic polymath, Bill was key in the early public and media enthusiasm for permaculture while my cautious, even sceptical, attitude to some of Bill's wilder claims reinforced my early detachment from permaculture as popular eco-fashion and led me along a path of more introverted skill development and research.[1]

It was in late 1974, as a first year Environmental Design student at the then Tasmanian College of Advanced Education (TCAE) in Hobart, that I met Bill and established a completely informal mentor relationship.[2] He was a senior tutor in the Psychology faculty at the University of Tasmania but I was attracted to his ecological thinking. The seed of the permaculture concept emerged from our long, lively and intense discussions (although Bill later attributed the origins to a diary entry decades before).

I moved into Bill's household, which included Bill's second wife Philomena and her son from a previous relationship, and over the following two years, Bill and I established a prototype permaculture garden on this two acre semi-rural property on the Mt Wellington foothill fringes of Hobart. We researched and debated the ideas, and I devoted all my time within the freewheeling Environmental Design course to "the manuscript". This household was the context where the ideas were being applied in the garden, the kitchen and across the fence with like-minded neighbours.

1 See my autobiographical piece "The Long View" in *Permaculture Pioneers: stories from the new frontier*, Dawborn & Smith, 2011, Melliodora Publishing

2 I give a brief account of our first meeting in "A chance meeting" (2010) in *David Holmgren: collected writings & presentations 1978 to 2021*, Melliodora Publishing

In 1975, Bill suggested we coin the term "permaculture" to describe our design system for sustainable land use and human habitation with a central role for trees and other perennial crops grown in polycultures. In 1976 we co-authored a two-part article about permaculture published simultaneously in the *Tasmanian Organic Gardening and Farming Journal* and the *Feral Gazette*, the student newspaper of the TCAE. For my Bachelor of Arts (Environmental Design) thesis, I successfully submitted a permaculture property design for self-sufficiency that used my unpublished manuscript as the primary reference!

After graduating, I focused fulltime on practical permaculture skill development (rather than further studies in the design professions) so handed the manuscript to Bill who was spruiking the concept at organic field days and countercultural festivals. Bill edited the text and added sections on aboriginal agriculture, intrinsic properties of biological systems, fungi, urban evolution and the flight to the land, as well as the "Permaculture tree" (page 97). My role at this stage was limited to supervising Janet Mollison's redrawing of my original sketches and additional drawings. Her drawing skills, and growing up with her father's rural lifestyle, gave Janet the ability to effectively interpret our ideas.

A pivotal interview with Bill Mollison by Terry Lane on 3LO (Melbourne ABC Radio), following an earlier interview of both of us by Robyn Ravlich, led to more than 15 publishers writing to us wanting to publish the permaculture manuscript. We also received over 1000 letters from councils, universities, schools and individuals, most of which were replied to by circular-style letters from Bill.

Although the great majority of the manuscript was my writing, we decided that Bill would be credited as lead author as he had a public profile and the greater skill set and interest in actively promoting the concept.

We accepted the offer of large multinational publisher Corgi and in April 1978 the first edition of *Permaculture One* was published in Australia.

The experience of working with a large publisher led both Bill and myself to pursue self-publication for our later works, as expressions of permaculture self-reliance.

Issues with the publisher included their commissioning of two graphic artists to redraw Janet's illustrations, which they regarded as unsatisfactory. This led to substantial delays, simplification of the concepts depicted and a less aesthetic finished product. Ironically, the illustration that Janet was least happy with, and the only one that would have been improved by a redrafting, was the only one retained, as the graphic designers had trouble interpreting it (the speculative mature permaculture system on page 55).

Apart from this issue with the graphics, the figure on page 73 includes poplar and carob that were never in my original design drawing. I never established if these were ad lib additions by the graphic designers or an example of Bill's tendency to add speculative ideas beyond the scope of evidence or practicality (part and parcel for a polymath capable of integrating knowledge across the disciplines).

In re-presenting this work we have resisted any attempt to correct this or other minor errors,[3] let alone embark on a revised edition, believing that the value of this work is primarily historical.

Another aspect of this work that should be emphasised is that it was written for Tasmanian conditions. As is standard practice in the publishing world, the text was edited to mask this particular focus. For those exploring permaculture solutions, especially appropriate perennial species, for cool temperate climates *Permaculture One* remains a useful reference.

Following standard business practice, Corgi chose not to reprint *Permaculture One* despite the growing interest in the ideas, including the formation of the Permaculture Association with members from around Australia as well as overseas.

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3 with the exception of the diagram on page 46 which has had "yards" changed to "years"

In 1979 Bill bought the printing plates from Corgi, set up his own imprint, Tagari Publications, and reprinted the book along with *Permaculture Two*, which he authored. In the same year we signed contracts for a US edition published by the International Tree Crops Institute. During the 1980s, a Portuguese language translation was published in Brazil, a German translation was facilitated by Declan Kennedy, pioneer permaculture teacher and designer, and an Italian edition was facilitated by leading Florentine environmentalist, Giannozzo Pucci. It has since been translated into at least three more languages.

Following the publication of Mollison's encyclopaedic *Permaculture: A Designers' Manual* (1988) by Tagari, Mollison partnered with Reny Mia Slay to draw together elements of *Permaculture One*, *Permaculture Two* and the *Designers' Manual*, plus the experience of the first decade of Permaculture Design Course teaching, into a concise text, *Introduction to Permaculture.*

With this publication in 1990, Mollison saw no need to keep *Permaculture One* in print, although an English edition remained available for some years. Over the last 20 years Holmgren Design continued to resell some this stock, as well as second hand copies and even unsold stock of first editions from Gould's Bookshop in Sydney. With those stocks depleted and interest in the origins of permaculture growing, this facsimile edition has been a potential project for Melliodora Publishing for years.

In recent decades I have found myself following my father's interest in history and politics. I see the ebb and flow of permaculture activism and influence over the decades as reflecting the pulsing patterns of the wider psycho-social, ecological and geopolitical environment, rather than just the good (and not so good) outcomes of the actions of those with a passion for permaculture.[4]

In the introduction to *Permaculture: principles and pathways beyond sustainability*[5] I acknowledged how permaculture (the concept) was muddied by the swirling waters of popular culture that propelled it beyond its academic and countercultural origins. I compared this process to how a decade later the concept of sustainable development got very dirty as it was propelled from academia into the harsh reality of international political discourse and governance.

Both permaculture and sustainable development can be seen as proactive responses to address the limits to growth crisis that was so clearly identified in 1972.[6] There is an obvious imbalance between the impact of the two concepts, one driven by passion, sweat and tears, the other by mainstream activism, power plays and big budgets, however it may be like the tortoise and hare parable. Permaculture's persistent commitment to small and slow, predominantly biological and community solutions will prove to be more effective at addressing the fundamental challenges facing humanity than the more complex technology, corporate capitalism and global governance that has been the focus of sustainable development. Of course many see the bottom-up approach of permaculture and the top-down approach of sustainable development as being complementary in the slow process of achieving the fundamental cultural change necessitated by both the environmental and human limits to growth.

While permaculture and sustainable development share a focus on actively designing solutions, permaculture can also be seen as complementary to the long lineage of grassroots environmental activism against the destruction of natural capital and the dispossession of indigenous and traditional peoples. The hard yards of oppositional environmental activism has led many to permaculture as a more rewarding pathway to creating the world we yearn for.

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4 For further discussion of these patterns see "Four decades of permaculture" (2018) in *David Holmgren: collected writings & presentations 1978 to 2021*, Melliodora Publishing

5 Holmgren, *Permaculture: principles and pathways beyond sustainability*, 2002/2017 revised ed., Melliodora Publishing

6 Donella Meadows & Club of Rome, *The Limits to Growth: a report for the Club of Rome's project on the predicament of mankind*, 1972, Universe Books

Another complementarity has been between permaculture productivity and the practices of personal frugality and voluntary simplicity. The first aims to generate an abundance of food and other basic human needs whilst the second aims to lessen our ecological footprint and improve quality of life. Both strategies radically reduce our dependence on, and contribution to, the globalised capitalism that is the engine of environmental destruction. I have argued that it would only require a significant minority of the global middle class to seriously pursue a combination of permaculture productivity and voluntary simplicity to prevent globalised capitalism driving humanity into one or more limits to growth.[7] Ironically it could be the tsunami of global debt – a limit inherent to capitalism itself – that stalls the engine of global destruction long enough to force a fundamental restructuring of human systems to work within biophysical limits, including climate and resource depletion.

While these perspectives are relevant to the diversity of permaculture activism in the affluent world, permaculture has also been a small but effective force in development assistance in the poorest regions and countries. Simple garden farming, silvopasture, water harvesting, compost toilets, biogas and wood stove technology have been implemented using local resources and skills to provide for basic household and community needs, whilst also healing the land and providing the foundations for renewed local economies. The escalating numbers of displaced people both within and across national borders is the frontline where small-scale permaculture design can help camp residents create more productive and liveable places in the aftermath of crises and big aid programs.

The permaculture design solutions that are relevant in these most desperate of circumstances reflect the same ethics and design principles that apply when the most affluent and privileged get their act together to lighten their load on the planet and make a productive contribution. Although I have always pointed to the dangers in rubber stamp approaches pushing permaculture design solutions that might not be relevant to the context at hand, it is amazing how permaculture projects around the world successfully demonstrate recurring themes such as garden farming, water harvesting and purification, tree planting and reafforestation, self-build housing, creative reuse, and collective organisation and sharing, amongst many others, despite the diversity of environmental, economic and cultural contexts.

We hope that access to this text in this facsimile form more than 40 years after it was first published will be useful to readers interested in practical information for cool climate permaculture, as well as researchers and activists interested in origins and sources for permaculture at a time of unprecedented relevance to the challenges facing humanity in the 21st century.

David Holmgren
Melliodora
November 2019

7 See "Crash on Demand" (2013) in *David Holmgren: collected writings & presentations 1978 to 2021*, Melliodora Publishing or at holmgren.com.au/crash-demand/

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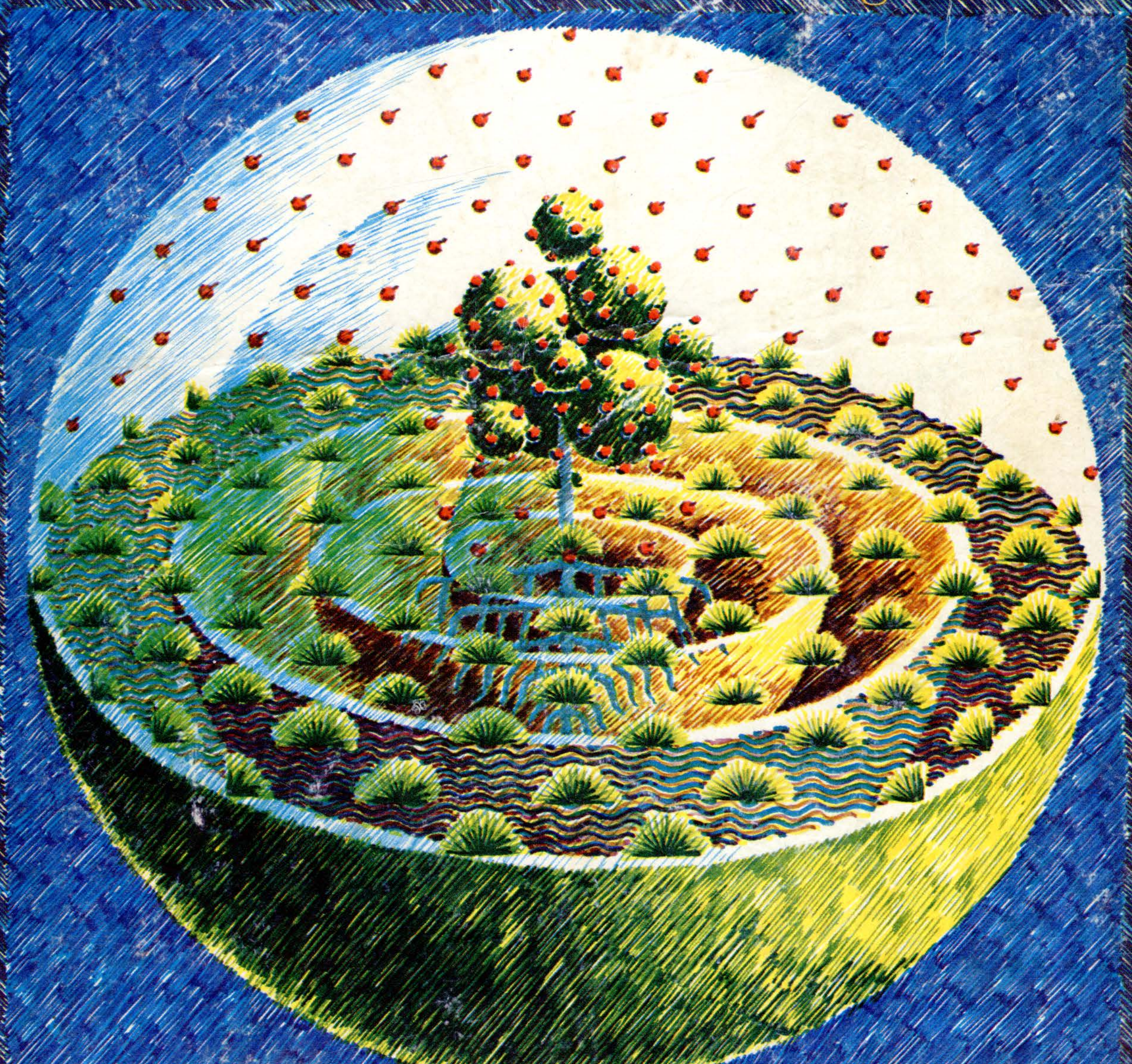
PERMA-CULTURE ONE.

A Perennial Agriculture for Human Settlements.

By Bill Mollison & David Holmgren.



PERMACULTURE 1

A perennial agricultural system for human settlements

by
Bill (B.C.) Mollison* and David Holmgren

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Three Voices

I

There are two kinds of men
That seems quite clear
One sees bamboo as grass
And one as spear

II

Bamboo is grass. How is bamboo a knife?
The grasses give us seed, and seed is life

I

One thinks of ownership
And one of earth
One shapes the forms of death
And one, rebirth

II

And what is fear?

I

It is the eye that sees bamboo as spear

I

And one makes war with wheat
And one makes bread
One sings of hope
The other arms, in dread

III

Let others labour, we shall own the land
They'll work for bread, and place it in my hand.

I

Our tool is knowledge
Yours the tools of steel
We feel the pulse of earth
You do not feel

III

Rip open breast and earth, make our demand
We will have yield, from women and from land

II

How can we yield; nature does not demand
What is their due, who think they own the land?

I

Their bread is salt; black water fills their bowl
Dust is their breath, blood in their lungs will howl

II

Science has closed its door
Looks to the sky
And through the keyhole sees
An eye, O God, an eye

II

Mend me the loom of man
Weave a soft shroud
Cover the wounds he makes
Catch me a cloud

I

Take off your cloak of dread
Take up the seed
Learning to grow is love
Fear is the root of greed

II

There are two kinds of men
That seems quite clear
And one is ruled by love
And one by fear

I

Our quietude, and this alone on earth
Weaves us our tapestry of love, and death, and birth

III

Our gardens are of stone, and stone is neat
Clean as a polished bone. What shall we eat?

III

When greed was all my love, my strength was none
There is no seed, for those who plant a stone

B.C. Mollison

Acknowledgements and Dedication

As in all endeavours, we must acknowledge our predecessors; a permaculture is made possibly by our ancestors, some remote, and an evolved permaculture is a legacy for posterity.

The involved mess of our first manuscript was first clarified by Zenda Onn, and later patiently edited and set out by Joyce Strong. Both gave more than normal help in preparing the final document. Val Hawkes assisted in correction, and Phil Mollison endured the innumerable fireside discussions of our formulative ideas. Janet Mollison, Moonyean McNeilage and Glen Chandler redrafted and greatly improved our poor illustrations. Jo Rowbury and Roy Day brought the work to public notice in Melbourne, and Jeremy Dawkins and Colin James served the same function in Sydney; in this way we spread the idea of permaculture, and contacted publishers and the media.

Our thanks are also due to those people in the A.B.C. who gave our ideas a public hearing, and thus hastened the completion of this book, especially Robin Ravlich and Stephen Rapley in Sydney and Warren Moulton and Terry Lane in Melbourne.

This book is dedicated to the children and grandchildren of humanity, whose fate and future lie with us.

Index

1.0 Introductory Comment. Permaculture Defined

Permaculture is a word we have coined for an integrated, evolving system of perennial or self-perpetuating plant and animal species useful to man. It is, in essence, a complete agricultural ecosystem, modelled on existing but simpler examples. We have designed the system, as it is presented here, for cool temperate conditions; using other and additional species it would suit any climatic region, and is designed to fit into urban situations.

We jointly evolved the system in the first place as an attempt to improve extant agricultural practices, both those of Western agribusiness, and the peasant grain culture of the third world. The former system is energy-expensive, mechanistic, and destructive of soil structure and quality. The latter makes drudges of men, and combined with itinerant herding, deserts of what once were forests. Perhaps we seek the Garden of Eden, and why not? We believe that a low-energy, high-yielding agriculture is a possible aim for the whole world, and that it needs only human energy and intellect to achieve this.

The permacultural concept has caught the imagination of hundreds of people in Australia where we have given verbal descriptions and short resumes of the system. It may well have a wider impact, as the time seems ripe for such a synthesis in a world of famine, poisons, erosion and fast-depleting energy. It is now possible to design agricultural systems to take advantage of some of the resources of the whole world, and to consider species from every country, so that the potential diversity of even temperate regions can be greatly enriched, almost to the point of tropical diversity and stability.

This study is therefore intended as a pioneer effort in the collection and analysis of the elements and principles of perennial agriculture; the sort of system that will supply the essential needs of a city, a small settlement, or large family. It may well be unsuited to a large commercial enterprise, or inapplicable to conventional farming, but has greater relevance to those who wish to develop all, or part, of their environment to near self-sufficiency.

Our initial orientation was to small groups, living on marginal land cheaply available, where the ethics of farming are aimed at a future, and different, life style and where regional self-sufficiency is more important than cash cropping for export, or monoculture for commercial gain.

The principles, if not the elements, of our study are applicable to any climatic zone.

It is recognized that annual cultivation is an integral part of any self-supporting system, but annual crops are not considered here (except in passing reference) as a component of the total system. It is taken as understood that normal gardening for annuals is part of a permacultural system.

1.1 Sources of Data

Numbered references for each section are, hereafter, given at the beginning of the section and listed in Appendix D. Minor references will be given in the text.

The main source of data on species and systems comes from published works, but use is made also of the experience of practical growers, recorded in interviews and discussions. Our own observations and experience contribute to this study, and we are asking for positive feed-back after publication of this study, with future revised editions in mind.

As the study is exploratory and innovative, a developed permacultural system is as yet only a theoretical possibility, but beginnings were made on an experimental basis as the study progressed, with promising results. Plants were obtained, and placed in a trial situation of 1 hectare (2.5 acres) and the results after two growing seasons were encouraging. Developed permacultures (of very few species) are available for study in many third-world areas. Finally, measurements and quantities are retained in the original units throughout the text, as most of the world understands some of the units, or has conversion tables. The reader must remember that all directions are given for the southern hemisphere.

1.2 Availability and Selection of Species

Plants and animals have been selected for their usefulness to man. Many species already growing in Australia are included, but rare or locally-uncultivated species are also considered. Seed merchants can, in most cases, supply seed of rare or exotic species. Selection is also made on the suitability of the species for Tasmanian conditions.

Section 7.1, considers species selection in particular systems in detail.

Appendix A gives some local sources of plants.

Appendix D gives the plant species considered, along with their characteristics and uses.

1.3 Orientation and Aims

A large, but as yet not well-analysed population of people have bought land in Tasmania and elsewhere in Australia with the intention of developing a subsistence agriculture, often in conjunction with part-time work while such a system develops. Some live in loose local associations, as families, communes, or co-operatives. Many are unfamiliar with any sort of farming, or indeed the normal rural skills, but are attempting to develop an information system which will help them achieve or approach their aim of self-sufficiency. It is to such people that this study is primarily directed. For some demographic analyses of this population, see Section 10.0.

The land they buy is normally cheap and has been over-grazed, burnt, cropped, or cut-over in past years. This frequently means isolated locations in valley headwater systems or uplands, poor soils, and regrowth or damaged forest remnants; in general, land of little value for immediate commercial usage. Most properties are small (5-10 hectares) and therefore uneconomical in the accepted sense. Resources such as cleared land, machinery, buildings, dams and fences, are often limited. It is with such areas that this study is concerned.

The study also acknowledges the potential of city areas for permaculture, both around and within buildings, and it needs little imagination to adapt the system to an urban situation, to roadsides, and other normally-unused areas close to settlement and main transport routes.

What we have attempted to do in this treatment is to create a tool, an idea for future developments in urban and rural areas; not in the nature of a fixed or dogmatic pattern, but as a model which integrates several principles of many disciplines — of ecology, of energy conservation, of landscape design, urban renewal, architecture, agriculture (in all its aspects), and the location theories of geography. We took into account problems of unemployment and of early retirement, of urban neurosis, and of the feeling of powerlessness and lack of direction common to many of us in today's world.

It is not a perfect, nor even a sufficient synthesis, but it is a start. People of all ages and occupations will find out how to adapt this idea into their lives and environment, and in doing so will be able to see beyond the immediate uses and ends. Societies need unified ideals and long-term goals, and this may be one of the contributions towards such ends, and towards the evolution of a truly environmental science in education and life.

2.0 ORIGINS, DIRECTIONS AND PRINCIPLES

2.1 **Agricultural Origins** Refs. 3, 42, 44

In the earliest centres of agriculture, S.E. Asia and northern S. America, vegetatively-reproduced plants were cultivated. These were mostly annual (or treated as such) being re-sown at harvest-time. Carbohydrate foods were obtained from them since these were not available in large quantities in the wilds. The scarcity of natural carbohydrates, combined with population pressure, was probably the basic incentive for agriculture. In the natural environment, game, fish, fruits and nuts were abundant and provided most nutritional requirements. There was little incentive to domesticate or cultivate for food other than for carbohydrate.

As agriculture spread to other regions, vegetative propagation of the high-carbohydrate plants was often less successful. Also, food resources in general were less abundant. Seed agriculture, selecting from local species and the weeds of gardens and rubbish heaps developed, providing nutritional and energy requirements in response to a lack of abundant food. In some regions, cultivation of perennials was developed, often becoming the basis of local support systems. The olive, grape, fig, chestnut and date palm are examples. Animals were domesticated mainly for milk. However, wild foods still represented a considerable proportion of the diet.

As populations rose in the regions most favourable to man, the availability of wild foods reduced. The incentive for cultivation and domestication increased, and many varieties of plants, including perennials, were planted and selected. In some areas complex agricultures developed, providing all food needs and other products such as fibres, and feed for domestic animals. In the garden agricultures of S.E. Asia and Central America, multi-use was the rule rather than the exception (fibre, poison, and starch, were obtained from the one species).

Such systems offer the best traditional agricultural model for a modern permaculture.

2.2 **Modern Agriculture** Refs. 1, 6, 27, 29, 39

With the rise of the modern era (the last three hundred years) and the availability of new energy sources (coal and then oil), profound changes occurred in agriculture. It was now possible to produce large quantities of food or other agricultural produce in one region, for consumption in another. Apart from the much-talked-about advantages, such a trend led to the destruction of local cultivated ecologies, as producers concentrated on a few cash crops. A cash economy and stable regional agriculture were, and are, basically imcompatible. Distant interests with no permanent stake in the productivity of the land colonized new regions for farming, and economic and social factors forced changes in the established agricultural regions; agribusiness developed.

The industrial system based on cheap energy sources brought new methods to the land, making possible on a large scale a complex range of specialized activities and practices never possible in pre-industrial times. The impact of high energy on the land itself was not considered.

Modern agriculture continued to concentrate on seed annuals, providing the foods people were familiar with, or rather those suited to mass production techniques. However, huge energies were also devoted to industrial crops such as wool, jute, cotton and rubber and products such as tea and coffee became available to industrial man at the expense of local ecologies in third-world countries. Large quantities of crops were grown for animal feed, the energy and protein inefficiencies being irrelevant in a high-energy society. Increasingly, good protein food such as fish, was degraded to feed domestic animals.

These trends continue today in the underdeveloped countries. In the developed nations, the agriculture of each area has become more and more simplified, but the scale of production has increased with more mechanisation and land amalgamation. Production of plant products for animal feed has reached high levels of the total crop — the world average being 50% of total production.[43] The food processing, storage, transportation and marketing industries have grown enormously. Use of pesticides, artificial fertilizers, hormones, antibiotics and other chemicals increased with production. The energy now needed to produce these crops far exceeds the calorific return from them.

While the productivity of modern agriculture is great (constant surpluses requiring the restriction of production), the efficiency is another matter. We find that the energy sustaining the system does not come from the sun *via* photosynthesis as in pre-industrial times, but mostly from fossil fuels *via* the industrial systems. As Odum[1] demonstrates, the high yields of today are not due to efficient or even sustainable methods, but to a high external energy subsidy.

The reduction or collapse of the energy subsidy will result in a catastrophic drop in production. The basis for support of even pre-industrial populations, at low standards of living, would not exist.

The actual damage which has been done to productive land and the environment at large by high-energy agriculture, in terms of soil breakdown, pollution, and breeding of resistant pest strains, is not really known but there are indications that it is considerable, wide-spread, and long-term. The extent of the damage will not really come home to mankind until the ever-expanding energy-base of our system comes to an end; as it surely will in the not-too-distant future.

2.3 Agricultural Futures Refs. 25, 29

Restructuring of agriculture is an essential part of any attempt to deal with the environmental crisis with which man finds himself faced (see 'Blueprint for Survival', Ref. 29). A shift towards people-intensive agriculture, with long-term aims of improved productivity and lower energy consumption is necessary. However, the resources and energy of the present could also be devoted to the development of plant varieties of greater genetic variability, as elements of low-energy symbiotic systems which would make a cultivated ecology. Only this type of action will escape modern agricultures' ultimate fate of slow degeneration, or total collapse, as non-renewable resources run out.

With their aims of maximum use of renewable resources (e.g. animal wastes), regional self-sufficiency, and maximum human involvement and understanding of the land and food production, the Chinese, (building on older traditions) seem to be the only people who have succeeded in avoiding the dead-end of Western, industrial agriculture. Some of the third-world nations are also attempting the same transformation. These changes involve a revolution of lifestyles and society in general. (See Kropotkin, *'Fields, Factories and Workshops'*[25] for the social rationale behind widespread involvement in and understanding of food production.)

2.4 Permaculture — Future System

This study considers the possibility of reduced energy subsidy for agriculture in the near future. However, permaculture as developed here is likely to attract those seeking independence from the industrial support base of conventional farming and for cities facing increased transport and food costs. For these people, reduced energy subsidy is real at present, and the small farmer is being forced off the land as energy costs rise.

Permaculture is the extended and developed evolution of a total support base for man, beyond those developed by pre-industrial societies. The fact that it is based on permanence serves to define it. Apart from conventional orchard practice and like monocultures, productive permanent plant systems have been little developed. However, some writers have recognised the undeveloped potential in perennial plants. Mumford* in his Utopian vision of the new order, mentioned tree crops partly replacing grain agriculture. Smith[18] in his well-researched, but rather optimistic book on tree crops, puts the case for tree agriculture on non-productive land in the U.S.A., referring to many tree agricultures. Some of these, such as the 'Cork-Pork' forests of Portugal, are most instructive. Smith develops the idea of a tree agriculture and gives the plan (Fig. 2.4.1) of a 'tree crop farm'. The tree farm develops some of the possibilities of permaculture, but is still a relatively simple crop system. Douglas[13] outlines work he has been involved in using tree crops for animal feed, viewing the system as revolutionized forestry. The Po Valley farmers of Italy, with their multi-storey agriculture of trees, under-storey and grain strips, again illustrate the principle of integrated yield. Blunden[45] refers to the Rev. H. Hunter, who, in 1811, described land use patterns around London. The orchards of the Isleworth and Brentford parishes are of interest. ". . . . . orchards of apples, pears and cherries yield an upper crop with an under crop of strawberries and raspberries planted between the trees. The orchards were surrounded with high walls on which peaches, plums and nectarines were trained". Anderson[44] considers the complexity of tropical garden/orchard systems, giving the plan of one he studied in Guatemala. He describes the system as requiring little work by the owners all-year-round, and always providing some yield. The productivity per land area, or labour unit, was extremely high (see Fig. 2.4.2). (See also Section 7.4 for information on other traditional systems of relevance to permaculture).

In spite of all this, little reference can be found to the type of system that is developed in this study. Thinking about the productive landscape in terms of an ecology which considers relationships, interactions and energy functions more than the individual elements is relatively recent (see Odum,[1] Chapter 4). Where 'cultivated ecologies' do exist, they are usually simple, involving the few elements (plants and animals) providing the traditional needs of the culture and are not necessarily transferable to other environments. The possibilities of complexity have not been explored.

The revolutionary nature of permaculture in reclaiming barren areas is illustrated by the case of the solitary shepherd Elzeard Bouffier, in France, who carried a bucket of acorns as he wandered in a deforested landscape, planting each seed with an iron-tipped staff. He succeeded in creating a forest of 40 square kms. Birds re-occupied the region, and brought in seeds of other species. Rivers began to flow as the humus retained run-off moisture, and villages, long deserted, were again occupied by some 10,000 people.[66] Think of the potential, in Australia, for

* Mumford, L. *'Techniques and Civilization'*, 1934.

Hershey's tree crop farm. Dowington, Pa.

O — Orchard

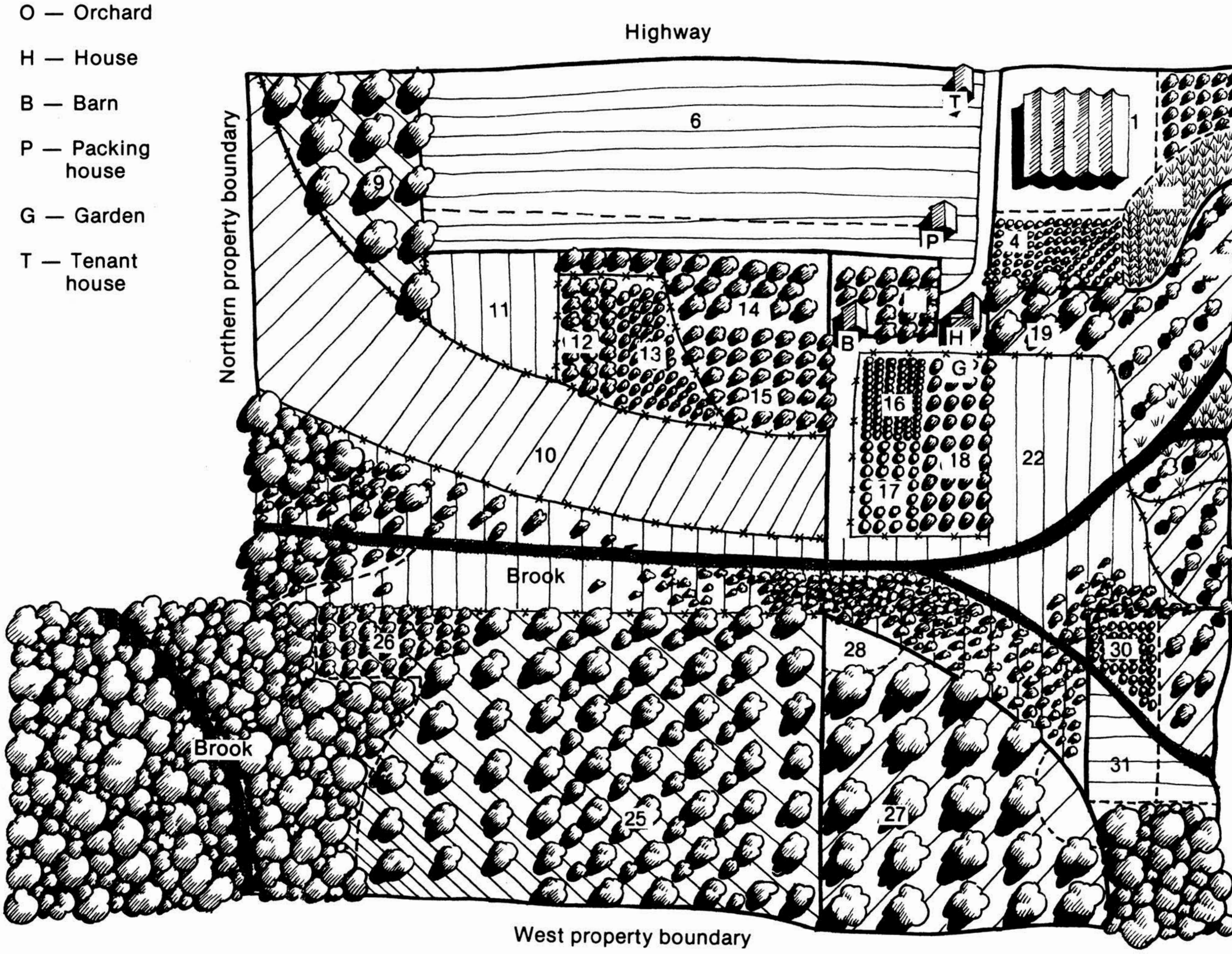
H — House

B — Barn

P — Packing house

G — Garden

T — Tenant house



—— Fence   -×-×-×- Electric Fence   - - - - - - - Between Crops

1 Nursery
2 Acre of test filberts
3 Swampy, drained in blueberries
4 One acre each of asparagus and raspberries
5 Holly
6 5 acre farm field
7 Nursery
8 Wild life fence row, many species
9 5 acres nuts mostly English W., some thin shelled Black 60 x 60 ft., Chestnuts set at 30 ft. on row. Hay
10 4 acre farm field
11 Bull pasture. Will be planted when 12, 13, trees large enough to pasture
12 Assorted, peaches, cherries, pears
13 Jujubes 3 varieties, 52 trees
14 Sugar maple for syrup
15 Chinkapin and bur oak for hog feed
16 Mulberry for hog and chicken feed
17 Wild plum for hogs, wild life, ornamental
18 Permissons
19 Select grafted oaks of 5 varieties — set in vista for effect from Home (H)
20 Honey locust, pasture
21 Swamp
22 Meadow
23 Brush land to be cleared
24 Woods
25 5 acres chestnuts 40 x 40 ft. Four rows of filberts as fillers. Here chestnuts are 50 ft. between rows
26 24 oaks on ground too low for chestnuts
27 7 acres planted same as (9) planted to orchard grass, ladino for hay
28 Sharp rocky knoll
29 Honey locust, sowed to orchard grass, mixture of ladino, birds-foot trifol, canary
30 15 rows, 1 each of hickory, pecan and hiccan varieties. Will be farmed till trees large enough to pasture
31 Sprout land of nearly solid stone

Figure 2.4.1 Plan of an Existing Tree-Crop Farm (after Smith, Ref. 18)

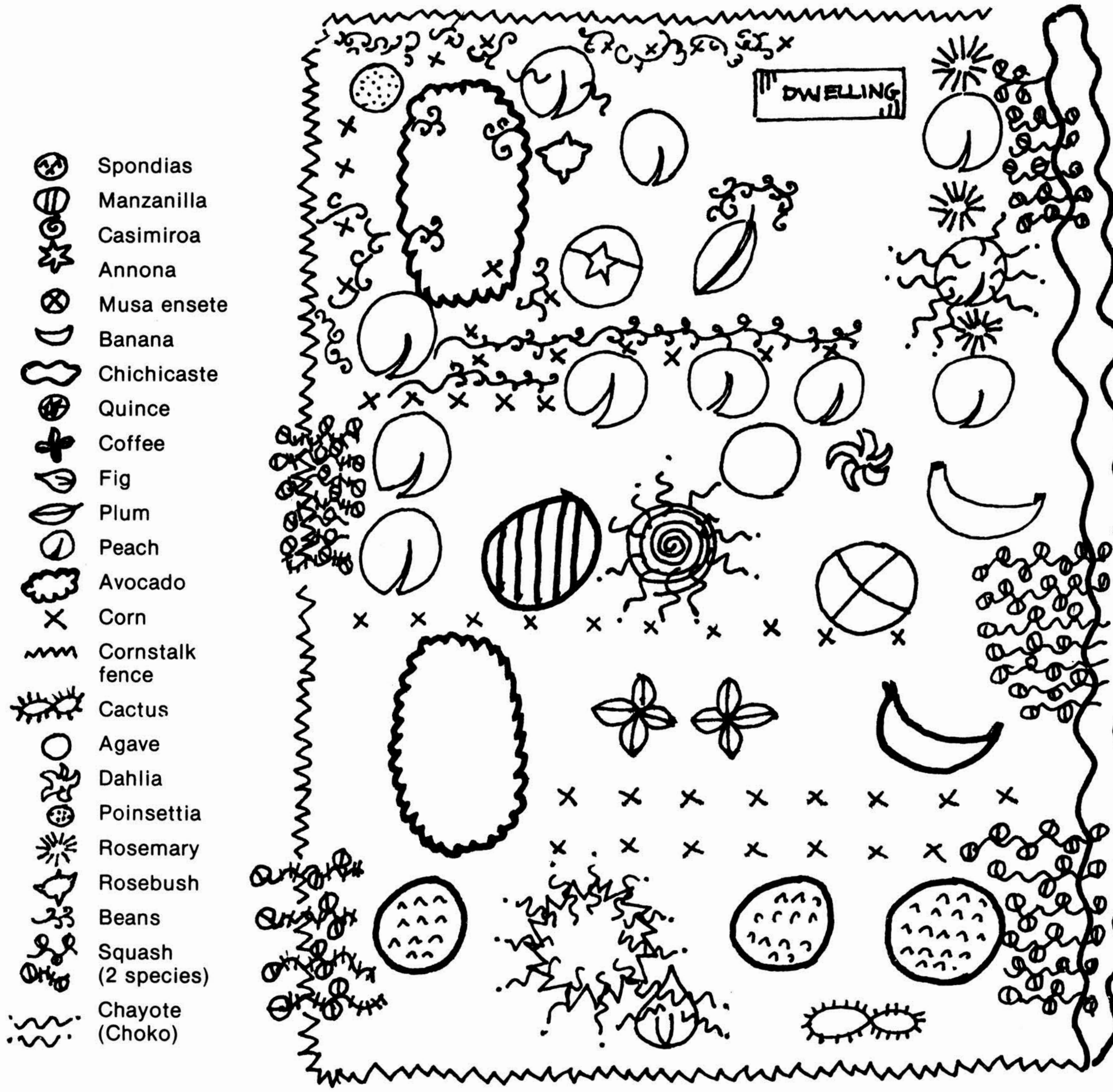


Figure 2.4.2 Guatemalan Garden (after Anderson, Ref. 44)

Diagrammatic map of an orchard-garden in the Indian village of Santa Lucia, Guatemala. The glyphs listed above, not only identify the plants shown in the plan on the right-hand side of the page, they indicate by their shapes, in what general category the plants belong. Circular glyphs indicate fruit trees (such as plum and peach) of European origin; rounded irregular glyphs indicate fruit trees (such as the manzanilla) which are of American origin.
The long irregular mass at the right-hand side represents a hedge of "chichicaste", a shrub used by the Mayas.

such a healing revolution in landscape. Many large sheep and cattle properties, now producing a few bales of wool or a few chemicalized carcases, could be made tremendously productive in this low-energy fashion, using free tree seed to set up an extensive permaculture.

2.5 Permaculture — Basic Characteristics

There are several characteristics of a permaculture beyond the definitive one:

1. Small scale land-use patterns are possible.
2. Intensive, rather than extensive land-use patterns.
3. Diversity in plant species, varieties, yield, microclimate and habitat.
4. Long term; an evolutionary process spanning generations.
5. Wild or little-selected species (plant and animal) are integral elements of the system.
6. Integration with agriculture, animal husbandry, extant forest management and animal cropping become possible, and landform engineering has a place.

7. Adjustable to steep, rocky, marshy or marginal lands not suited to other systems.

2.6 Ecosystem Stability and Diversity Refs. 1, 39.

Permaculture, unlike modern annual crop culture, has the potential for continuous evolution towards a desirable climax state. Annual crops are destroyed when harvested and must be replanted, whereas in permaculture the plants and animals, often long lived, grow and change with the system. Succession of species occurs as the ecosystem moves towards climax. The great variety of plant types from large, top-storey trees to herbs, creates habitat and food diversity allowing a complex array of fauna. Each element serves several functions in the ecosystem, and each function is common to many elements. Thus a system of checks and balances develops, helping to prevent epidemic outbreaks of pests, and population fluctuations should reduce in severity, number, and frequency (e.g. the carrying capacity for a particular domestic animal species stabilizes).

The soil becomes more complex without the destruction by cultivation of the humusphere which absorbs and stores nutrients (leaves and manure) and water for later use by the plants. The humusphere or natural mulch acts as a control on pioneer plants (weeds) and reduces leaching, runoff and erosion, but most importantly, harbours flora and fauna of great variety (see Section 7.5 for more on soil ecology).

The structural diversity of a permaculture increases microclimate variation, which allows a greater range of useful plants. Plants changing the microclimate state for man and other species is another example of the symbiotic interactions which can occur in permacultures. Symbiotic relationships of this type are characteristic of complex ecosystems.

Some of these aspects mentioned aid in the nett yield to man, while others, such as a complex array of herbivores, may reduce yield. However, the 'costs' of diversity must be accepted as system stability becomes critical, which it does if independence and regional self-sufficiency become goals of future communities.

In the event of a definite climatic trend, permacultural species both buffer the change, as moderators of local climate, and provide species for extension of a more suitable assembly for increased cold, dry, or steamy conditions. At present, many of the species that would be needed to replace others in any such change are not commonly under cultivation or established in temperate areas. As in other factors, the principles of permaculture permit some plants at low yield to occupy space, trading-off yield now for stability in a changeable future.

Finally, by designing for complexity, a safeguard against catastrophic changes in the environment such as fire, drought, climatic change and plagues of all types is established. Any change will affect some species and the system will be deflected, but the basis for a productive permaculture will remain. It is no longer sensible to ignore the possibility of sudden and prolonged changes in the biosphere due to the unknown effects of modern activities. Design of support systems with maximum flexibility and diversity is the best response to a potentially unstable environment.

2.7 Yields Refs. 1, 39.

The productivity of agriculture is usually assessed by the *yield per unit area.* Yields/unit area from any particular *species* are likely to be lower in a permaculture ecosystem than in a monoculture. However, the *sum of yields* from a permaculture will be greater, simply because a single-species system can never use all available energy and nutrients. For example, a multistorey plant system uses all available light for photosynthesis. Species of trees, as Kern [39] points out, have different-shaped root systems tapping different water and nutrient sources. Therefore in mixed forest stands there is more complete use of resources than in single-species stands. A plankton-eating fish in no way competes directly with an algal browser in a pond, since it cannot use the algal food. Poultry and guinea fowl can range on the same area since the former are primarily seed-eaters, and the latter grazers. Thus a complex permaculture can maximize use of all available resources and so increase total yield.

Symbiotic interaction in a well-designed and controlled permaculture can further increase yields. Plants and animals may not merely co-exist without competition but the presence of one may improve the environment for others. For example, top-storey trees improve the environment below for many berry species. Some species fix nitrogen, of benefit to nearby plants. A hive of bees increases yield in many fruit trees by improving pollination. Mulberries aid the growth of grape vines.[14]

Nett yield is only one value to consider. In commercial agriculture all value is converted to money, diversity of yield being less important. In subsistence agriculture, human needs determine the value of yields and since our needs are diverse, so should the yields be diverse.

Man requires nutrition difficult to obtain from a few foods. Although carbohydrates are readily available from simple systems, foods providing the more complex nutritional requirements (proteins, vitamins, fats, and minerals) are not all available from simple agricultures. This is especially true for vegetarians.

In modern food-supply systems, full nutrition and a varied diet are provided by a world-wide transport, storage, and marketing network. This reticulation of food is, of course, more energy-expensive than local agricultural diversity and is only possible due to fossil fuel subsidy. Already, the costs of food reticulation are out of hand and are having their effects back at the production site — the farm. 'Efficient' methods have been forced on the producer even if it is to the long-term detriment of the land or quality of the produce. Pesticides, large amounts of fertilizers, unwise cropping sequences and cultivation techniques, have become common-place (Refs. 6, 16, 29) in an effort to reduce monetary costs and to raise yields, in the hopeless race to remain economically viable.

A community supported by a diverse permaculture is independent of the distribution trade and assured of a varied diet, providing all nutritional requirements, while not sacrificing quality or destroying the land that feeds it. In the city, part at least of the wastes are usefully applied to mulch and compost systems in permaculture, and the integration of food and shelter makes for minimal transport fuel costs.

2.8 Energy Costs Refs. 1, 29

Energy trapped by plants in photosynthesis is the "prime mover" of all ecosystems, including food production. In the modern world, harnessing of fossil fuels has revolutionized agriculture. Most of the fossil fuel energy supporting agriculture is consumed *via* the industrial society in the form of pesticides, machinery, research, intensive crop strains, and artificial fertilizers. However, the energy subsidy on the farm is small when compared with the total costs of transportation, packaging, processing, storage and marketing.

Data from ecologists is scant on the energies of modern food production, but figures for *direct* consumption of non-renewable fuels in food production are horrifying enough. In Australia, the fuel (food calories) of production is 15-20% of the fuel energy used to supply it. 90% of this fuel energy is consumed in the transport, storage, marketing and cooking of the food.[27] The energy inputs per unit of protein formed in modern agricultures are even more frightening. Figure 2.8.1 indicates the inefficiencies of protein production under modern methods.

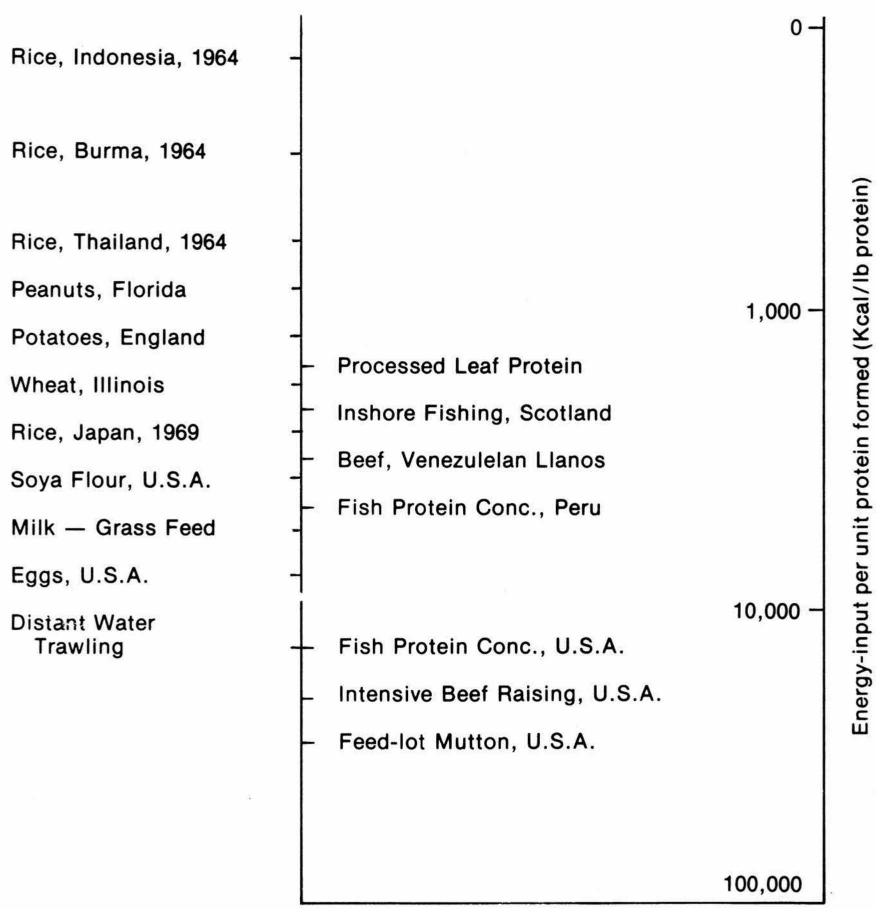


Figure 2.8.1 Typical Energy Subsidies in Modern Protein Production (after Slesser, M. How Many Can We Feed? **Ecologist** 3 (6)

No data is available on the energy budget of a fully-developed permaculture. The greatest savings on energy are in the elimination of costly transport, packaging and marketing. On-the-site energy costs would be relatively high during establishment, especially if rapid evolution is an aim. Plant propagation, mulching, watering, protection from predators and pests, would be expensive during the first few years. Most of these costs give long-term benefits or are eliminated completely after establishment. For example, propagation cost of olive trees, taken over the lifetime, would be insignificant. Watering is not very important after the first few years, especially if mulching is adequate. The elimination of annual sowing, ploughing, fertilization and pesticide application would lower total energy consumption. The lack of need for new research-intensive crop strains and complex specialised machinery would also minimize consumption of energy. Careful choice of self-storing yields such as nut, root and seed crops further reduces the need for energy inputs. Sophisticated storage is then not needed.

2.9 Labour Inputs

Permaculture is labour-intensive in establishment and harvest, but the nature of the work is important to consider. Rather than the menial and repetitive labour of sowing, ploughing and reaping in a labour-intensive annual crop system, work in the permaculture system usually involves observation and control rather than power functions. This is a more or less continuous process — with few times when the loading is heavy, or cropping time critical. Anderson's[44] Guatemalan garden/orchards illustrated this aspect. The use of animals in harvesting (free-ranging within part of the system) reduces the need for human labour. Management of animals on range, rather than harvesting feed for them, is an example of a control function replacing a power function.

If work is mainly control function, the people involved have the ability to continuously observe the system, learning from it in a feed-back mode in order to adjust and improve methods and techniques. This includes plant selection for a complex network of characteristics which it is useful to propagate.

In a labour-intensive annual crop system where menial, repetitive work occupies most of the time, the ability to advance understanding of the system and provide effective control is limited. In modern commercial agriculture, the farmers' contact with the system has been reduced to the point where he is a business manager. He is performing control functions, but in a man-made mechanistic system of trucks, tractors, fertilizers, pesticides, money and quantities of output. In this situation, the farmer is totally dependent on the research work of agricultural scientists for knowledgeable and effective control of the organic aspects of the system. Likewise, the peasant with an annual grain culture is at the mercy of the seasons and of pathogens and pests.

A look at the type of agriculture which we are proposing, in the context of the wider society, is interesting. It is often stated that in modern industrial societies 10% or fewer of the population provide the food for the rest, allowing society to diversify activities and interests. The thesis is that the freedom from production allows us, as a society, to progress to a higher level of civilization. If we look more closely at food provision in society, we find that the farmer is only one member of a complex system which includes truck drivers, shop assistants, agricultural scientists, packers, food process workers, marketing board officials and countless others — all essential if the provision of reticulated food is to continue. To say that we have more diverse occupations as a result of such a system is meaningless if everyone is thereby fixed in his role. The separation of food supply into many specialised occupations doesn't relieve us of personal drudgery, nor enable us to make a significant or creative contribution to a progressive evolution. This is not a defence of peasant economies, but simply an attempt to show that modern agricultural systems are not all they are made out to be, as alleviators of agrarian or urban drudgery.

In line with Kropotkin's[25] far-sighted views of the last century, we believe it is socially and ecologically desirable for all regions to be self-sufficient in food, and for all people to have some contact with the process of food production. That this is possible with labour-intensive agriculture and a moderate level of technology is certain. This study is directed in the long term, towards the aim of regional self-sufficiency.

2.10 Establishment and Maintenance

The development of established permacultural systems can be a long process (the development of a mature forest can take over fifty years). The full return on establishment costs takes a long time but yields and useful functions from the herb layer and understorey begin within a year.

The principle of ecological succession in which useful but relatively short-term elements of an understorey system give yields early but are succeeded by other elements until a 'climax' state of maturity is reached, can operate under the control of man. The processes of succession and climax in a particular system will be discussed in detail in a later Section (5.5).

In general, the establishment of a mature system in the shortest possible time requires fairly high resource conditions. Mulching, tree propagation, planting, protection and watering, can involve considerable initial effort, but not as much as the annual effort for commercial cropping operations. In contrast, maintenance work in permaculture is low and by the time of maturity work on some elements of the system is nil. This is partly due to the use of wild and little-selected plants. Generally, highly cultivated plants need high nutrient levels, protection from pests, pruning and other work by man in order to ensure high yields and even survival of the variety.

If it is possible to develop a system which, when mature, provides diverse products for a community with minimal work input, it leaves the community free to engage in more complex and useful activities than the continual effort of food production. Although useful, under present high-resource conditions, this would secure a higher standard of living than normally possible under low resource conditions.

2.11 Plant Material — Cultural Diffusion

Refs. 7, 42, 44

The mobility of man, materials and information across the planet is now continuous and large scale (due to the use of fossil fuel). This mobility has made the great variety of cultivated plants of all regions available everywhere. A large proportion of our common vegetables arrived from the Americas after 'discovery'. The explosion of available, cultivated, useful plants in the last two hundred years gives us a tremendous advantage over early subsistence systems. Prior to the modern era, people mostly cultivated plants which grew locally. Thus the peoples of the Mediterranean began cultivation of the olive, chestnut and carob thousands of years ago. Cultivation over long periods increased the variety and usefulness of the local plants, but the ability to develop complex cultivated ecosystems of useful plants was limited.

As mobility increased, it became possible to tap the immense variety of useful species as well as the work of plant selectors of other regions. For example, from China we not only gained new species, but often hundreds of cultivars representing thousands of years' work — as in the case of the persimmon and jujube. In the Americas, cultivation of corn, potatoes, peppers and tomatoes was at a level far removed from the original wild varieties. The exchange of useful plants continued through to this century. However, actual local cultivation of a wide variety of species has slowed, or even reversed, as specific areas specialize in particular crops for a particular mass product, such as frozen peas.

Complex permaculture demands the use of a great variety of plants, so availability of as many useful species and cultivars as possible should become a priority. Appendix 'B' contains many species generally uncultivated in Australia, and most are not cultivated commercially to any significant extent, while a few may not be in the country at all. Improving the availability of increasing numbers of species and cultivars will provide the material for greater complexity and diversity in permaculture.

2.12 Perennial Forms of Annuals

Quite ordinary vegetables may be replaced, at least in large part, by perennial forms. Broccoli is one such, lettuce, spinach, celery and onions, others. Onions which are perennial are tree onions, potato onions, chives (two species), shallots, Welsh onions, and "ramps", the latter a forest, strong-tasting allium. Garlic too may be replanted soon after harvesting at the end of summer, and as it then grows through the winter, it is in effect a plant/replant species.

Celery we pick a few stalks at a time, unblanched, as needed. Some seedlings forms are perennial, and these can be further developed, rather than encourage annual varieties. Parsley is 'perennialised' by sowing for a year or two in a weed-free bed, allowing it to seed down in alternate years, and keeping it well manured with liquid manure.

Those who have septic tanks, in country areas, can select an area below the outfall, pump out the tank *via* a standpipe, cover the sewage sludge with thick sawdust (3" to 6") and retire. If this is done in spring, a bed of tomatoes results — the seeds were in the sewage. Melons, and some other cucurbits also grow. Corn scattered on the area will also do well under the sawdust mulch. In this way, much energy is saved in planting.

2.13 Aboriginal Agriculture

It is our contention that the faeces of men, buried near caves or huts, contained the first agricultural seeds, and that subsequent selection of the fruits proceeded in the same way. G.A. Robinson (see Plomley's *Friendly Mission,* 1971) found "sweet native plums" in "groves" around Tasmanian aboriginal settlements, and the native tree tomato or kangaroo apple is only thick on old, disturbed, or occupied sites. Such plants eventually develop a reliance on man, and are thereby domesticated. Thus, man probably developed agriculture as an unconscious result of fixed abode over time. It is nonsense to say that aboriginal populations are not agriculturalists, as their cultures regulate the harvest and management of the land and its products, using controlled fire and clearing as a tool, and selection as a (conscious or unconscious) propagating strategy. Any group that does not regulate gathering or hunting selects for their own extinction.

Over some tribal areas, explorers reported only cream-coloured or white kangaroos, again suggesting that (by taboo or selection) even animal species were altered by aboriginal man. Fire, the main tool, was rigorously controlled and directed, no doubt keeping desirable 'edge', and renewing growth in overgrown shrubby systems producing little low browse for animals.

The 'tameness' of all animal species, bird and mammal, in early explorations also suggests that the aborigine moved amongst his food species more as a herder amongst a flock than as a hunter feared by all other species. Aboriginal Tasmanians lived in small tribal territories only a days' walk across, and resided there for some 20,000 years before whites came. From such a long period of control and selection, each region was (could we have understood and had we asked) a highly-evolved permacultural region sufficient to sustain tribal life indefinitely.

It is a challenge to modern man to develop as sophisticated a system of world species, integrated in a single resource assembly, and so ensure a sustainable society in modern terms. It is in large part a philosophical approach to land, asking of it what it can yield under management, rather than forcing unsuitable plants to crop at maximum yield, and thus causing all the ills of erosion and pest plague.

3.0 SELF-SUFFICIENCY

Self-suffiency is a much-used term to describe a state of living which is much more independent of the reticulation system than normal, modern living. To be totally self-sufficient is to have the ability to produce all requirements and needs; food, tools, clothing and shelter.

We do not subscribe to the isolated fortress mentality of a totally self-sufficient approach, but believe in designing for the whole society of man.

Self-sufficiency in food is not as easy to achieve as it might seem. If the materials, chemicals, seed and tools necessary for maintenance of the food support base are largely imported, then food self-sufficiency is an illusion. For example, a large range of animals supported on purchased feed, or a field of wheat ploughed by a complex petrol-driven tractor mean little in terms of independence; this is the present condition of modern society.

Independence in areas other than food is extremely difficult for small groups. Further, overall self-sufficiency is a pointless goal, but reduction of dependence on the wider industrial system can be taken a long way, reducing the need for people to work in the industrial society and to consume its products. Thus, the available fossil fuel energy can be freed for essential, rather than profligate inessential uses.

As Peter Bunyard* says, "self-sufficiency tends to be insular and destructive". More relevant and realistic is community co-operation. When people have established themselves in an area, a complex network of resources, skills and needs, with some specialization, should evolve. This inter-independence within a locality and independence in relationship to outside areas will establish itself in time, within a permacultural framework.

In the cities and towns, tools, clothing, and shelter are plentiful, and it is there we most need to consider group survival in terms of food, and to develop permaculture for the direct use of man. Thus, broad-scale agriculture can be turned to the provision of fuel needs to sustain local transport networks, using alcohol instead of petrol as a renewable fuel.

Some specialization of species will inevitably occur as plants demonstrate their suitability for a particular soil, niche, or climatic regime, and thus the basis of local trade will be established, based on ecological rather than economic factors. On a smaller scale, a person with just enough room for a productive vine or tree can trade for more varied produce with neighbours.

In a developing permaculture, it will soon become apparent that local centres for processing to oil, flour, medicinal products, soap and so on will develop, and regions should in this way evolve unique product patterns, involving more and more people in useful full-time and part-time work as the secondary product system evolves. The scope for local specialty production is as varied as the permaculture.

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* Bunyard, P. "Ecological Living — Dream or Reality?". *The 'Ecologist'*, Jan. '75.

4.0 PRODUCTS FROM PERMACULTURE Refs. as for Appendix 'B'

Resources available from the plant would vary considerably in their ability to be used by small agrarian communities. Those of critical importance will be considered first and others which are useful later. Products from plants which require extensive processing will be ignored in this treatment, but will need future consideration as permaculture develops. We are, at present, assembling data on the necessary techniques for using the products of a permaculture.

4.1 Food

Human food requirements fall into two classes — energy foods and nutritional foods. Energy is mostly provided by carbohydrate-rich foods, but also oils, fats, and even protein.

High carbohydrate food is scarce in a hunter-gatherer ecosystem, but abundant in modern agricultural systems. In a permaculture, carbohydrates are readily available from many tuberous plants (see Table 4.1.1) and some nuts, such as sweet chestnut (78% carbohydrate). However, a permaculture will not provide a carbohydrate suitable for a bread flour in the class of wheat flour. Sugars, on the other hand, are abundant in virtually all fruits. Concentrated sugars are available from the carob pod and dried fig (both 50%). High yields of honey would be an obvious source of energy in a permaculture. Oils and fats are available in abundance from nuts (see Tables 4.1.9 and 4.1.11) as well as animals supported by the system.

Table 4.1.1
Plants with Food Products from Roots, Tubers or Shoots

Acorus (sweet rush)	Choko
Apio	Common reed (rhizomes and shoots)
Asparagus	Earth almond
Asphodetus microcarpis	Horse radish
Arrowhead	Jerusalem artichoke
Bracken (rhizomes and shoots)	Kudzu vine
Bamboos	Oca
Capuchin	Queensland arrowroot
Chinese artichoke	Reedmace
Chicory	

Human nutrition is a complex subject with much debate as to what is necessary for good health. One thing is certain; a large range of organic and inorganic chemicals are needed for the human body to function properly, many of these performing critical functions in minute doses. It is thought that small quantities of essential oils and even dangerous alkaloids, help in the functioning of various organs and glands.[48]

Research on the long-chain polyunsaturated fats (available from meat), indicates they may be critical in brain development. The list of vitamins which perform useful functions in maintaining health continues to grow. The only sure way to provide all nutritional requirements is a diverse diet, with a minumum of processing adulteration. There is no doubt a developed permaculture would provide for nutrition better than any limited, traditional agriculture or modern crop system, without resorting to importation of some foods to provide for diversity. A well-developed system would approach the best of the hunter-gatherer ecosystems for diversity.

Table 4.1.2
Plants Giving Storable Food Product(s)

A. **Nuts:**
- *Almond
- Black walnut
- Bunya pine
- Butternut
- Dwarf chestnut oak
- *Filbert and Hazel
- Ginkgo
- Japanese Walnut
- Macadamias
- Pecan
- Pistachio
- Stone pine and other nut pines
- Scarlet runner beans
- *Sweet chestnut and other chestnuts
- *Walnut
- White oak

* of greater importance than others.

B. **Fruits:** (suitable for local drying and storage)
- Apple
- Apricot
- Fig
- Grape (some varieties)
- Jujube
- Nectarine
- Peach
- Prune plum

C. **Flours and Meals:**
- Burr oak and other oak spp. (tannin removal necessary)
- Carob
- Common reed
- Bracken
- Honey locust
- Horse chestnut (tannin removal necessary)
- Kudzu vine
- Mesquites
- Sweet chestnut
- White mulberry

D. **Cooking oils:**
- Almond
- Beech (American and European)
- Hazels
- Live Oak
- Olive
- Walnut

Table 4.1.3
Fresh Fruit

Alpine Strawberry	Loquat
Apple	Mediterranean medlar
Apricot	Medlar
Banana passionfruit	Mulberry
Black currant	Nectarine
Blueberries	Peach
Cape gooseberry	Pear
Checker berry	Persimmon
Cherry-plum	Plum
Chinese gooseberry	Raspberry
Cloudberry	Red currant
Custard bananas	Snowberry
Feijoa	Strawberry
Fig	Strawberry guava
Grape	Sour cherry
Grapefruit	Sweet cherry
Jujube	Tree tomato
Loganberry	

Table 4.1.5
Expressed Oils

Bitter almond	Pecan
Apricot	Stone pine and other pines
Beech	Walnuts
Hazels	Castor oil plant
Olive	

Table 4.1.6
Volatile Oils

Acorus	Lemon
Bay	Mints
Lemon balm	Rosemary
Lavender	Walnut

Table 4.1.4
Fruit Used in Cooking

Apple	Huckleberry
Barberry	Japanese quince
Bilberry	Lemon
Blueberry	Peach
Cape gooseberry	Pear
Cornelian cherry	Plum
Cranberry	Quince
Elderberry	Tree tomato
Gooseberry	

Table 4.1.7 (after Smith)[18]
Average Composition of Nuts

Nut	Refuse %	Water %	Protein %	Fat %	Carbohydrates % Sugar Starch		Crude Fibre etc.	Ash %	Food Value per Pound (Calories)
Acorn (fresh)	17.80	34.7	4.4	4.7	50.4		4.2	1.6	1,265
Almond	47.00	4.9	21.4	54.4	13.8		3.0	2.5	2,895
Beechnut	36.90	6.6	21.8	49.9		18.0		3.7	2,740
Butternut	86.40	4.5	27.9	61.2		3.4		3.0	3,370
Chestnut (fresh)	15.70	43.4	6.4	6.0	41.3		1.5	1.4	1,140
Chestnut (dry)	23.40	6.1	10.7	7.8	70.1		2.9	2.4	1,840
Water chestnut		10.6	10.9	0.7	73.8		1.4	2.6	1,540
Filbert	52.8	5.4	16.5	64.0		11.7		2.4	3,100
Ginkgo		47.3	5.9	0.8	43.1		0.9	2.0	940
Hickory	62.20	3.7	15.4	67.4		11.4		2.1	3,345
Pecan	50.10	3.4	12.1	70.7	8.5		3.7	1.6	3,300
Pine nut pinon	40.6	3.4	14.6	61.9	17.3			2.8	3,205
Pine nut, pignolia (shelled)		6.2	33.9	48.2	6.5		1.4	3.8	2,710
Pinus edulis		3.1	14.8	60.6	18.7		1.8	2.8	
Pinus pinea		4.2	37.0	49.1	5.5		1.0	4.2	
Pinus gerardiana		8.7	13.6	51.3	23.4		0.9	3.0	
Pistachio		4.2	22.6	54.5		15.6		3.1	3,250
Walnut	58.80	3.4	18.2	60.7	13.7		2.3	1.7	3,075
Walnut, black	74.1	2.5	27.6	56.3		11.7		1.9	3,105

(All tables giving protein yield figures should be interpreted by reference to Frances Moore Lappé, *Diet for a small planet* F.O.E./Ballantine, 1974. This book is an excellent guide to the role of protein in nutrition, and in modern agriculture.)

Table 4.1.8 (after Smith)[18]
Food Value of Various Fruits

Fruit	Total Solids %	Ash %	Protein %	Sugars %	Crude Fibre %
Apples	13.65	0.28	0.69	10.26	0.96
Blackberries	13.59	.48	.51	4.44	5.21
Cherries	22.30	.65	.81	11.72	.62
Currants	15.23	.72	.51	6.38	4.57
Dates (dried)	66.86	1.20	1.48	56.59[1]	3.80
Figs	20.13	.57	1.34	15.51	
Grapes (dried)	21.83	.53	.59	17.11[2]	3.60
Oranges — Navel	13.87	.43	.48	15.91	
Peaches (dried)	10.60	.40	.70	5.90[1]	3.60
Pears	16.97	.31	.36	8.26	4.30
Persimmons (dried)	35.17	0.78	.88	31.72[2]	1.43
Plums	15.14	.61	.40	3.56[2]	4.34
Raspberries	13.79	.48	.53	3.95	5.90
Strawberries	9.48	.60	.97	5.36	1.51

1. Fats and carbohydrates.
2. Nitrogen free extract.

Table 4.1.9 (after Douglas)[13]
Average Nutritive Value of Various Tree Products for Human and Livestock Diets

Species		Food Composition (per 100g) Protein (g)	Carbo-hydrate (g)	Fat (g)	Calcium (mg)	Iron (mg)
Walnuts	Juglans spp.	16.0	15.5	64.0	99.0	3.2
Chestnuts	Castanea spp.	6.5	78.0	4.0	53.0	3.4
Hazelnuts	Corylus spp.	12.8	17.0	62.0	210.0	3.5
Hickorynuts & Pecans	Carya spp.	9.4	15.0	71.0	74.0	2.5
Carob	Ceratonia siliqua	21.0	66.0	1.5	130.0	3.8
Mesquites	Prosopis spp.	17.0	35.0	2.0	260.0	4.0
Pigodias	Pinus spp.	31.0	13.0	47.5	11.0	4.5
Pinons	Pinus spp.	14.0	20.5	60.0	12.0	5.2
Honey locust	Gleditsia spp.	16.0	30.5	7.5	200.0	3.8
Almond	Prunus amygdalus	19.0	20.0	54.5	235.0	4.8

Table 4.1.10 (after Smith)[18]
Food Value of Nuts Compared with Milk

	Pints of Milk Containing as much Protein as 1 lb. of Named Nut	Calories in Amount of Milk Shown in Column 1	Calories in 1 lb. of Named Nuts	Ozs. of Named Nuts Needed to Replace 20 oz. of Milk
Acorn	2.4	780	2620	8.3
Almond	6.4	2080	3030	3.2
Beechnut	6.6	2145	3075	3.0
Butternut	8.5	2762	3165	2.4
Chestnut	3.2	1040	1876	6.4
Chinquapin	3.3	1072	1800	6.4
Hazelnut	5.0	1625	3290	4.0
Hickorynut	4.6	1495	3345	4.8
Pecan	3.6	1170	3455	5.6
Pinon	4.4	1430	3205	4.8
Persian walnut	5.4	1555	3300	3.7
Black walnut	8.5	2762	3105	2.4

Table 4.1.11
Animal Forages and Feeds

A. **Nuts, Pods and Seeds**

Almond	Horse chestnut
Beech	Kudzu vine
Black locust	Mesquites
Black walnut	Mirror plant
Bamboo (*A. macrosperma*)	Oaks
Carob	Siberian pea tree
False tree lucerne	Chestnuts
Fat hen	Walnut
Hazels	Wild rice
Hickories	Wood millet
Honey locust	

B. **Fruit**

Apple	Natal plum
Cherry plum	Nectarine
Cornelian cherry	Olive
Damson plum	Peach
Hawthorns	Pear
Laurelberry	Persimmon
Loquat	Sloe
Med. medlar	Sour cherry
Medlar	Sweet cherry
Mulberries	

C. **Foliage**

Bamboo (*A. racemosa*)	Lespedeza
Chicory	Lucerne
Comfrey	Lupins (perennial)
Esparto grass	Pampas grass
False tree lucerne	Wild rice
Jerusalem artichoke	
Kudzu vine	

D. **Roots, Tubers, Rhizomes**

Bamboos (most spp.)	Jerusalem artichoke
Chicory	Kudzu vine
Comfrey	Oca
Common reed	Queensland arrowroot
	Reedmace

Table 4.1.12 (after Smith)[18]
Analysis of Feeds for Farm Animals

Feed	Moisture	Ash	Crude Protein	Crude Fibre	Nitrogen Free Extract	Fat or Ether Extract	Digestible Protein	Digestible Carbo-hydrate Equivalent
Barley[1]	9.6	2.9	12.8	5.5	66.9	2.3	10.4	63.8
Corn[1]	12.9	1.3	9.3	1.9	70.3	4.3	7.1	74.8
Wheat[1]	10.6	1.8	12.3	2.4	71.1	1.8	9.8	63.3
Wheat Bran[1]	9.6	5.9	16.2	8.5	55.6	4.2	12.5	48.7
Cottonseed Meal (good)[1]	7.3	5.8	36.8	13.5	30.0	6.6	30.9	42.1
Alfalfa Hay[1]	8.3	8.9	16.0	27.1	37.1	2.6	11.5	42.0
Alfalfa[1]	72.9	2.6	4.7	8.0	11.0	0.8	3.6	12.8
Potatoes[1]	78.9	1.0	2.1	0.6	16.3	0.1	1.3	16.3
Turnips[1]	90.6	0.8	1.3	1.2	5.9	0.2	1.2	7.4
Honey Locust[2]								
U.S.D.A. Grounds	4.1	3.7	13.4	16.3	61.3	1.2		
New Mex. Agri. Col.[2]	5.20	3.58	4.50	14.56	69.94	2.22		
Carob: Entire Bean[2]								
Italian	11.3	2.9	5.1	6.0	74.4	0.3		
Portuguese	8.3	3.1	4.3	7.9	76.1	0.3		
Algaroba or Keawe[4, 7]								
Sample No. 1	—	2.14	10.84	26.48	56.40	.77		
Sample No. 2	—	—	9.88	31.29	53.13	.62		
Mesquite Beans[1]								
Hawaii, 5 samples	12.3	3.3	9.00	23.4	51.4	0.6		
Arizona, 4 samples	6.3	4.5	12.7	24.5	49.5	2.05		
Calif., 2 samples	11.4	4.0	9.07	22.6	51.3	1.0		
New Mexico, 1 sample	4.8	3.4	12.2	32.0	45.1	2.5		
Texas, 7 samples	6.9	4.4	12.4	25.7	47.9	2.7		
N.M. Tornillo beans	5.1	3.0	9.8	19.3	61.8	1.0		
Mesquite Tree[5]								
No. 1348[8]	7.25	4.31	12.48	25.67	55.51	2.03		
No. 1345[1, 10]	6.21	5.24	14.12	22.17	54.80	3.69		
No. 1313[10]								
Pods, 70%	5.48	5.71	5.70	30.70	55.46	2.40		
Seeds, 30%	7.69	3.38	37.54	5.75	46.89	6.45		
Carob Bean[6]								
Pods and Seeds[1]								
1704	11.91	2.67	7.96	5.60	44.96	1.00	12.94	13.96
Minimum	9.12	1.67	3.26	4.98	26.99	1.00	3.25	6.39
Maximum	19.81	3.46	15.22	17.42	43.57	3.82	18.69	41.56
Average	13.28	2.57	6.75	9.29	39.80	2.17	11.08	19.44
Pods Without Seeds								
2200	12.27	2.50	3.77	9.96	40.28	2.64	6.88	21.70
2201	18.08	2.39	3.33	8.24	37.54	2.86	20.54	7.02
2371	5.70	3.87	3.40	13.62	18.36	3.08	13.04	8.93
2493	8.21	2.71	7.18	4.73	24.48	.71	8.36	43.62
Minimum	3.70	1.76	2.02	3.14	24.48	.22	3.00	7.02
Maximum	24.70	3.87	7.18	15.31	48.36	4.02	20.54	43.62
Average	11.50	2.72	4.50	8.78	36.30	2.37	11.24	23.17

1. United States Department of Agriculture, Bureau of Animal Husbandry. The carbohydrate equivalent shown in the last column of the Table is the sum of the digestible crude fibre and nitrogen-free extract, plus 2.25 times the digestible fat.
2. United States Department of Agriculture, Bulletin No. 1194.
3. Analysis No. 12053 Misc. Div. United States Department of Agriculture, Bureau of Plant Industry, Washington, D.C., of an unusually broad-podded variety of honey locust pods obtained near grounds of New Mexico Agricultural College Mesilla, New Mexico.
4. Hawaii Agricultural Experiment Station, Bulletin No. 13, Edmund C. Shorey, Chemist.
5. Composition of entire mesquite beans. Analysis from *"The Mesquite Tree"* by Robert H. Forbes, Bulletin No. 13, Arizona Experiment Station.
6. Bulletin No. 309, University of California, *"The Nutritive Value of the Carob Bean"*.
7. *Prosopis juliflora:* entire beans.
8. Gathered August 1 on Rillito river.
9. Sample furnished by N.R. Powell of Pettus Bee Company, sent by W.J. Spillman.
10. Gathered October 7 on Santa Cruz river.
11. It should be noticed that these maximum and minimum figures refer to a particular element in a number of different samples. They are not complete analyses of one sample like Nos. 1704, 2200, 2201, 2371 and 2493.

4.2 Medicinal Substances

In a diverse diet there are many substances (vitamins, essential oils, alkaloids and antibiotics) which act to improve health and prevent upset (sickness) of the system. The use of a wide range of culinary herbs is important for this reason. Many of the medicinal plants listed in Table 4.2.1, are used in this preventative manner.

Specific preparations from these plants for curative uses cover a large range of common illnesses and injuries. Knowledge of the preparation and use of botanical substance in medicine is not something gained easily or quickly. Because the field is large and complex, it is not dealt with in detail. Some basic information on herbal medicine is available in Refs. 40, 41, 48 and 67.

In terms of health generally, gardening and gathering provide the natural exercise and interest needed by man, and as the seasons change he always has something to look forward to.

Table 4.2.1
Plants with Medicinal Properties

Acorus	Lime
Angelica	Lovage
Almond (bitter)	Licorice
Bay laurel	Lemon balm
Bergamot	Marsh mallow
Bilberry	Mallow
Black currant	Marjoram
Borage	Mullein
Buckbean	Mints
Castor oil plant	Nasturtium
Chicory	Parsley
Comfrey	Plantain
Cowslip	Rue
Coltsfoot	Rhubarb
Dandelion	Rosemary
Elderberry	Raspberry
Fennel	Sorrel
Good King Henry	Squill
Hawthorn	Sage
Horse radish	St. John's wort
Hyssop	Thyme
Hops	Valerian
Juniper	Violet
Lavender	Walnut
Lemon	Yarrow

4.3 Fibres

Fibres for rope, twine, cloth and paper are available from cool temperate permaculture (see Table 4.9.1, pp. 22-23). The processing is often quite simple, so these plants should be considered seriously in any self-support system.

4.4 Animal Products

A large range of animals both domestic and wild, supported by permaculture, provides an extensive list of products easily available with simple processing. For example:— hides (leather, rope, furs), feathers (down and feathers), glue, soap, gut fibres, wool and hair, blood and bone.

4.5 Timber

Although quality timber is widely available from native forest, a permaculture can provide special timbers such as hickory for tool handles, bamboos for poles, stakes, arrows, beams, and willow switches for basketry.

4.6 Tans and Dyes

A great variety is available from a permaculture (see Table 4.6.1).

Table 4.6.1
Dyes

Blackcurrant	—	Fruit
Bracken fern	—	New fronds
Barberry	—	Ripe fruit
Dandelion	—	Flowers
Elderberry	—	Fruit
Fennel	—	Foliage
Horse chestnut	—	Bark and leaves
Hops	—	Leaves and inflorences
Japanese walnut	—	Bark and fruit
Medlar	—	Bark
Mints	—	Foliage
New Zealand flax	—	Flowers and buds
New Zealand spinach	—	Foliage
Pinus spp.	—	Cones
Plum	—	Leaves
Peach	—	Leaves
Rhubarb	—	Leaf stalks
Tamarillo	—	Fruit
Walnut	—	Bark and husks

4.7 Miscellaneous

Soaps, waxes, oil for lighting (olive), rubber and latex, lubricants, gums, resins and other products are available from some plants suitable for inclusion in a permaculture (see Table 4.9.1, pp. 22-23). Dalton [35] considers a wide array of chemicals which can be produced from plant materials. Some of the processes are complex, but others — such as distillation and fermentation of wood — are possible as local processes.

For 'Selected Products from the Plant Catalogue (Appendix B)' see Table 4.7.1 and for 'Food Values of Crop and Livestock Products per Acre' see Table 4.7.2.

4.8 Fuel from Permaculture and Its Effective Use

Permaculture is, in the short and long term, a provider of solid fuels as branches, prunings, bark, and deadwood. Burned in an open fireplace, most of the useful products of such fuel is dissipated to the air. In 'natural' systems, especially in dry-summer climatic regimes, the accumulated fuels of the forests burnt either in a "controlled" or catastrophic wildfire produce more pollutants as ash and turpenes than any other source, at least in Tasmania. The effect of fire on nutrient loss in soils can be severe.

There is therefore an urgent need to design a fire complex to reduce such wasteful solid-fuel losses as are produced by either open hearths or wildfires. Such a system should have the following features:—

1. Controlled burning, using both spin-control for air regulation, and dampers in the flue or flues.
2. Fire-box separate from hot-air ducts, so that flue gases may be further treated, and air led directly to house or heat-store.
3. Accessory chambers. These could comprise the following facilities:—

a) Ash-pit, for soap and garden alkali (for lime replacement where limestone is scarce).
b) Charring oven, for high-temperature roasting of clay (for pottery), shells and rock (for gardens or mortar), or wood (for charcoal production). Charcoal further used to fuel forges or small cooking ovens and as filters, for smoke, gas and water.
c) Steam chamber, for leading steam to wet distillation or timber-bending chambers, kilns, cookers, engines, and the like.
d) Drying chamber, for food products, wet clothes, etc.
e) Smoke chamber, for either hot or cold smoking of fish, sausage, or other products.
f) Hot water coils, leading to, or accessory to, solar water-heating devices.
g) Gas collector to store methane which was driven off wood burnt either in the primary combustion chamber, or in the roasting oven. For clean cooking or engines.
h) Cold-distillation coils, for all flue gases, using a nearby pond or dam if necessary, so that products such as methanol, creosote, tars, acetone and wood alcohol can be collected.
i) Stone-filled storage walls or under-floor spaces, to store excess heat, as ducted hot air.
j) Direct (insulated) cooking-top, for pot cookery, and sunken slow-cooker with insulated top, for long-term cooking at low heat.

Table 4.7.1
Selected Products from the Plant Catalogue (Appendix B)

(Selected (Products (Available (From (Plants (Catalogued	Waxes and Soaps	Resins	Gums	Brewing	Tans	Fibres	Rubber and Latex	Lubricants	Soap
Bunya Bunya Pine		×							
Chinese Tallow Tree	×								
Carob Bean			×						
Hops				×					
Jerusalem Artichoke						×			
Kudzu Vine						×			
Lacquer Tree		×							
N.Z. Flax						×			
Oak spp.					×				
Walnut					×				
Common Reed						×			
Asphodelus microcarpus			×						
Bayberry	×								
(Carandy Wax [Cerifern]	×								
(*Copernica australis*									
Chaguar Fibre						×			
Chairmakers Rush						×			
Chille		×					×		
Chingma						×			
Colligua ado fern	×								
Ensete ventricosum						×			
Esparto Grass						×			
Castor Oil Bush								×	
Horse Chestnut									×

Table 4.7.2. (after Smith)[18]
Food Values of Crop and Livestock Products Per Acre

Food Products	Yield Per Acre Bushels	Yield Per Acre Pounds	Calories per Pound	Pounds Protein per Acre	Calories per Acre	Acres to Equal One Acre of Corn
Field						
Corn[6]	35	1,960	1,594	147.0	3,124,240	1.00
Irish Potatoes[6]	100	6,000	318	66.0	1,908,000	1.64
Wheat[6]	20	1,200	1,490	110.4	1,788,000	1.75
Dairy Products						
Milk[6]	...	2,190	325	72.3	711,750	4.39
Cheese[6]	...	219	1,950	56.7	427,050	7.32
Meat	(live lbs)	(dressed)				
Pork[6]	350	273	2,465	22.7	672,945	4.64
Beef[6]	216	125	1,040	18.5	130,000	24.00
Poultry Crop[6]						
Meat and Eggs	66 lbs	111 eggs	....	27.5	349,000	21.00
Nut Crops						
Chestnuts (fresh	...	1,600	1,140	.....	1,824,000	1.71
Persian Walnuts	...	1,000[1]	3,075	.....	1,266,900	2.47
Black Walnuts	...	1,000[2]	3,105	.....	766,250	4.03
Hickory Nuts	...	1,000[3]	3,345	.....	1,672,500	1.86
Pecans	...	1,000[4]	3,300	.....	1,650,000	1.89
Acorn	...	1,400[5]	1,265	.....	1,455,762	2.12
Keawe[7]	...	.....	.....	.....	....	....

In comparing these nut crops with corn it should be remembered that the figures for the nut crops are supposed to be annual averages, whereas corn, even on the best of land, is almost always put in rotation: and therefore there is rarely less than one crop in three years, often one crop in four or five years. Many of these tree crops MIGHT have side crops also.

1. Based on California production (p.215).
2. Quantity is estimated yield. Calories are for edible portion. Assume 25% edible. See 1919 report Northern Nut Growers' Association for tests of weights, also 1927 report of same. Some yield more than 25% kernel.
3. Yield estimated by W.C. Deming for full stand grafted trees. Calories for edible portion. Assume 50% edible. See 1919 report Northern Nut Growers' Association where many nuts were more than 50% edible.
4. Quantity, Georgia Experiment Station Estimate. Calories for edible portion. Edible portion estimate 50% kernel.
5. Quantity authors' estimate. It is probable that the figure for yield is too low, edible portion.
6. From U.S. Dept. of Agric., Farmers' Bulletin No. 877: *Human Food from an Acre of Stable Farm Products,* by Morton O. Cooper and W.J. Spillman from whom the idea came.
7. Counted as calories and considered as stock food it outranks corn.

k) Ash and soot collection by efficient flue-cleaning, for garden use.

Others may think of additional facilities, but these are all possible primary uses of a fire complex, leaving a cool and clean residue of air to escape to the atmosphere. Further, if the fire complex is situated in a greenhouse, and is itself a fairly massive brick-stone system, it will provide the necessary background heat for winter nights.

With controlled burning, a large fire-box is possible, and long wood or piles of brush can be loaded for a 24-hour burn.

Both methanol and methane, products of dry distillation of wood, give portable power.

For 'Schematic Fire Complex' see Figure 4.8.1.

4.9 Permacultural Technology

The use of cultivated and wild plants by man can be classified according to the cost of processing necessary to get useful products. The costs can be measured in time, effort, skills, knowledge and technology required for processing. In the wider economic system, this is called Secondary Industry.

For the small community aiming at self-sufficiency, there are limits to the complexity of worthwhile processing. The limits change with community size and resource, the state of the wider industrial economy, and community values. Therefore species which give products *via* processing can be considered a valuable resource without the necessity of immediate use. For example, a stand of mature cork oaks could at some future date provide cork, if the special effort

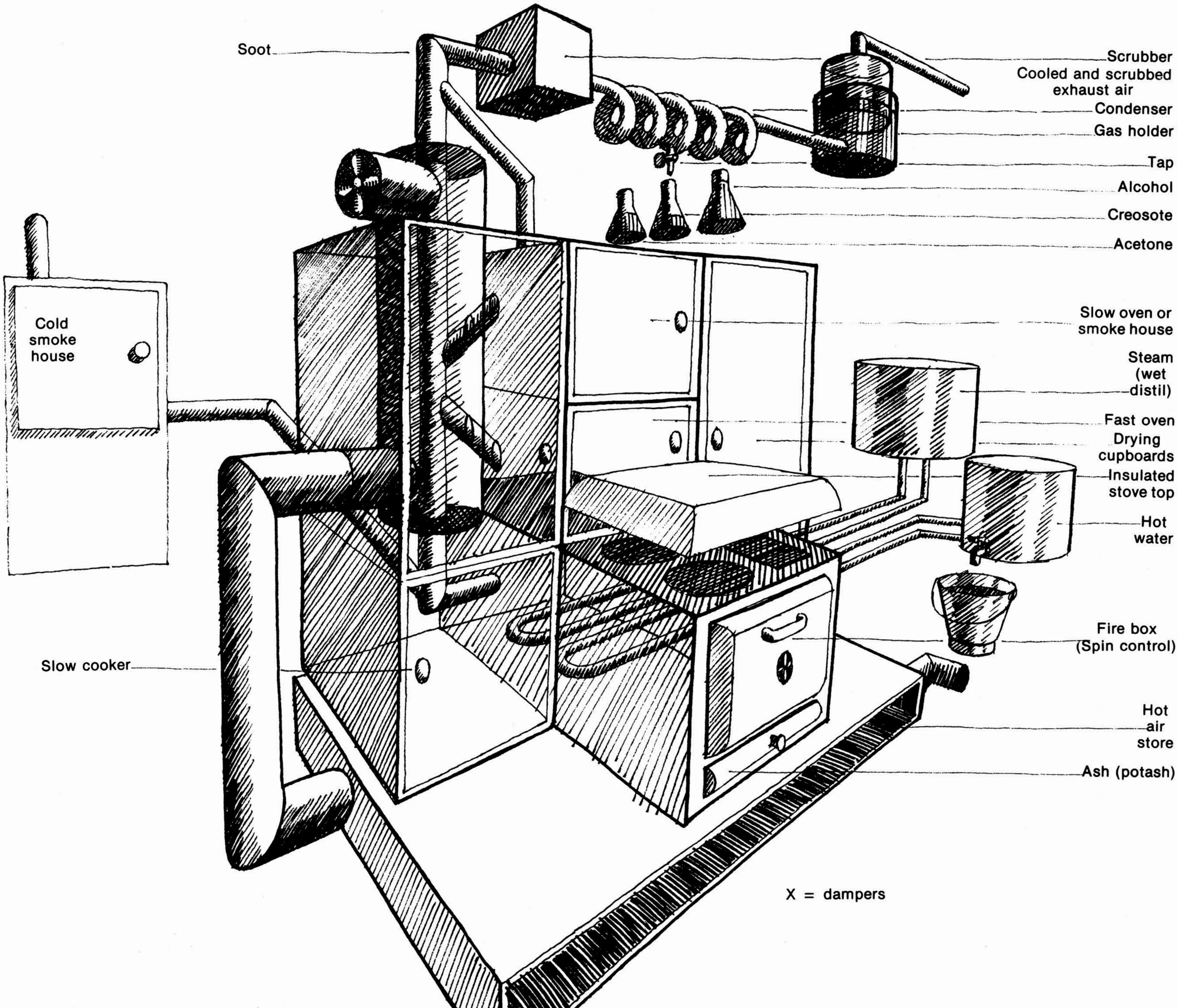


Figure 4.8.1 Schematic Fire Complex

Table 4.9.1.
Levels of Use for Some Species from Appendix B

Level 1 Self-regulating functions and uses, e.g. windbreaks, animal barrier plants, bee plants, plants for sheltering animals.
Level 2 Self-operative use with some control work, e.g. yields harvested by animals.
Level 3 Uses with simple harvesting, e.g. fresh fruit.
Level 4 Uses with processing usually involving simple machinery and/or skills, e.g. grinding carobs for coffee, garden stakes from bamboo, drying of herbs.
Level 5 Uses with processing involving particular skills, knowledge and equipment, e.g. expressing olive oil, making maple syrup, some medicinal preparations, rope from flax, seasoned timber from walnut trees.
Level 6 Uses with processing rarely attempted just for the needs of a small community, e.g. distilling lavender oil, paper from bamboo, methanol, methane, acetone and other chemicals from dry distillation of wood.
See Ref. 35 for variety of industrial products available from plants.

Plant	Level	Use or Function
Almond	1	Bee forage
	3	Culinary nuts
	5	Almond oil
American-beech	3	Culinary nuts
	5	Beech oil
	5	Wood for pulleys etc.
Bamboo	1	Windbreaks, animal shelter
	2	Forage
	3	Vegetable
	4	Stakes, poles, beams
	6	Paper
Borage	1	Bee forage
	3	Culinary herb
	4	Cosmetic, medicinal herb
Carob	1	Forage
	4	Coffee, other culinary uses
	4	Prepared stock feed
	6	from seeds
		(over 200 products may be derived from carob beans)
Cherry plum	1	Bee forage
	2	Animal forage
	3	Fresh fruit
Comfrey	1	Bee forage
	2	Animal forage
	3	Harvested, dried forage
	3	Culinary herb
	3, 4	Medicinal herb
Common reed	3	Vegetable
	3	Thatching material
	4	Food products — flour, sugar, gum
Dandelion	1	Bee forage
	3	Vegetable
	4	Medicinal uses
	4	Roasted root as coffee
	4	Flowers as dye
Hawthorns	1	Barrier plant
	1	Habitat plant/birds, etc.
	1	Bee forage
	3	Culinary uses of berries
	4	Medicinal uses of flowers, fruit
Honey locust	1	Shelter belt tree
	1	Barrier tree
	2	Animal forage
	4	Ground meal — culinary
	4	Ground meal — stock
	5	Timber
Laurel Berry	1	Bee forage
	1	Barrier plant
	1	Shelter plant
	2	Forage for birds
	3	Culinary uses

Lucerne	1	Bee forage
	1	Soil improvement
	2	Forage
	3	Harvested fodder
	3	Leaf, seed vegetable
Mints	1	Bee forage
	3	Culinary herbs
	3	Medicinal herbs
	4	Dyes
	6	Methanol
N.Z. flax	3	Flowers as dye
	5	Fibre
Oak spp.	2	Leaf mulch against insects
	2	Forage
	4	Ground feed
	4	Flour
	4	Cork
	4	Bark, etc., tanning
	5	Timber
Osier willow	1	Bee forage
	1	Fire control
	1	Erosion control
	5	Willow basketry
Persimmon	2	Stock forage
	3	Fruit
	5	Astringent juice for glue (used with bracken root)
Walnut	2	Nut — forage
	3	Nuts — culinary
	3	Fruit — culinary
	4	Dye
	5	Timber
	5	Expressed walnut oil
	6	Citronella
Wild rice	2	Forage
	3	Harvested feed
	3	Vegetable
	4	Flour

involved in harvesting becomes worthwhile. New Zealand flax plants can be made into an excellent rope, if necessary.

Obviously, the use of flax for rope is at a different level to the use of fresh fruit. The higher levels of use, where skills and technology are necessary, may be beyond the capabilities of a small community. However, each community can balance the product against the cost of production. A comparative table of the levels of use for species in the catalogue, is useful in making decisions on the value of the species (see Section 7.1) and as an indication of the range of products the community could expect to produce itself.

Simple presses, stills and grinders can be adapted to diversify yields from permaculture and it is in this area of the extraction, fermentation and distillation of special products that we need more data and design.

For 'Levels of Use for Some Species from Appendix B' see Table 4.9.1.

4.10 Some Intrinsic Properties of Biological Systems

Too little attention has been given to trees as sources of power in their own right. Trees are large sails, and in wind sway powerfully up to 2 metres or more. This motion can be translated, by wires and pulleys, to work as sawing, pounding, or pumping energy; in fact, for any task not needing constant work input. A forest absorbs enormous wind energies, which could be used by man.

Mention has been made of trees as water catchment (Section 6.5.1), and water from tall trees led to tanks, can give domestic or stock water at head, even on flat sites. Trees are also trellis supports for vines and provide stout platforms or skyhooks upon which wind machines may be supported or suspended (Savonius rotor types). No doubt many other uses can be found for the intrinsic properties of trees apart from their direct yields.

Mussolini used Tasmanian bluegums, on banks, to pump out the malarial Pontine marshes of Italy, and thus earned his soubriquet of "bull-frog of the Pontines". While some species act as pumps, others appear to provide surface moisture.

(Murray, J. S. and Mitchell, A. ***Red gum and the nutrient balance,*** Soil Conservation Authority, Victoria, undated. (See tables 4.10.1 to 4.10.3).)

Trees are also de-salinators of soil, allowing rain to carry the salts to subsoil levels and preventing, by shade and humus, the surface evaporation which leads to salt concentration in the soil. This factor may become more critical as over-use of irrigation causes salt-pan evolution in the inland.

Instances of trees as fences, barriers to cold air flows and windbreaks, are given elsewhere in this treatment, but architects and planners have under-used the potential cooling effects of tree shade on buildings and their moderating effects on microclimate and noise. There is need for a study of the whole macro-physics of forests and the use of trees and animals in heating and cooling buildings. Studies of termite mounds give some clues to how a complex building can be maintained at constant temperature and humidity without the use of pumps, heaters and evaporators.

Wherever biological solutions replace technological devices, not only is energy saved but most biological systems operate on free energy (sunlight). Stephen Lesuik, Dept. of Architectural Science, University of Sydney (Australia) is in process of investigating the use of plants in moderating energy use in buildings; and in the evolution of such systems, biotechnology will prove a future energy-conserving discipline (see also Section 8.4 for greenhouse heating). Summer shading of greenhouses can be achieved by the use of runner beans and other winter-deciduous vines.

TABLE 4.10.2
CHEMICAL STATUS OF SURFACE SOILS (0,4")
UNDER RED GUM AND IN THE OPEN AT COLERAINE

	Under Red Gum	Open		Under Red Gum	Open
H_2O air-dry (%)	3.3	6.0	Exchange-able Cations (m-equiv. %)		
pH	7.1	6.0			
Conductivity (umho/cm)	165	37	Ca	14.3	1.4
			Mg	3.0	0.5
Soluble Cl (%)	0.013	0.002	K	0.8	0.3
Organic C (%) (Walkley & Black)	4.9	1.1	Na	0.8	0.1
Total N (%)	0.34	0.08	Total	18.9	2.3
			Exchange Capacity	22.1	4.1
C/N Ratio*	19	18			
HCl Sol. P. (%)	0.025	0.005			
HCl Sol. K (%)	0.06	0.04			

* C/N ratio calculated assuming a Walkley and Black recovery of 75% of organic carbon.

TABLE 4.10.1
NUTRIENT CONTENT OF LITTER, CANOPY DRIP, AND RAIN IN THE OPEN
A naturally regenerating stand of red gum, Gringegalgona.

Source	Period	Total Rainfall (in.)	Nutrient Return lb/ac.							Total Litter (lb.)
			N	P	K	Ca	Mg	Na	Cl	
OLD TREES * (5% of Total Area)										
Litter	5 May '60-4 May '61		19	1.2	6	25	6	4	N.D.	2,800
Canopy Drip	5 May '60-4 May '61	30.67	6	1.1	28	13	11	71	143	
Total:	5 May '60-4 May '61	30.67	25	2.3	34	38	17	75	—	
REGROWTH * (95% of Total Area)										
Litter	5 May '60-4 May '61		38	1.9	10	49	15	5	N.D.	5,400
Canopy Drip	5 May '60-4 May '61	30.67	3	0.7	16	6	5	29	51	
Total:	5 May '60-4 May '61	30.67	41	2.6	26	55	20	34	—	
Rain: Nearby	22 Nov. 60-4 May 61	9.25	0.5	0.1	0.7	0.8	0.7	4.2	7	
Coleraine ☆	1 Sep. 55-1 Sep. 56	33.61	0.5	N.D.	1.5	3	3	21	38	
Cavendish ☆	1 Sep. 54-1 Sep. 55	21.75	N.D.	N.D.	1	3	2	14	20	

* Nutrient additions to areas beneath canopy only.
☆ From Hutton and Leslie (1958)
N.D. Not determined

"The results show that rain washes large amounts of potassium and smaller amounts of nitrogen, phosphorus, calcium, and magnesium from the canopies to the surface soil. Litter adds organic matter, and is a rich source of calcium and nitrogen and a moderately rich source of magnesium and potassium." **(Murray and Mitchell)**

Table 4.10.3 presents an analysis of herbage growing under trees and in the open at Coleraine during the spring flush on 29/10/59.

TABLE 4.10.3
SPRING HERBAGE ON 29/10/59 AT COLERAINE

Species	Fresh Wt. of Herbage g/m²	
	Under Red Gum	Open
Introduced grasses	265	3
Native grasses	32	80
Onion grass [*Romulea rosea*]	27	51
Flat weeds	34	53
Clovers	15	3
Other species	7	4
Unidentifiable plant parts	131	68
Total Fresh Weight	510	262

The introduced grasses are mainly *Lolium* spp., *Holcus Lanatus, Bromus sterilis,* and *Bromus mollis.* The native grasses are mainly *Danthonia,* spp., *Poa australis,* and *Microlaena stipoides.* The flat weeds are the composites *Hypochoeris radicata, H. glabra,* and *Taraxacum officinale.* The clover is largely *Trifolium subterraneum.*

5.0 PERMACULTURE — THE CULTIVATED ECOSYSTEM

Before discussing mixed cultivated systems, it seems appropriate to consider parallel natural systems, for it is necessary to "..... recognise that successful long-term agriculture demands the achievement of an artificial 'climax', an imitation of the pre-existing ecosystem".[29]

5.1 Natural Ecosystem Models Refs. 1, 19

The temperate deciduous forests of the northern hemisphere have structural and functional aspects of relevance. The annual leaf-fall of these forests in response to the seasonal change from summer to winter is the dominant characteristic.

In these forests, most photosynthesis occurs during summer in the leaves of the trees. Spread across the top of the system, they absorb most the available light. The biomass of the system is concentrated in the perennial parts of the trees. The trees act as a pump in nutrient cycling, by drawing deep nutrients as well as topsoil and litter nutrients up to nutrients as well as topsoil and litter nutrients up to the leaves for structure-building in the plant. The annual fall of leaves in autumn returns much of this nutrient to the litter-bed on the forest floor. A smaller proportion of the leaves and also fruit such as acorns, are consumed mainly in autumn by herbivores, and indirectly by carnivores. The whole system puts matter and energy into storage as floor litter, acorns and animal fat for the dormant period of the winter when respiration exceeds photosynthesis. Since the top-storey trees absorb most of the available energy, the photosynthesis and thus the biomass of understorey plants is low. However, understorey plants such as berries are often adapted to grow and reproduce in low light conditions. Some, particularly the few annuals of the forest, grow rapidly in early spring, using the light for growth and fruiting before the leaf canopy of the trees blocks out the sun. The understorey microclimate is considerably modified by the canopy. Apart from light penetration, rain, wind and temperature effects are moderated in summer to provide a more stable microclimate. These moderating influences are reduced in winter due to the autumn leaf fall (see Section 6.3).

The consumers in the forest live in a great variety of habitats — from tree tops to underground burrows. As in other systems, their wastes, and eventually their bodies, contribute high N.P.K. nutrients to the litter. The litter itself is a complex system, being basically a nutrient store which is gradually made available to plants by the decomposers, flora and fauna. It also provides a habitat for many consumers, including fungi, which themselves provide a source of food for other consumers.

The broad-sclerophyl ecosystems of the Mediterranean climate of the world are also relevant. Such systems are also seasonal, but more because of the summer drought than winter cold. The trees are evergreen, but do not usually form a dense canopy as in the deciduous forests. Evergreen shrubs and annuals are more important, due to the availability of light. Drought resistance by various adaptations is a characteristic of the whole range of vegetation. Fires are sometimes an integral part of this type of system, beginning new growth cycles.

The effect of Mediterranean vegetation on microclimate is less than in forests — if only because of its lesser bulk and density. However, hot, sunny, sheltered spots and cool, moist positions do occur in woodlands. Habitats are varied, dense shrubs near ground level being more important than tree tops.

Many other ecosystems can be looked at as models. For example, grasslands and heathlands — as well as the typical Australian sandplains scrub systems. However, more important are various microsystems, especially those involving water — such as river back-swamps, annual inundation flats, ponds and marshes. Cliffs and rock outcrops often have their own particular species, as in the granite outcrops of the West Australian wheatbelt.

At a higher level of sophistication, study of natural ecological systems could be used directly in the design and refinement of cultivated ecosystems, in a way beyond the capacity of this primary study.

5.2 Permaculture and Landscape

Complex permaculture can be developed on any type of country; alluvial river flats, rocky hills, swamps, deserts, alpine regions. It is not necessary to try to change the stable landscape to achieve particular conditions, as is done in simple agricultural systems. Every landscape and natural ecosystem will dictate the general nature of permaculture possible; this is desirable if the system is to have long-term viability.

Although permaculture could be established on fertile areas such as river flats, these areas are the best locations for intensive grain agriculture or vegetable gardening. Smith[18] advocated the use of tree agriculture on upland country, giving as a contrasted example the instability and destructiveness of grain agriculture on hill country, mainly due to soil erosion. The chestnut forests of Corsica, and the "Cork-Pork" forests of Portugal, are testimonies to the stability and productivity of forest agriculture on "worthless" land. Douglas[13] suggests rural landscapes, composed of forest belts and blocks with pasture strips from headwaters and ridges to flood plains (see Figure 5.2.1).

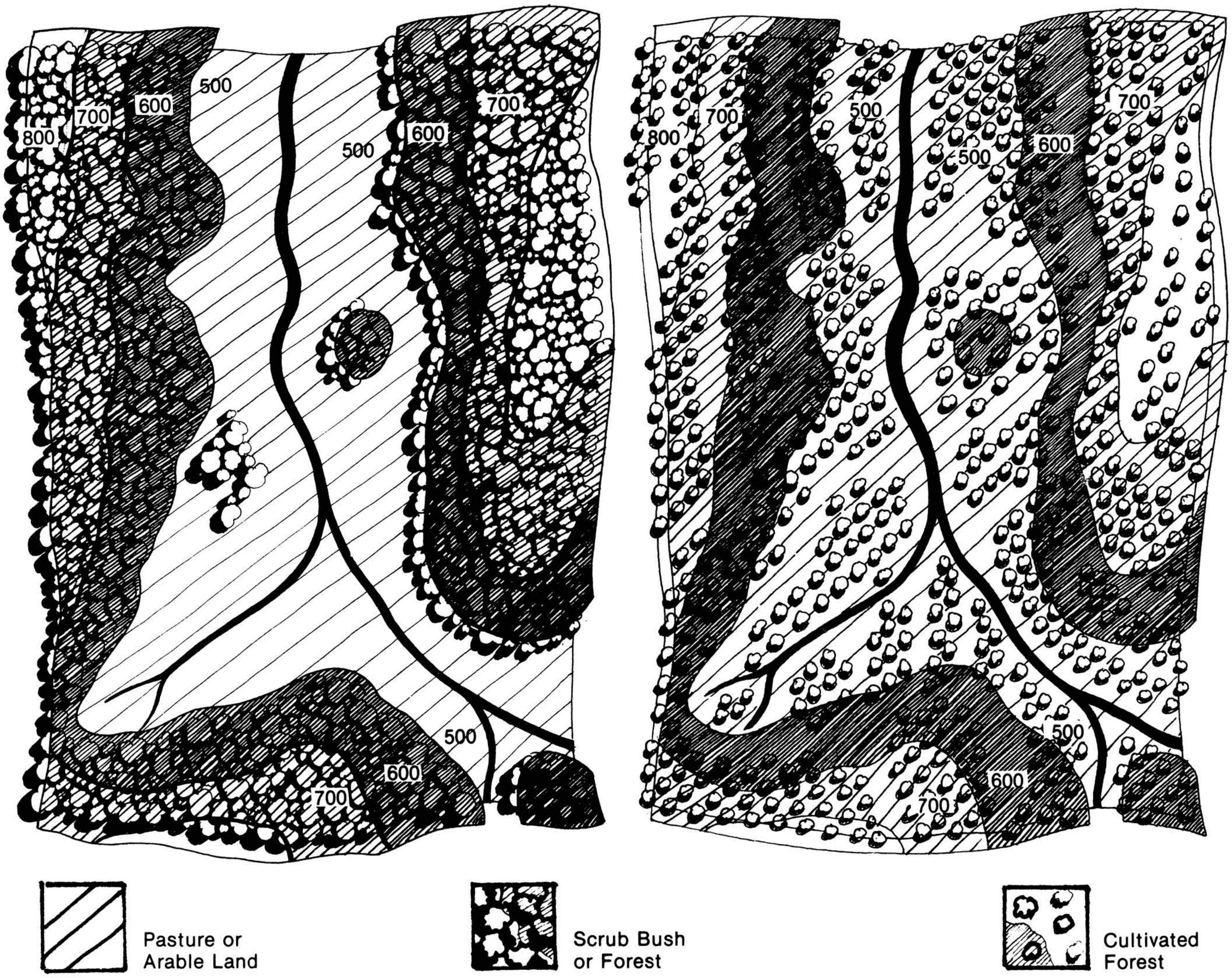


Figure 5.2.1 Forestry Layout (after Douglas)

Introduction of three-dimensional forestry in marginal areas completely transforms the scenery. Instead of small farms growing field crops in patches of moderate soil near river banks (left) the whole area is effectively exploited (right). Belts and blocks of trees yielding cereal-substitute crops replace the previous waste, or scrub grazing of little value. Grazing strips for livestock lie between the new plantations.

However, since land is not under rational integrated control, the long-term planning and management of the wider productive landscape in an intensive, ecologically viable way, remains in the visions of Kropotkin and Gandhi. In China such ideas have been put into practice on a large scale. Australian examples are the keyline systems of P.A. Yeomans.

5.3 Structure and Edge in Permaculture

The structure of plant systems is determined by *the characteristics of the plant species in association with each other, under the specific local conditions of site and climate.* Specimens of the same species may have quite different forms and sizes, in different systems and sites. For example, carob on dry, rocky banks in hot climates matures as a small savannah tree, while on a deep, rich, well-watered site it can be a large tree with dense foliage. Hazels, as an understorey in dense forests, are tall, spindly plants to 30ft. or more, while in the open, untended, they are shrubby thickets to 10ft. Pecans on moist soils will attain 40ft. in height, but on rich alluvial flood plains, may reach 150ft. and spread almost as far. With such differences within species, the structure of the system cannot be easily determined. However, without the rigid production goals which limit commercial agriculture, it is feasible to some extent to allow a system to develop naturally and observe the results.

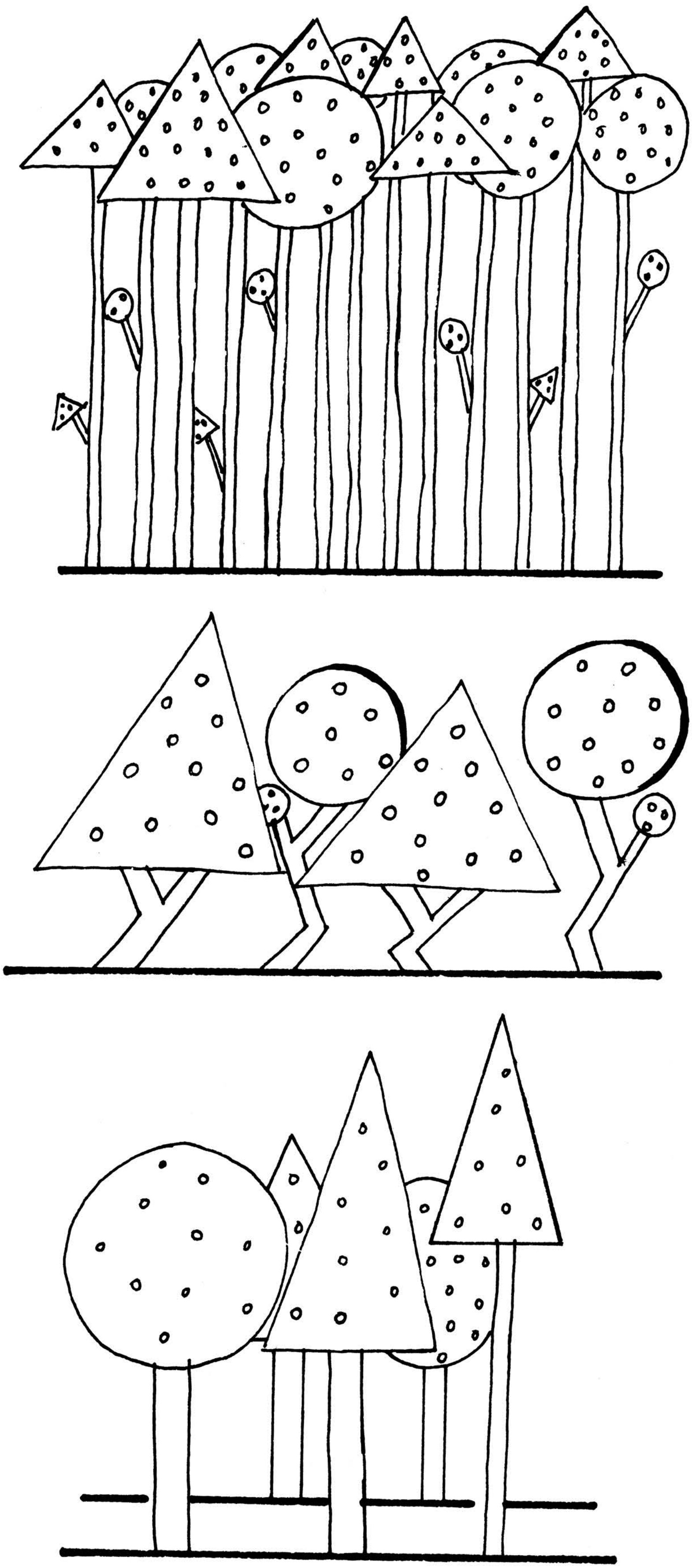


Figure 5.3.1. Control of Forest Density
(Forms of Stands)

a) **Dense Forest Stand:**
- Maximum number of trees/unit area
- Straight stems; first-class timber
- Full, closed canopy; little understorey possible
- Minimal bearing surface/tree

b) **Open-grown Forest:**
- Minimum number of trees/unit area
- Dense canopy, but some understorey possible
- Large bearing surface/tree
- Poor timber quality

c) **Thinned Forest of Type (a):**
- Yields pole timber as thinnings
- Remaining trees yield good timber
- Open canopy permits understorey
- Maximum bearing surface/tree

(The most useful form of forest)

The structure of a permacultural system is dominated by trees. Although trees are no more important than smaller elements in the system, their size, longevity, and the extensive nature of tree culture (number of plants/unit area), means that they determine the limits of the system. The planting of relatively few trees covers considerable areas of land eventually. For example, pecan orchards with 50 ft. spacings, grow into a full forest with only 17 trees/acre, while fruit orchard with 10 ft. spacings, needs 435 trees/acre.

Areas free of large trees should be part of any system, to allow the culture of smaller plants requiring maximum sun, but the proportion of land without large trees and not under self-established pasture could be considered small. Even on dry, north-facing slopes on the East Coast, with much of the site occupied by open woodland of carobs, figs, mulberries and olives (few large trees), the broad form and structure would still be dominated by the largest elements. Use of the large elements to create desirable structural forms in the plant community can be instrumental in the modification of microclimate (see Section 6.3).

Figure 5.3.1, indicates how density in a forest affects various characteristics. The thinned forest is a most useful structure in permaculture.

The "edge effect" is an important factor in permaculture. It is recognised by ecologists that the interface between two ecosystems represents a third, more complex system which combines both. At interfaces species from both systems can exist and the edge also supports its own species in many cases. Gross photosynthetic production is higher at interfaces. For example, the complex systems of land/ocean interfaces — such as estuaries and coral reefs — show the highest production per unit area, of any of the major ecosystems (Ref. 19). Forest/pasture interfaces show greater complexity, than either system in both "producers" (plants) and "consumers" (animals). It seems that the Tasmanian aborigines burnt forest to maintain a large interface of forest/plain, since these transitional areas provided a great variety and amount of food. Animals are found in greater numbers on edges, for example.

Ecosystem edges provide particularly valuable conditions in a permacultural system. For example, northern forest edges are sunny and sheltered (Section 6.3); north-facing dam walls (land/water interface), have seepage which is very valuable to species needing warm conditions and plentiful water — such as some bamboo species; marsh areas (land/water interface), allow the development of whole systems of useful plants; hedgerows and dense barriers (open country/dense vegetation interface) provide habitat for many species of animals.

In view of the edge effect, it seems worthwhile to increase interface between particular habitats to a maximum. A landscape with complex edge is interesting and beautiful; it can be considered the basis of the art of landscape design. And most certainly, increased edge makes for a more productive landscape. For plant types see Figure 5.3.2. For edge development see Figure 5.3.3.

5.4 Permacultural Evolution

As previously indicated, permacultural systems develop over long periods (a lifetime or more). Some nut trees take 30 years or more before maximum yield is achieved and have life expectancies of hundreds of years. To plan a system according to an image of the "finished product" is not only a pointless activity but also counter-productive.

Although stability has been stated as a characteristic of permaculture, this is only relative to more traditional agricultural ecologies. Evolutionary change is the essence of the support system. A permacultural forest may achieve maturity in 200 years, but if rising productivity is the aim, selective logging could provide valuable timber and let light reach the rich forest soil, allowing new cycles to begin in the sheltered forest clearings. So although a permaculture may move naturally towards a climax state this should not be seen as the total product, or purpose, of its development.

Pioneer plants colonize new habitats, facilitating the establishment of other species by modifying the environment to a more favourable state. They can fix nitrogen, loosen heavy soils, reduce salt in soils, stabilize steep slopes, absorb excess moisture, provide shelter, and so on. Often pioneer species are relatively short-lived; wattles (acacia) are an example in the development of rain forest from burnt areas. The concept of pioneer species can be used to advantage in establishing a system, providing yields quickly and modifying the environment. Lucerne pasture improves the soil in many ways, provides forage for bees and fodder for grazing animals. Pampas grass can provide forage and shelter for plants and animals. Nut-bearing pines could be considered a long-term pioneer for wind-tender *Araucaria* species on exposed sites. Comfrey will come up through dense weed growth, helping to control the area if planted densely enough, and providing yields in the first year. The concept of pioneers implies succession. As the environment changes, or plants reach old age, succession occurs with other species becoming dominant. A rampant comfrey pasture could be reduced to occasional plants by a dense top-storey. Berry fruits, intensively cultivated for years, could be reduced to a low-yielding understorey in a nut forest, as old age and lack of light gradually reduced their vigour. These successions should not be considered undesirable and expectations of such changes should

Figure 5.3.2 Plant Types In Association

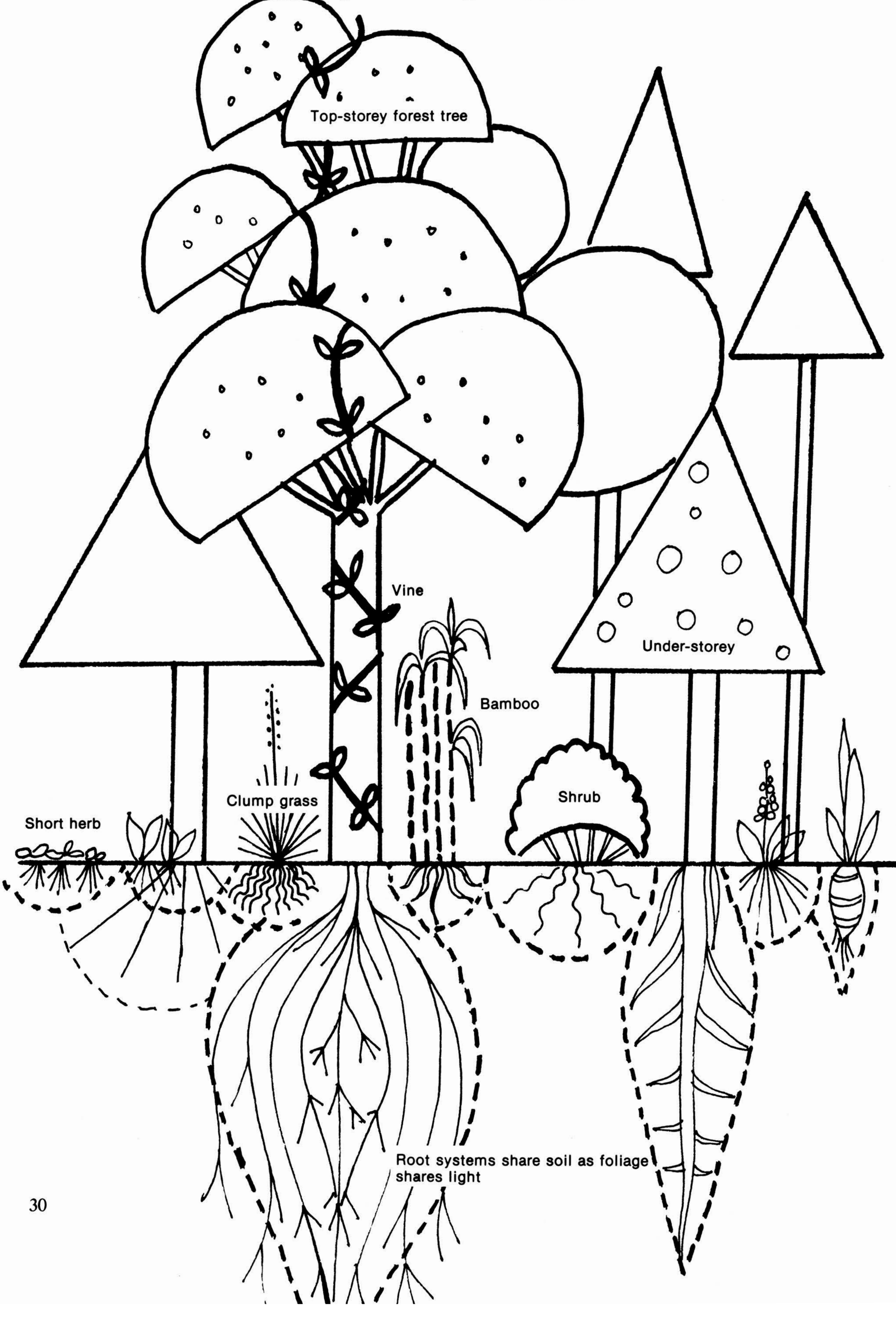
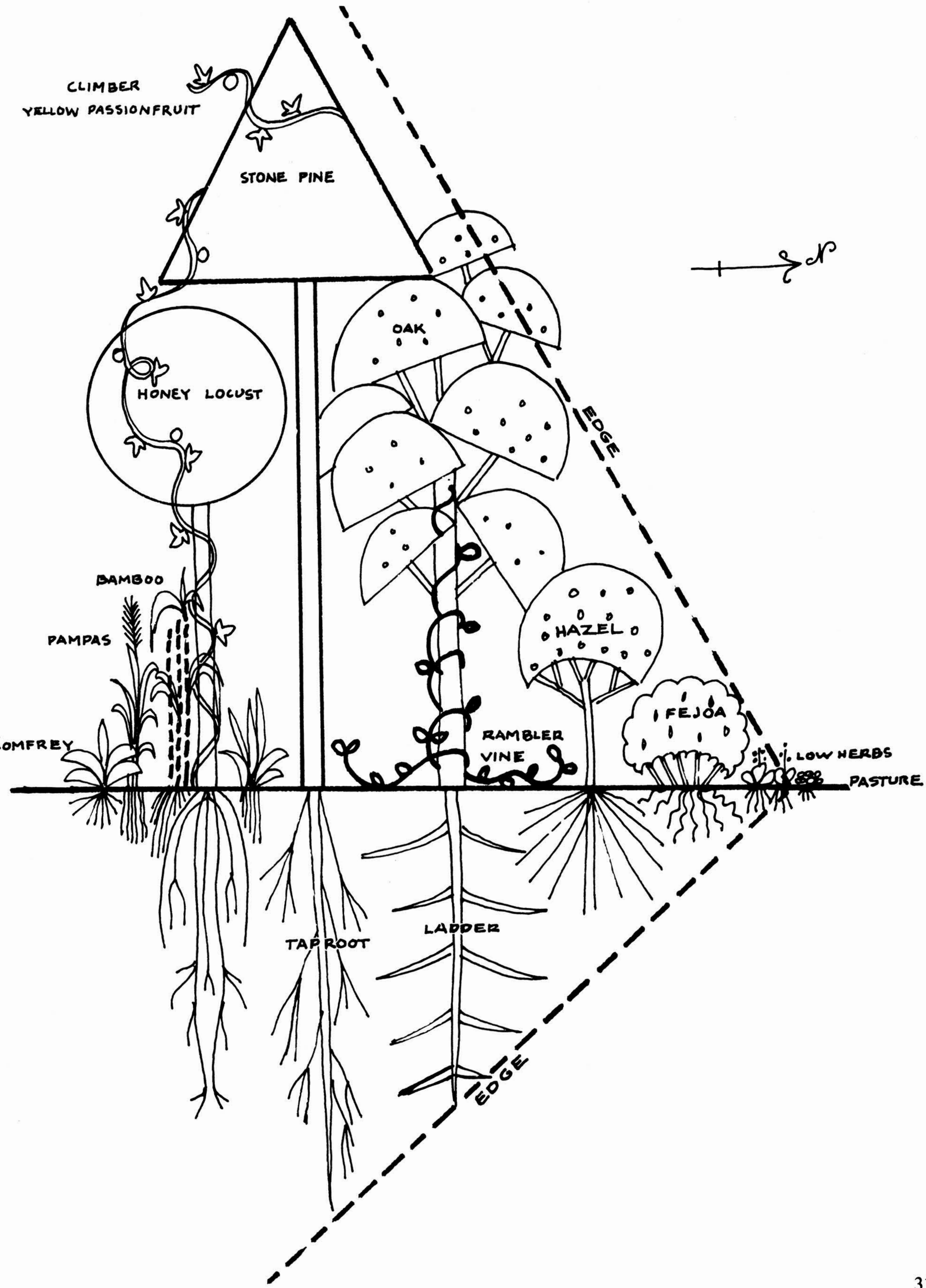


Figure 5.3.3. Development of a north-facing edge in permaculture



not discourage the planting of small shrubs and large trees at high densities. By the time a Pecan shades out a gooseberry bush, many years of produce will have been harvested from the bush and nut yields will be increasing. Natural succession will be in accordance with the aims of the cultivator.

The following diagrams are examples of simple, permacultural evolution and succession. In Fig. 5.4.1 all the elements are planted at once, the smallest (lucerne), establishing first. The larger pampas and tree lucerne begin to eliminate some of the pasture but the total forage increases. Finally, the largest and slowest maturing element (oaks), begins to dominate the other elements and provide the main forage (acorns). In Fig. 5.4.2 the time scale for change from pond to marsh is arbitrary, since it depends on many factors. New species are added as conditions change.

5.5 Pest Control in Permaculture Refs. 26, 39

Any life-form acting to inhibit yields to man, from uncultivated or cultivated systems can be considered a "pest". This definition needs some qualification.

A particular species, by its actions, can cause minor trouble in a system without being a real pest. This is especially so within many lower life forms, such as insects, which have very little effect in small numbers. However, when conditions are favourable populations of species with short reproductive periods can rise dramatically and be a great problem. As Ryder[26] says "it is more instructive to think in terms of pest "situations" rather than regard certain species as immutable enemies of man". Thus a species only becomes a "pest" at certain densities, in particular situations.

We may find that although a particular species is a pest, its function in the ecosystem is important and indirectly of benefit to mankind. In other words, the effects of any particular species should be looked at carefully before we label it a pest.

Some of the ways in which life-forms function as pests in cultivated systems are:

a) Competition with cultivated plants for light, space, nutrients and water, i.e. weeds.
b) Competition with man for the same yield, e.g. blackbirds eating berry fruits.

In a self-support system where diversity of yield is desirable, competition from both animals and plants can often be turned to advantage. For example, many weeds are useful (especially as herbs) and some of the species in Appendix B are considered noxious weeds in annual culture. Blackbirds can become table meat. Plants are damaged by many life-forms; physical damage by larger animals, such as goats debarking trees, rabbits eating young plants and possums breaking fruit spurs and branches is a common form of pestilence. Parasites such as aphids and moulds cause considerable damage while viruses can result in fatal diseases in plants.

Prevention can play a major role in pest control. As mentioned previously (Section 2.6), complex ecosystems tend to be more stable than simple ones and less prone to unchecked rises in particular populations. It is generally accepted that monoculture leads to dramatic increases in pest populations, these benefiting from the presence of the crop while the new environment may be unfavourable to their predators — plague is the result. If we have a system with diverse plant and animal species, habitats, and microclimate, the chance of a bad pest situation arising is reduced. This is especially true of arthropod pests.

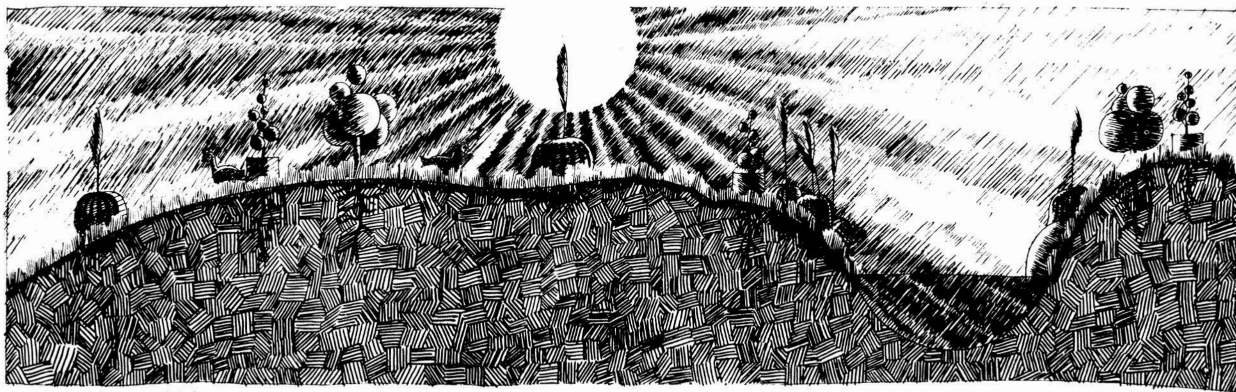
Healthy plants are less prone to disease and insect attack and more capable of competing successfully with weeds and coping with parasite attack. Plant health is partly a result of suitable soil, climate, sunlight and other environmental factors. Provision of good site conditions enhance plant health. There are indications that rapid growth, due to large amounts of soluble fertilizer increases susceptibility to disease and that disease among cultivated or tilled crops is higher than that in uncultivated crops.[39] The elimination of both these expensive practices in permaculture should also result in improved plant health.

Plant association can be significant in control of particular pests. In California, blackberries near vineyards have provided over-wintering sites for an egg parasite of the grape leaf-hopper. Practical observation of symbiotic and antagonistic plant associations is recorded in the literature on companion plants (see Ref. 14).

Pest control by the presence of higher animals is an aspect of the previously stated fact that complex ecosystems (with many plant and animal species) are less susceptible to pest plagues than simple systems (crops with no animals). Rock piles can encourage the presence of large populations of lizards — such as the Slender Blue Tongue — which eat slugs and other pests. Frogs are consumers of insects and will inhabit the vegetation, even to tree-tops, if small ponds or water holes exist close-by for breeding. Elimination of that hyper-predator, the cat, will quickly raise frog and lizard populations. The absence of cats will also encourage a greater variety and number of birds which control many insect pests.

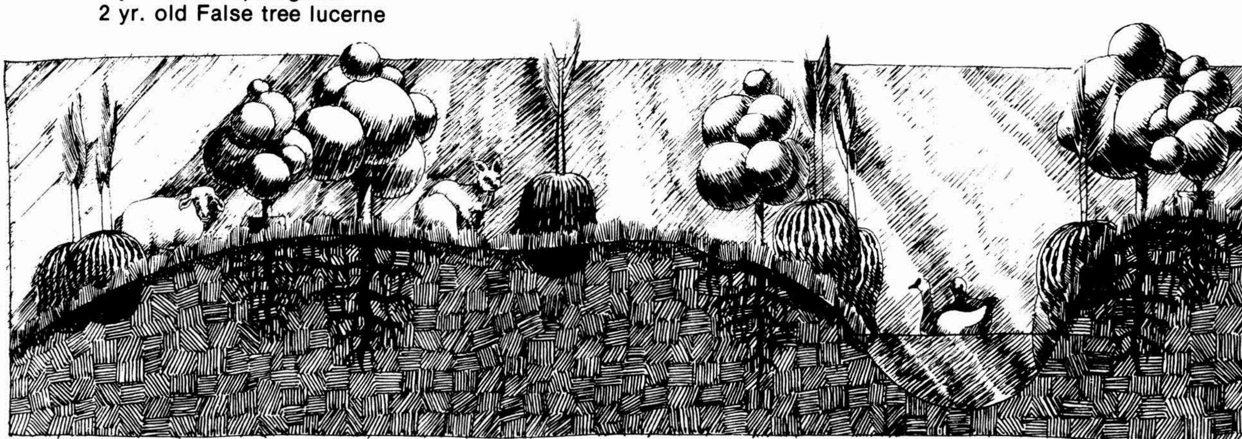
Ducks, hens and other domestic birds are generalized feeders, keeping the areas in which they range fairly free of many pests, particularly slugs and snails.

One interesting case of pest control by animals is worth relating. The Codling Moth is one of the worst



Stage 1
1 yr. old Lucerne pasture
2 yr. old Oak seedlings — staked
2 yr. old Pampas grass
2 yr. old False tree lucerne

Animals — guinea fowl



Stage 2
5 yr. old Lucerne pasture
6 yr. old Yielding oaks — staked
6 yr. old Pampas
6 yr. old False tree lucerne

Animals — add sheep, wallaby or geese

Stage 3
14 yr. old Lucerne — remnant pasture
15 yr. old High yielding oaks
15 yr. old Pampas — stunted
15 yr. old False tree lucerne — restricted and overmature

Animals — add cattle or pigs

Figure 5.4.1 A Simple Permacultural Succession

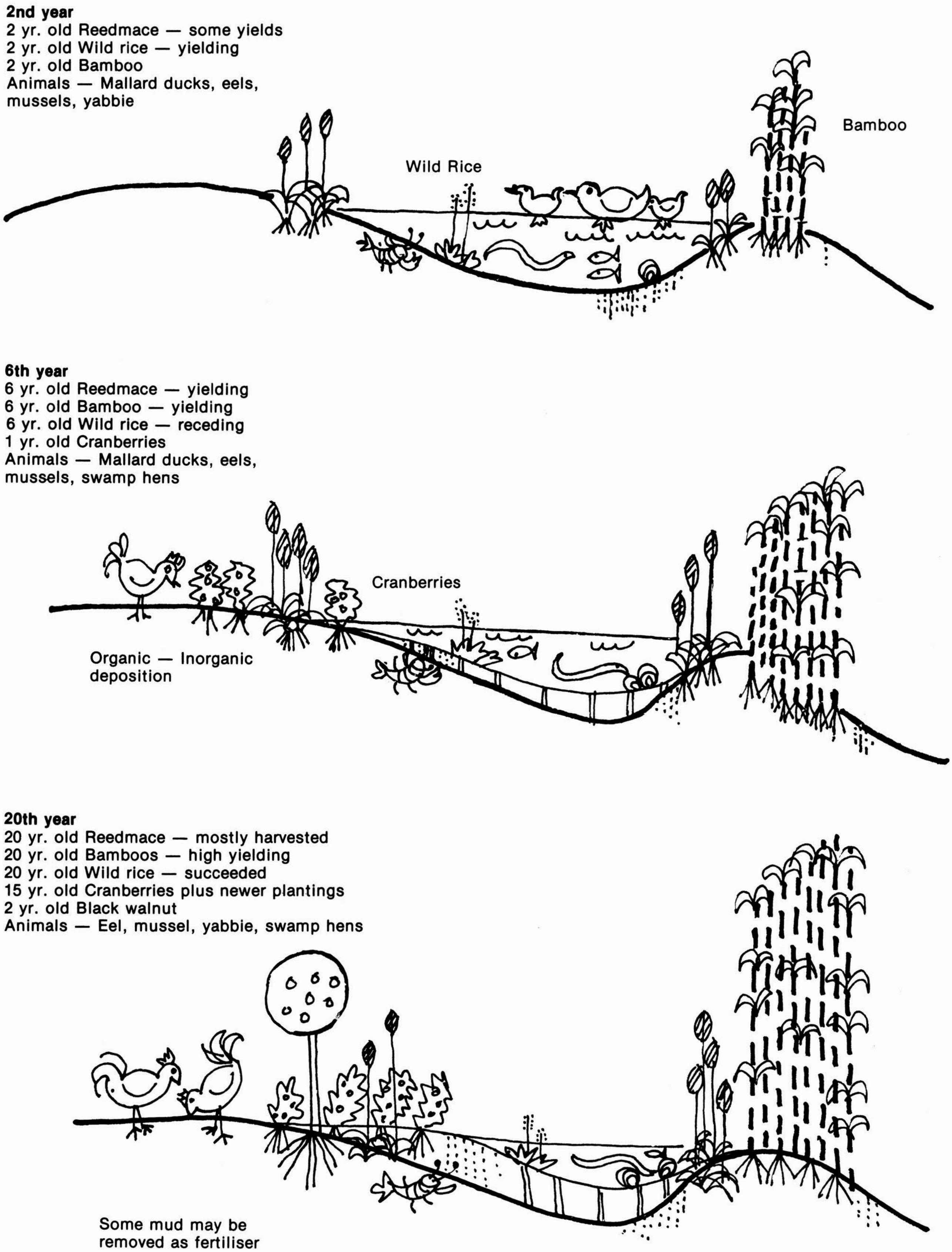


Figure 5.4.2 Succession From Pond to Marsh

pests affecting apples, pears and quinces, causing the fruit to drop prematurely or to be infested with grubs. Before the rise of the chemical pesticide industry, pigs were used to control Codling Moth in the Huon district of Tasmania. A few pigs on range during the season ate all the fallen fruit, thus reducing the chance of the moth completing its life cycle. The replacement of this effective control by expensive and dangerous pesticides is a sad and sorry story.

It should be remembered that pest control is an integrated process, where elements of the system assisting in control are there for other purposes also. For example, the blackfish, duck and pig are all food resources; mulching has many other functions apart from reducing susceptibility to disease in plants. Pest situations need an integrated approach rather than a simple solution, as a chemical spray. However, all the foregoing discussion doesn't mean pestilence is not a problem or that it is possible for us to be "in tune" with nature. Personal action is sometimes distasteful but necessary. Identification of a dangerous viral disease in a prize nut tree may require its destruction to prevent the spread of the disease. Possums damaging fruit trees may require the use of a rifle. We believe a certain philosophical attitude is required for understanding pest situations and their effective control.

By cultivation we are creating a new ecosystem with food and other resources available to mobile species from outside our system. While we can develop the system to be largely self-regulated with the individual elements as healthy as possible, we must accept the consequences of the agricultural support base. Control of species from the surrounding ecosystems, as well as our own introductions (e.g. rabbit and cat), is essential. The remnants of orchards and gardens we find over all rural areas are indications of what happens when the controlling influence of humans disappears.

An element in plant establishment is the secretion by some plants of substances which inhibit growth in other species. Pines and oaks are noted for this and (*New Scientist,* 17th Feb. 1977, p.393) bracken secretes phenolic compounds which are toxic to other plants. These features may be used as positive aids to control weeds or appear as nuisance factors which make plant establishment difficult. Thus allelochemistry or companion planting may give clues to antagonistic or positive effects of one species on others. For the non-chemist, observation is the best guide to procedure.

A 'pest' is an animal out of place, or for which we have no direct use, but a little consideration may convert such species into a positive advantage in permaculture; thus, flies can be a major source of free fish food if attracted to ponds and trapped there. Flywire cones leading into a glass-topped box baited with damp blood and bone is an effective trap for flies and wasps. See figure 6.3.4.2.

Possum, in Tasmania, may provide furs and are quite edible, if marinated in wine; where not needed they can be live-trapped and removed, but distant removal of 10km or more is needed, or the animals will 'home' to their original area.

Deep mulching attracts blackbirds, which in spring destroy small seedlings by scratching. Sparrows are attracted to young lettuce and peas. Again, live-trapping by means of wheat-baited funnel traps (sparrows), or artificial fruits attached to rat-traps (blackbirds), or mist-nets spread in flyways will take these species, which give a good protein yield for those who are willing to take time and trouble to prepare them.

We take the view that most local pests can be usefully converted, either directly or indirectly, to a useful product in the permaculture. Exceptions may be the incursion or irruption of species from outside the system. In southern Australia, plague locusts are in this category, and although many perennials withstand defoliation and regenerate from tubers, roots, adventitious shoots and buds, the locust problem must be dealt with as a national matter than as a local problem, and the "scald plains" of the inland which provide the shaded egg-sites needed by the locust reduced by the ecological management of grazing animals.

The advantages of diverse plantings both in species and cultivars is that the pattern of pest attack may reveal beneficial companion planting or mulching effects, and permit the development of resistant strains for further propagation. *Phytopthora cinnamomi,* the soil fungus that is ravaging the native forests of Australia has much more reduced effect on deep-mulched avocado trees on loam, than it has on clean-tilled plantings in sandy areas. Potato scab has recently been shown to be uncommon if a seaweed foliar spray is used (*The Mercury,* Hobart, 14 July 1977) and so on. Such organic remedies will be extended as controlled observations are made.

6.00 SITE PLANNING

"Stable man-made regional landscapes are rare. They exact unremitting human effort and concern".* However a stable, productive, and inherently beautiful landscape is perhaps the greatest material asset a society can inherit. Skill in landscape planning seems evident in some pre-literate agrarian cultures, but since the rise of professional skill rather than cultural traditions, landscape planning has focused on the urban environment and become cosmetic rather than utilitarian. Design of the productive rural landscape in modern industrial countries follows no stable traditional patterns nor any new rational science or art of landscape planning. Even the British Countryside Commission's 1974 report on landscape planning of the productive rural landscape maintains the dichotomy between the productivity of the landscape and its aesthetic value.+

In Australia, Yeomans[20, 21] has formulated ideas on landscape planning for broad-acre pastoralism and has put them into practice with great success. Yeoman's Scale of Permanence for agricultural landscape design is worth considering. He sees eight basic elements in landscape planning. In order of permanence:—

1. Climate.
2. Landform.
3. Water supply.
4. Farm roads.
5. Trees.
6. Permanent buildings.
7. Subdivisional fences.
8. Soil.

In any landscape planning, relative permanence is of great importance if the planning itself is to be part of some ongoing evolution of the landscape. Time-scales for complex landscape evolution span many generations and cannot be considered a finite task. For the purpose of putting planning and design work into perspective, Yeomans's Scale of Permanence is very useful. However, we would amend the scale to adapt it to planning for permacultural systems, as follows:—

1. Climate.
2. Landform.
3. Water supply.
4. Farm roads.
5. *Plant systems.*
6. *Microclimate.*
7. Permanent buildings.
8. Subdivisional fences.
9. Soil.

Site planning for permaculture is a complex synthetic task. Colin Moorcroft's[6] statement on the built environment is well worth considering in relation to permacultural planning. ". . . Each element should, wherever possible be capable of more than one function and conversely each function should be performable in more than one way". We believe however, that a combination of permacultural principles and Yeoman's keyline system comes close to a total integrated landscape ecology, of utilitarian and aesthetic value.

6.1 Landform

Landform is a basic unchangeable characteristic of a site (without resorting to very expensive technologies). Its influence on microclimate, water retention and drainage, access, soil depth and character, is fundamental.

A thorough knowledge of the landform of a site is necessary if its influence on these other factors is to be understood. Water drainage and divide lines, cliffs and exposed rock outcrops, areas susceptible to land slip, altitude and gradient of slopes, are all basic information best depicted on a large-scale contour map.

Naturally some sites are more valuable than others, but a variable site with all aspects, good dam sites, flat areas and steep slopes is most useful. Features such as cliffs should not be considered a disadvantage, since they often allow the development of specific systems not possible elsewhere.

6.2 Climate

Before looking at more detailed local factors in site planning, the climate of the area needs to be considered carefully since it is the basic limiting factor in the species diversity possible in any area.

The Tasmanian climate can be classified as "Marine West Coast" — a mild, wet climate similar to that of the West of Europe and New Zealand. However, within that classification variation is considerable. The mountainous terrain and the complex coastline make for considerable climatic variation. For example, rainfall from Mt. Wellington, through Hobart, to the Eastern Shore, drops from 60" to 25" to 18" with cloud cover following the same trend; all this is a distance of less than 10km.

Excepting local variations, the chief limiting climatic characteristic in cool temperate regions is the mild summers. Many useful plants we may wish to grow are fully adapted to Continental climates which have high summer temperatures for the ripening of fruit. The olive, fig, and other trees are limited in Tasmania due to the low summer temperatures which

* Lynch, K. *Site Planning.*

\+ Manten, A.A. *Agricultural Landscapes in Britain.*

are insufficient, in some cases, for proper ripening of fruit.

Minimum winter air temperatures and frost are also limiting, but less so for woody perennials than for delicate annuals. The deciduous plants, even those from quite low latitudes, are almost immune to damage by frosts as experienced over most temperate regions. Rainfall and its annual distribution can limit the range of suitable plants due either to excess rain or lack of it. Summer rain can be harmful to the fruiting of some plants. For plants suited to very cold regions, etc. see Table 6.2.1 below.

Table 6.2.1
Plants Suited to Very Cold Regions with Hard Frosts Regular Winter Snowfalls and Poor Summers

Acorns	*Horse chestnut
Bamboo (some spp.)	Horse radish
*Beech	Jerusalem artichoke
*Black currant	Leatherwood
Black locust	Lespedeza
Black walnut	Loganberry
Blueberries	Mints
*Butternut	Mulberries
*Buckbean	N.Z. flax
Checkerberry	Oaks (many spp.)
Cherry plum	Osier willow
*Cloudberry	Pampas grass
Comfrey	Siberian pea tree
Cranberry	Sloe
Damson plum	*Snowberry
Elderberry	Sour cherry
*Gingko	*Sugar maple
Gooseberry	*Tupelos
Hazels	Walnut
Hawthorns (some spp.)	*Wild rice
*Hickories	Wood millet
Honey locust	

* need special habitats.

6.3 Microclimate Ref. 31

"Microclimate is the summation of environmental conditions at a particular site as affected by local factors rather than climatic ones".[31] The factors are topography, soil, vegetation, water masses and man-made structures. These factors overlay the climatic characteristics of a region to give local environmental conditions as measured by: temperatures and temperature ranges; relative humidity and its range; wind speeds, ranges, regularity and direction; frost, rain, snow, dew and other forms of precipitation.

Microclimatic variations can be very great, even within relatively small localities. This diversity ". . . can be attributed to the varied nature of the surfaces underlying the air layer near the ground".[31] Since the permaculture system includes a great diversity of useful plants favouring different environments and since plant communities themselves greatly affect the microclimate, the subject is well worth in-depth investigation.

In broad-acre farming, crops are grown which suit the climate, ignoring the microclimatic characteristics of a site. Modern farming methods actually contribute to making the microclimate uniform to such a degree that it becomes an insignificant aspect of the environment. Only in a few cases has microclimate been considered in detail by commercial farmers: the success of vineyards in the Main valley of Germany appears totally dependent on the microclimate as altered by man.[31]

Understanding site microclimates and the ways to alter them enables the permaculturist to grow an expanded range of useful plants. For example, the grapes, fig, olive, carob, and orange are all dependent, to varying degrees, on favourable microclimate for successful cultivation in temperate regions.

6.3.1 Topography

Topography is the most obvious and most permanent factor affecting microclimate. Aspect, "the orientation of slopes", is commonly known to affect site conditions due to the variation in the amount of radiation received. This radiation is the sum of:—

1. Direct solar radiation.
2. Diffuse sky radiation.
3. Reflected radiation.

Only direct solar radiation is affected by aspect; sky radiation, coming from all directions, is independent of aspect; reflected radiation is particular to positions and locations rather than aspect. Since the declination of the sun, from the vertical is approximately from 20 deg. to 60 deg. north in Tasmania, northerly aspects receive considerably more direct radiation than horizontal or southerly aspects. Very steep slopes (48 deg. or more) will receive the most radiation in winter, while lesser slopes (20 deg. - 30 deg.) will receive the maximum for summer (see Figure 6.3.1.1).

Northeast aspects receive maximum direct radiation for the morning period, while northwest aspects receive most for the afternoon period. Northwest slopes tend to heat up more slowly during the day, avoiding damage to plants by rapid frost thaws, but reach higher temperatures.[31] The significance of aspect is changed if the sun is shaded by other topographic features, such as opposite ridges or mountains. For example, in parts of Hobart, northwest aspects fall into full shade in the late afternoon due to the shadow of Mt. Wellington.

Cloudiness also changes the significance of aspect.

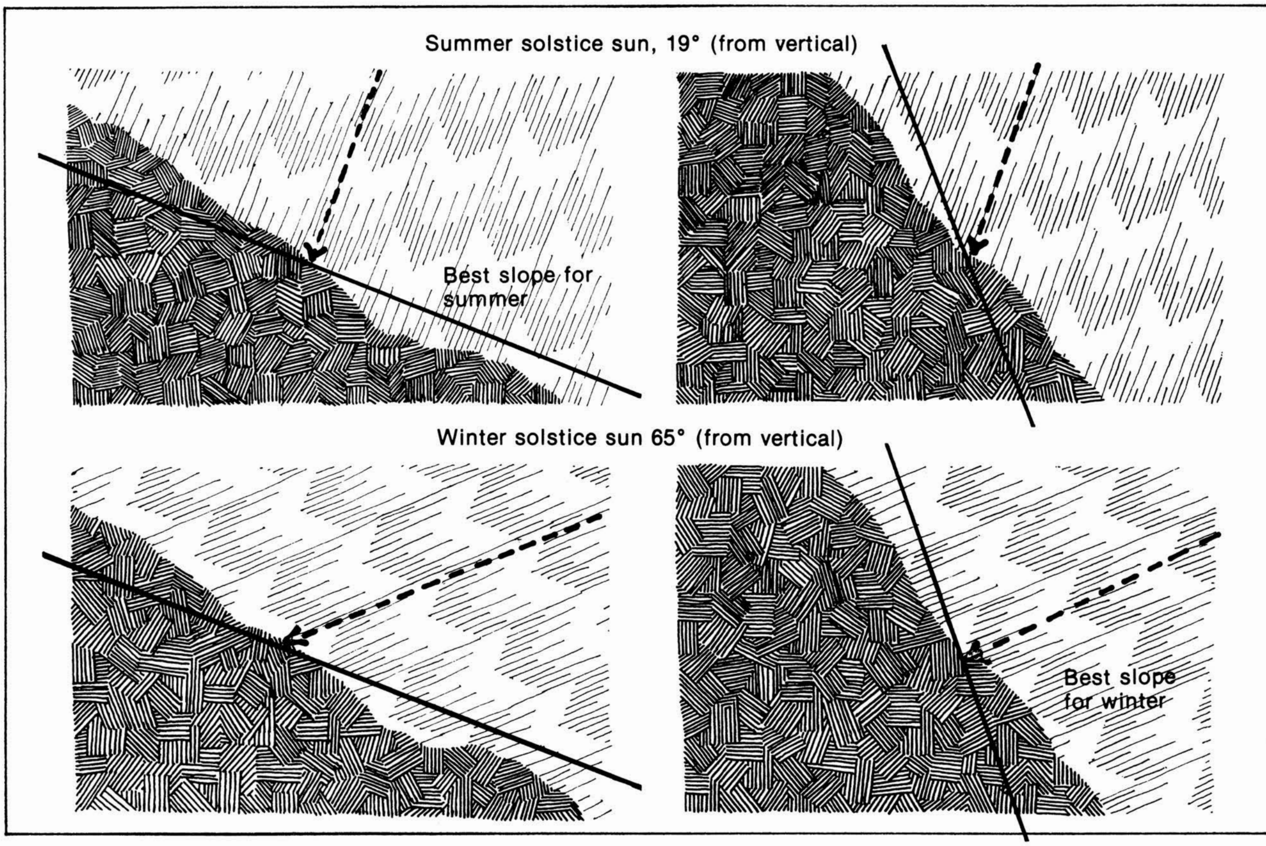


Figure 6.3.1.1 The effect of aspect on direct solar radiation

As cloudiness increases as a climatic factor, the proportion of radiation due to diffuse sky radiation increases to as much as 40% or more and, since this is independent of direction, aspect is less important in cloudy climates.

The influence of aspect on plant communities can be readily seen in the bush. Often north-facing slopes are occupied by dry sclerophyl woodland, while south slopes are covered by wet sclerophyl forest. The use of aspect generally means use of north slopes. These are most valuable for permaculture since they help overcome the limiting factor of lack of heat for ripening. However, many cool climate berries and forest trees such as beech and horse chestnut, would do best on shady southerly aspects.

Cold air drainage is another way in which topography influences microclimate. The old rule, "concave land surfaces are cold at night, while convex surfaces are warm", is basically true because cold air is heavier than warm air and tends to flow off convex hills into concave valleys.[31] This lends to the formation of frost-hollows where cold air collects late at night, resulting in increased likelihood of frosting. Night temperature minima in hollows are affected by other complex factors which make prediction of frost danger difficult but they usually balance out to have little nett effect on frost risk. "Field observations showed repeatedly that cold air does not flow like water but more like porridge or thick syrup".[31] Speeds are usually less than 1m sec^{-1}. These two facts lead to great variation in frost risks and severity. Detailed work in the Mossan valley in Germany, showed that forest across a valley effectively dammed cold air — resulting in a frost dam. Openings of 400-500m were needed to allow drainage. If this is so, constrictions in a valley due to landform would also dam cold air, increasing frost danger above the dam while reducing it below. The Teapot property at Jackey's Marsh, near Meander, Tasmania, is just behind a valley constriction and frosts occur all year round.

However, all this doesn't mean that hilltops are the most frost-free areas. Observations show pools of cold air remain on flatter ridge tops and plateaus, leading to almost as bad a frost danger as in the valleys (see Figure 6.3.1.2).

The most frost-free sites on hilly terrain are the upper slopes of valleys. Research indicates the upper slopes are usually much warmer, night and day, than either valley floor or ridge. This warm area is known in

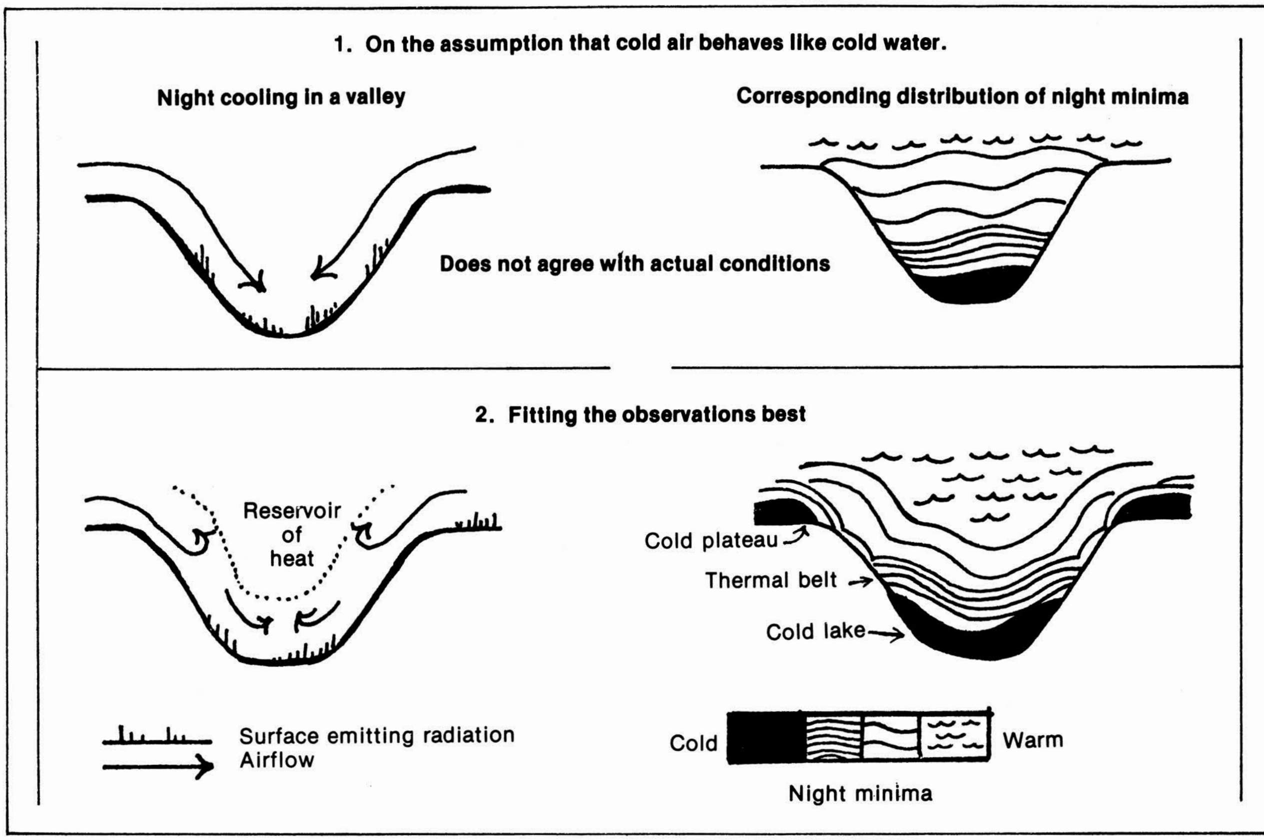


Figure 6.3.1.2 Development of the Thermal Belt (after Geiger)[31]

Europe as the Thermal Belt and has long been favoured for village, monastery and country-house sites (see Figure 6.3.1.3).

Observations of plant growth patterns confirm the favourable nature of the thermal belt (see Figure 6.3.1.4).

Topography also affects winds. In mountain country the prevailing winds may come from the wrong direction. At locations in the foothills of Mt. Wellington, Tasmania, south-westerlies come from the north-west, due to local valley conformation. More important, microclimatically, are valley winds. At night, down-slope cold air drainage may develop into gusts but generally warm up-slope winds by day are stronger. However, as far as microclimatic planning is concerned, only the prevailing winds are of real significance. Local topography can provide shelter from winds.

For many species such as citrus, shelter from cold winds is much more critical to successful culture than actual temperatures. With prevailing winds across a ridge, wind speed increases on the windward slope, while decreasing on the leeward slope. For significant protection on leeward slopes, wind speeds need to be at least 5m sec^{-1} and slopes 5 deg. or more. Shelter by ridges from cold winds, particularly south-westerlies and hot northerlies, are very important (for different species) in site planning. It should be remembered however, that topography which gives complete wind protection often results in increased frost risks due to lack of turbulence at night.

6.3.2 Soils

Soils can affect microclimate, due to differing thermal conductivity, light reflectivity (albedo), water and air content. Soils must be considered a minor factor since their influence is usually masked by vegetation cover and mulches.

Mulching and natural litter have interesting effects on microclimate. "F. Firbow has shown that the temperatures in Oak and Beech woods in Central Europe may be very high by day in spring before the trees break into leaf because of the extremely poor conductivity of the litter of dead leaves on the ground. In the first few days of May, temperatures of up to 43 deg. C within the litter bed were measured".[31] Most litter and mulch layers absorb radiation and water easily but transmit little through the soil. Similarly, mulch is easily frosted but never more than a thin skin. Geiger says mulching's effectiveness in increasing crop yield has been proved but the quantitive changes it brings about in microclimate have rarely been measured. Mulching has been used extensively to retain moisture since it increases the time in which adequate water is available to plants, and in sheltered positions such as forests it increases humidity. Work on the water-holding capacity of a natural forest litter showed the time for absorption to full capacity was 2 minutes — while the release time was 16 days. [31] The implications of this water retention for drier areas is obvious.

Our experience is that mulching is invaluable for areas where water is in short supply, although for annuals the mulch can be removed for spring warming of the ground.

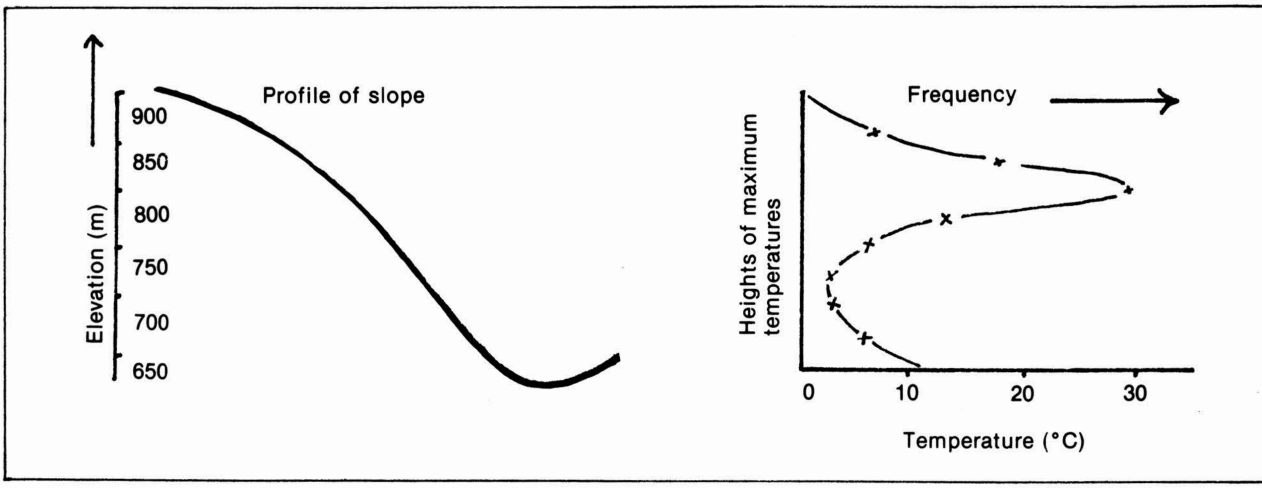
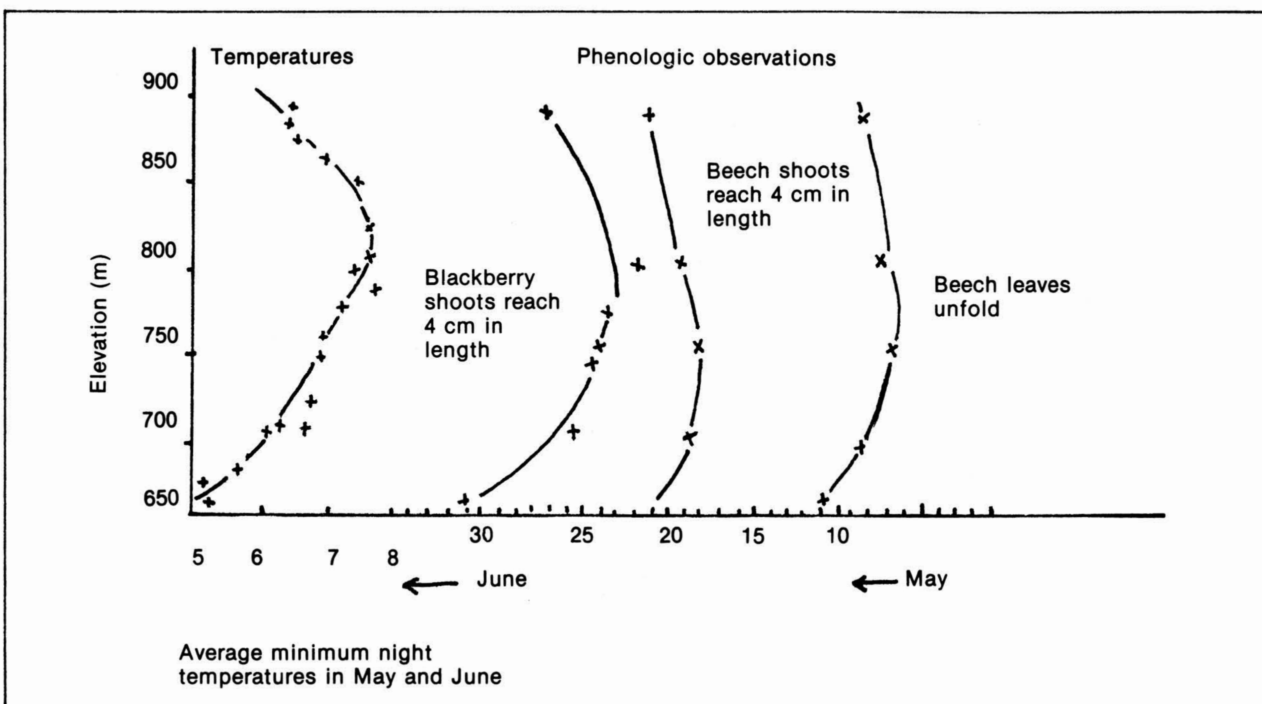


Figure 6.3.1.3 Location of the Warm Zone on the Slopes of the Grosse Arber In Spring (after Geiger Ref. 31).



Figures 6.3.1.4 The Close Relation Between Night Temperature (Left) and Plant Growth on Grosse Arber (after Geiger Ref. 31)

6.3.3. Vegetation

"Vegetation makes the climate milder, more maritime in type".[31] It is common knowledge that frosts are rare in forests, that it is cool in a forest on a hot day. The soil rarely dries out and rainfall under a tree canopy is a soft, slow dripping. These are qualitative indicators of a mild microclimate.

Microclimates within vegetation are mild, due to the characteristics of radiation absorption, reflection and transfer of plants. Baumgartner's work on radiation balance in a dense forest shows that although the radiation available at the forest floor is the lowest of any level in the forest, the radiation loss period at night is very short, (3 hours in his study), resulting in extremely stable environmental conditions.[31] The canopy and upper levels of the forest act as a heat store, radiating energy at night. Similar effects are experienced in buildings sited in forest clearings, reducing the need for both cooling and heating energies.

Winds are always low or absent in vegetation. The top of the vegetation is similar in condition to air/water boundaries, in that turbulence can be strong but does not penetrate far into the vegetation. This results in a low evaporation rate. The cooling effect of rapid evaporation is absent and humidity is high, or more importantly, stable.

Although moisture available to large plants (trees) in a forest is fairly stable, precipitation varies greatly through the forest. This can be significant for small understorey plants. Most trees in full leaf, divert rain to their periphery (the dripline), giving precipitation averages up to 160% of that for open ground, while beneath the tree it may fall as low as 50%.[31] Some trees funnel rain around the trunk. In dense forest stands, the water-holding capacity of the crown area affects precipitation. With light showers, sometimes for several hours, no rain may reach the ground, evaporation removing the moisture held in the tree crowns. This interception has been recorded at anything from 6% to 93% of total precipitation by Ovington.[31] As a result, forest floors are rarely as wet as open paddocks are in winter, while their capacity to hold moisture is high. This, combined with the interception phenomenon and moisture uptake by trees, means runoff from a forest is almost nil. Although not strictly microclimatological, this is a most important effect. Everybody knows trees stop erosion but the figures show the magnitude of the effect of clearing of land on both land and streams.

Two similar adjacent valleys in the Hartz Mts. in Europe, one wooded, the other almost completely deforested (pasture):—[31]

Rainfall on 7th July, 1950, 16.4mm in 37 min.
Runoff. Wooded valley: 75 lit.km^{-2} sec.$^{-1}$
Cleared valley: 200 lit.km^{-2} sec.$^{-1}$
Water Purity for 1950 runoff.
Wooded valley: 18.6 tons suspended solids
0.05m^3 km^{-2} pebbles
Cleared valley: 56.0 tons suspended solids
2.00m^3 km^{-2} pebbles.
Streams in both valleys carried^{-1} 5-10mg.lit suspended solids in non-flood conditions.
Flood load. Wooded valley: 10mg lit^{-1} suspended solids.
Cleared valley: 550mg lit^{-1} suspended solids.

Although plant communities, particularly forests, affect microclimate in ways generally favourable for plant growth at the understorey level, they inhibit it by the lack of light available for photosynthesis. Ellenberg has shown light intensity near the forest floor varies considerably even in dense forests and understorey flora is closely correlated with maximum light intensity. In temperate regions forest stands with less than 30% of the outside radiation penetrating have very little understorey. However, many useful plant species, particularly the berry fruits, are specifically adapted to low light levels. Fungi too, have a high tolerance to shade and provide forage for man and domestic animals.

Deciduous trees allow outside weather conditions an increased influence over internal forest microclimate but it is not as great as one might think. The change in light availability on the forest floor has little effect because few plants are growing during winter.

So far, we have dealt with the microclimate of forests — particularly dense forests. The forest microclimate provides a protected environment for the cultivation of plants needing stable humid temperatures and little light. Thus, species are limited in number. Forest environments develop a complex litter ecosystem based on organic decay which can provide food for domestic and useful wild animal species. Habitats for many animal species is another asset of forest environments. The forest microclimate is ideal for the propagation and raising of plants, especially those from temperate regions. Trees often grow better in forests than in the open, especially during their immature stages.[39]

However, greater diversity of plant communities having more varied microclimates will allow a greater diversity of plant species and systems, even on small land holdings. A mix of forest, clearing, hedgerow, field, woodland and intensive crop cultivation would be far more capable of diverse productivity at high nett yields/ha. than a simple forest system. Therefore, it is very important to consider the microclimate of forest edge and clearing, the effects of thinning, hedgerows and windbreaks.

The microclimate of forest edge is dominated by the effects of the transition from forest to open ground. The edge affects radiation collection and winds, depending on orientation. It should not be overlooked that the arrangement and orientation of forest edges can be used to accentuate wind speeds, if this is a desirable effect in cooling summer breezes. Venturi systems leading to fixed windmills may be advantageous in some situations.

The diagram in Figure 6.3.3.1 shows that northern edges receive most radiation but with peaks at the equinoxes rather than mid-summer, which could be significant for spring flowering and autumn ripening. The temperatures in Table 6.3.3.1 indicate that north edges are significantly warmer than either forest or open country in summer. The greater diurnal range at the edge is due to high daytime temperatures rather than low night temperatures.

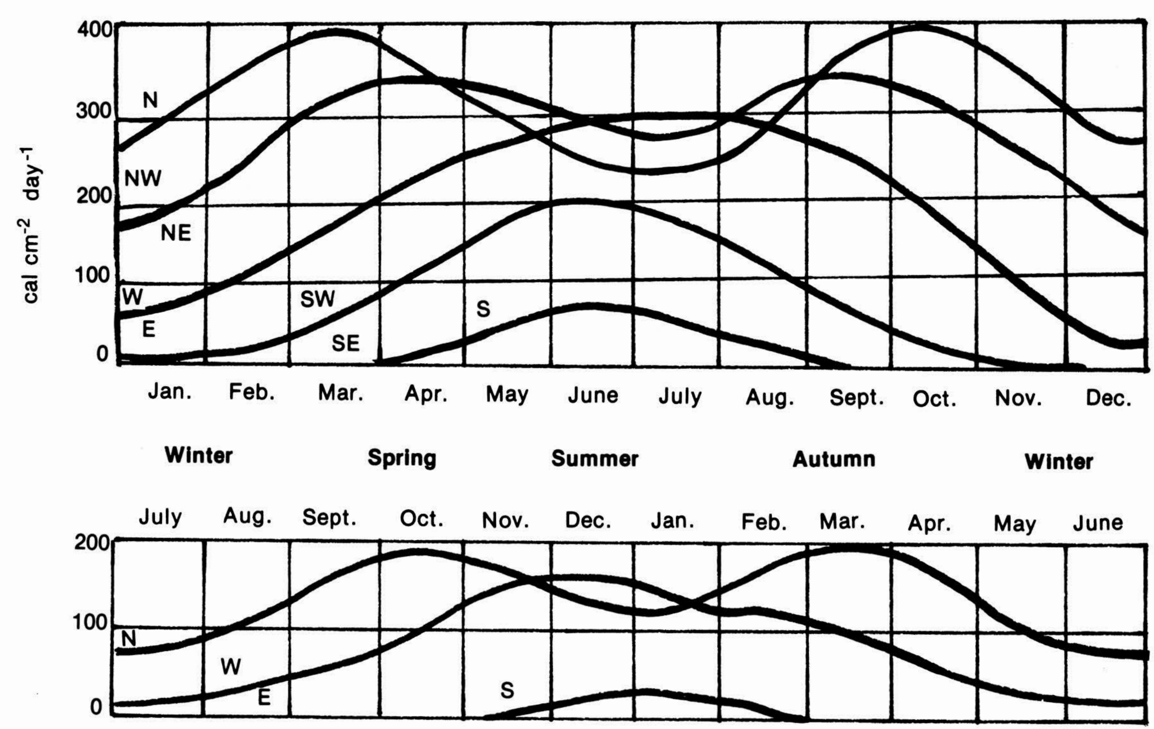


Figure 6.3.3.1 Daily Totals of Direct Solar Radiation at Stand Edges Facing in Various Directions on a Sunny Day (above) and on a Normal Day (below) Throughout the Year. Data for Central Europe (Geiger)[31].

Table 6.3.3.1
Air and Soil Temperatures (deg.C) at Edges of a Forest (after Geiger)[31]

Observation Site	20m in Forest	At Forest Edge	35m out of Forest	100m out of Forest
Air temp. at 10 cm				
at 14.00	18.4	22.4	20.0	20.8
at 05.00	9.0	8.0	6.8	6.0
Difference	9.4	14.2	13.2	12.8
Temp. 10cm in soil				
at 18.0	11.2	17.8	17.2	17.0
at 08.00	10.6	13.6	13.0	12.8
Difference	0.6	4.2	4.2	4.2

Warm forest edges could be used to advantage for plants which are marginal, due to insufficient warmth and light for ripening of fruit.

Edges of forests tend to be sheltered from wind. Even in the face of prevailing winds, air speed is considerably reduced by the pressure build-up. However, with winds at an angle to a forest edge, speed increases, due to the air stream along the edge. Convoluted edge is therefore needed to produce sheltered pockets.

Frost danger can be associated with forest edge if the forest acts as a dam to the downslope drainage of cold air. However, because of the moderating influence of the forest, the danger is not very great.

Forest clearings tend to have a much more moderate climate than open country but variation in rainfall, evaporation, dew and radiation, means microclimatic variation in clearings is considerable.

Thinned forests, or forest screens, have interesting microclimatic characteristics and are similar in some ways to an open woodland. However, tree density and height of thinned forest are usually greater than those of woodland due to differences in tree form (see Figure 6.3.3.2).

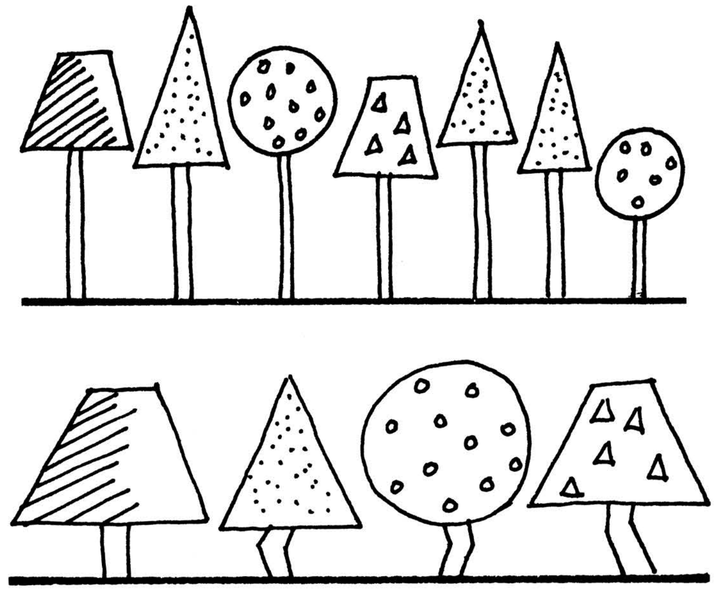


Figure 6.3.3.2 Form of Thinned Forest and Woodland
(Same species on different sites)

Comparisons of temperature data for a 14m diameter forest clearing and a thinned strip 50 to 60m wide, in a mixed silver fir and beech forest, showed the clearing had a milder climate but even so, had lower night minima than the strip. Therefore a thinned forest would seem to have more favourable temperatures (higher by day), than a clearing for plants such as citrus. Winds in a thinned screen are generally less than a clearing, especially large clearings, as these can develop eddy currents. Winds in a screen are in the same direction as in the open but slower. The wind characteristics and the amount of radiation reaching low levels accounts for the favourable microclimate of forest screens (see Figure 6.3.3.3).

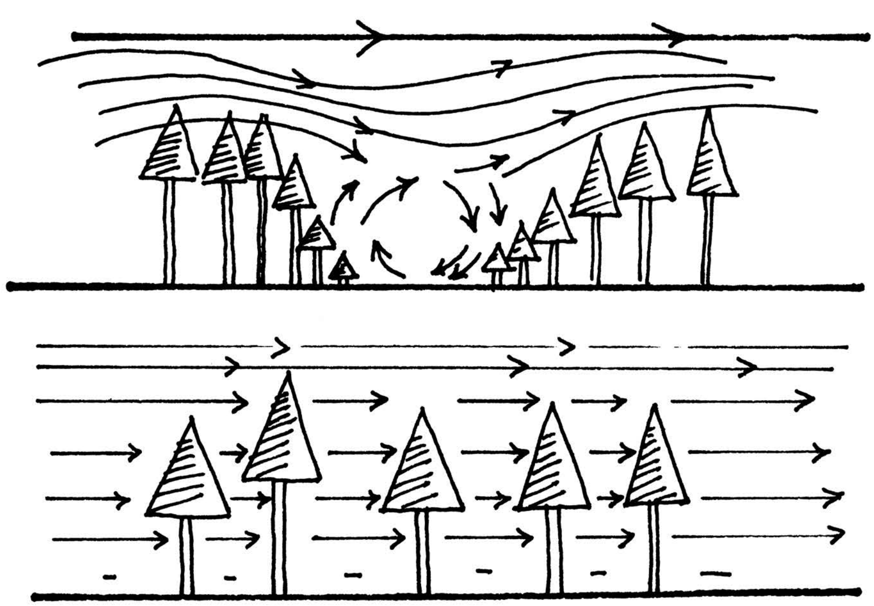


Figure 6.3.3.3 Air Flow in a Regeneration Area and Under a Screen of Old Trees (after Geiger)[31]
Arrows indicate intensity as well as direction of air currents.

In considering forest edge, clearing and screen, we are beginning to look at plant structures rather than broad habitats. Windbreaks have considerable influence on microclimate. They are one of the few "tools" of conventional agriculture in changing microclimate to advantage. The effect of a shelter-belt on winds can vary considerably depending on tree density, height and species. Figure 6.3.3.4, shows that in very dense belts greatest reduction in wind speed occurs up to a distance, on the lee side, of 3 times belt height, but from 3 to 30 times belt height, a medium dense belt is more effective. It also shows that a belt of deciduous trees in winter is still useful in reducing wind on the lee side. "According to Jensen shelter belts without foliage have 60% of the effect they have in summer when in full leaf"[31] (see Figure 6.3.3.5).

Although shelter belts may result in increased frost risk due to cold air damming and wind reduction at night, "during the day soil and air temperatures are significantly higher in the sheltered area. Observations made by G. Casperson . . . show that excess temperatures of 10 deg. C were found on sunny days in the shelter of a 3m high hedge of hawthorn at a site near Potsdam".[31]

Winds tangential to windbreaks tend to increase speed along the windbreak. Perpendicular windbreaks in the form of a corner or T junction are more effective in reducing wind from many directions. "The arrangement proposed by M. Woelfle in 1938 (Figure 6.3.3.6) proved its value in the Upper Rhone valley. The hatched strip shows the network consisting of a mixed stand 50m wide and 15m high. The area inside is subdivided of by hedges 5m high that perform secondary functions by fencing off cattle, protection of birds and providing a source of hazel nuts and a place to build up stones cleared from arable land. Similar effects are achieved by stone walls in Western Ireland, where the small sheltered fields are highly productive due to the interaction of shelter and heat radiation from the walls.

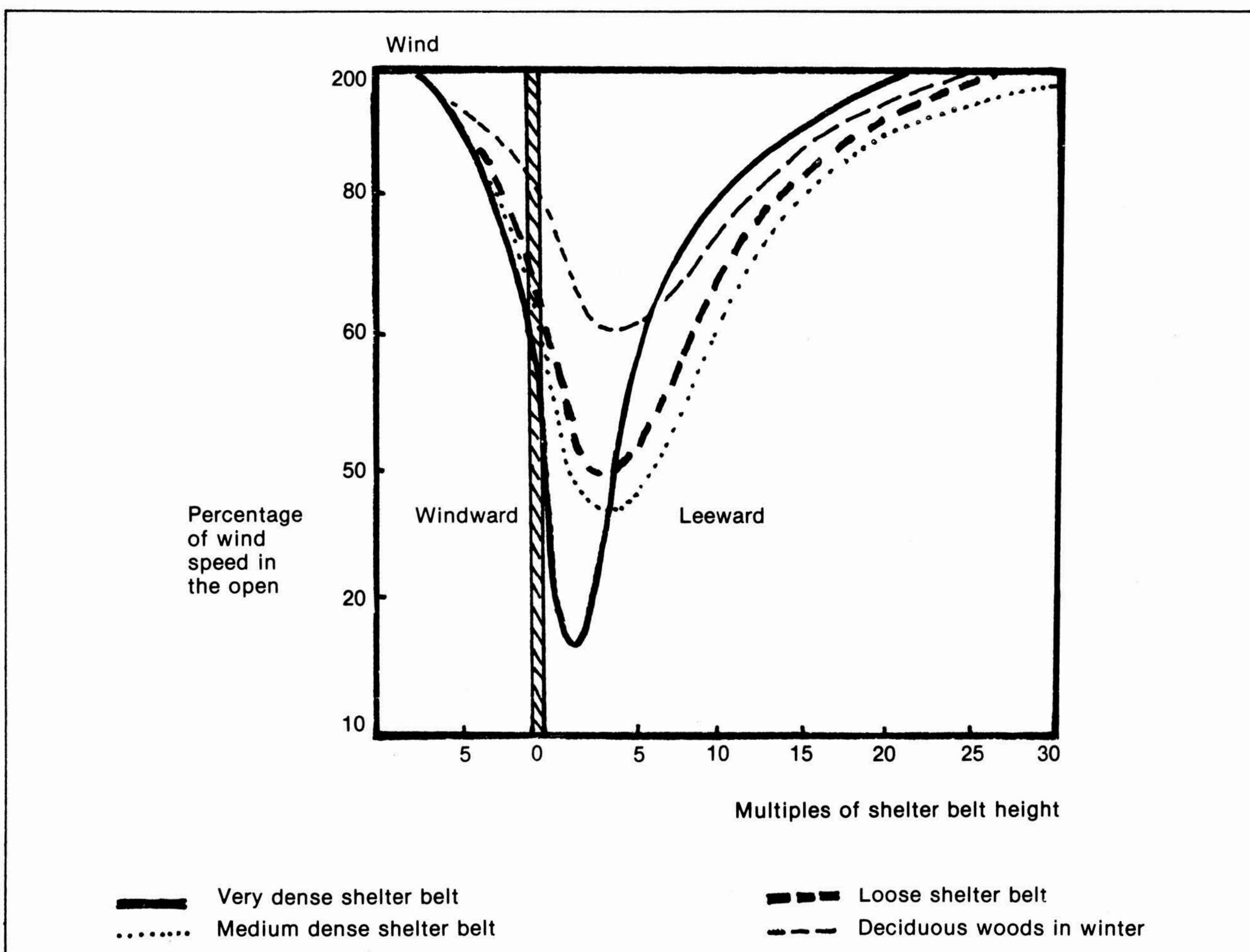


Figure 6.3.3.4 The Effect of a Shelter Belt as a Function of its Penetrability (after Geiger)[31]

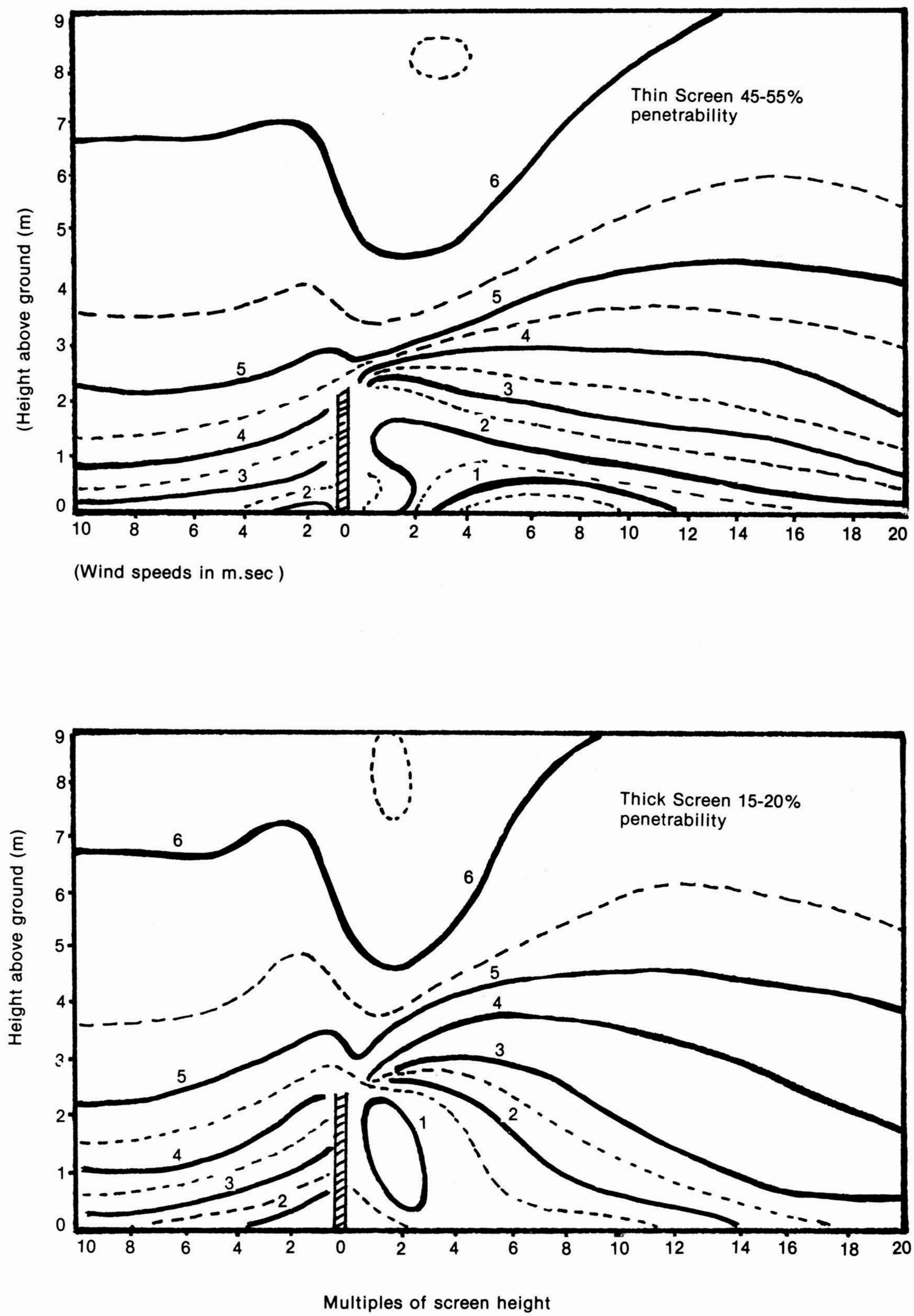
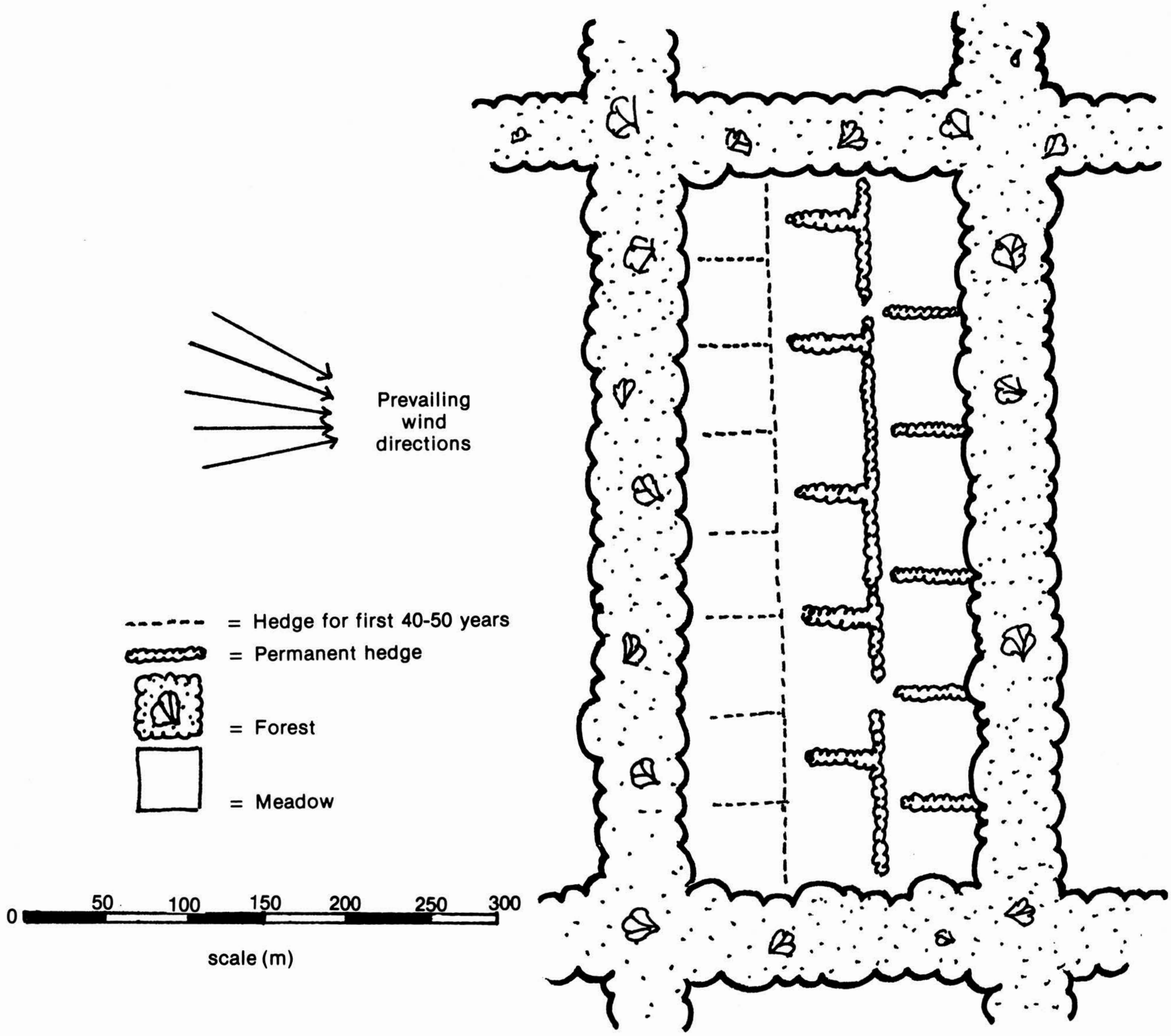


Figure 6.3.3.5 Wind Field Around Two Reed Screens of Different Density (after Geiger)[31]



6.3.4 Water Masses

Large water masses moderate climate but small lakes, ponds and dams are significant in site microclimate for reflected light. Although diffuse reflection from water surfaces is very low, mirror reflection can be quite high when the sun is low. Tests on the banks of the Main river, Germany, in March (spring), showed that light from below (reflected) was 65% of that from above.[31] Success of vineyards in the Main valley, Germany, is partly due to this reflected radiation. Therefore, sunny southern banks (N. facing) of ponds, dams and lakes, as well as rivers, should be considered favourable spots for marginal plants requiring extra light and heat. The cool night winds along rivers do not have an equivalent however, in still ponds. Free water surface is needed for maximum reflection, so that dams or rivers used in this way should be kept free of surface vegetation, using fish or mammals as browsers on surface weed. (See Figs. 6.3.4.1 and 6.3.4.2).

6.3.5 Man-made Structures

With enough money, any useful plant can be grown using greenhouse and hothouse environments; greenhouse culture is independent of location and should be part of any integrated self-support system, particularly in urban environments. In addition (Ref. 24), the greenhouse can become an efficient

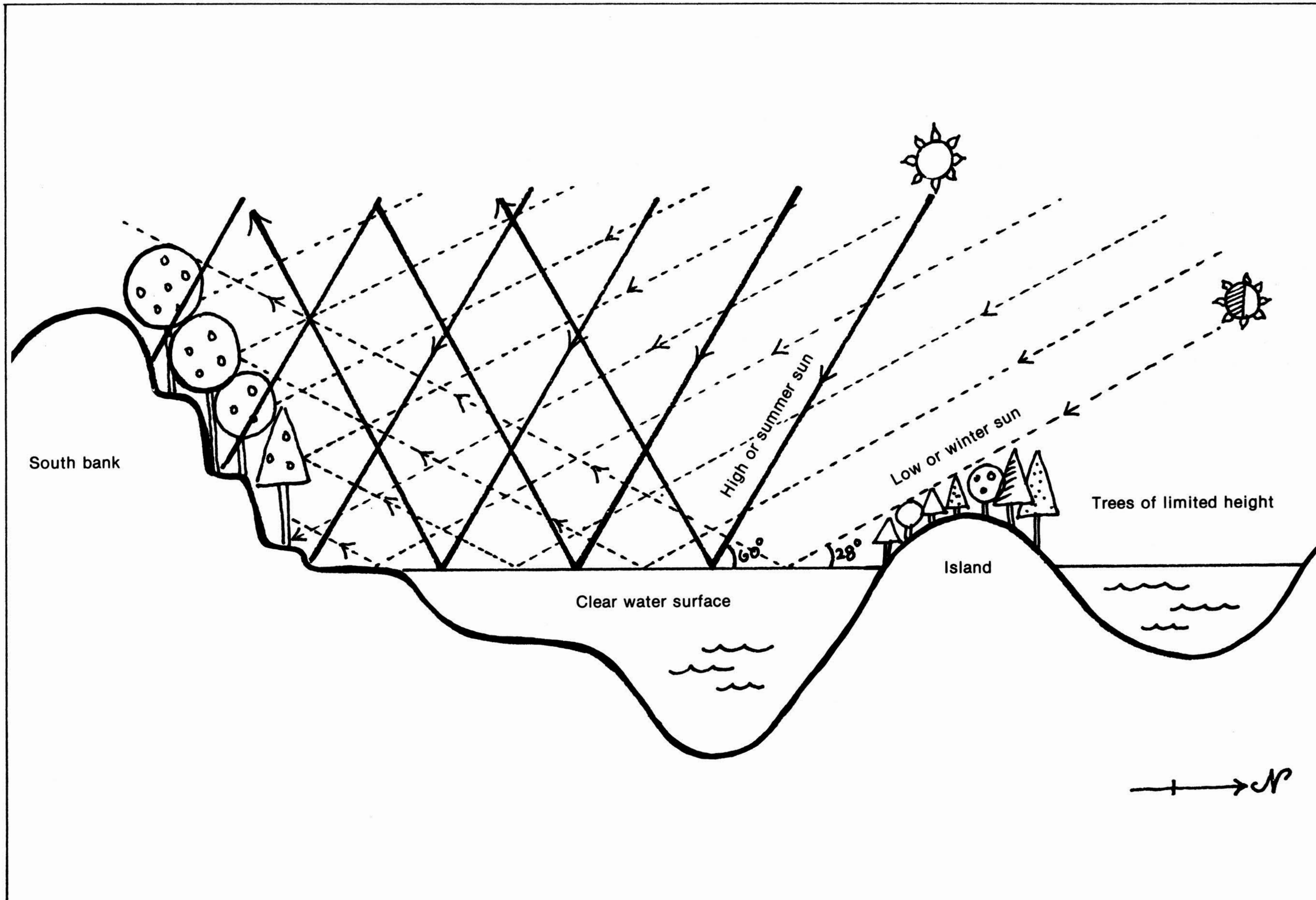


Figure 6.3.4.1 Pond Surface Used as Reflector for Low Sun Angles. Islands and Underwater Shelves Provide Specialised Habitats

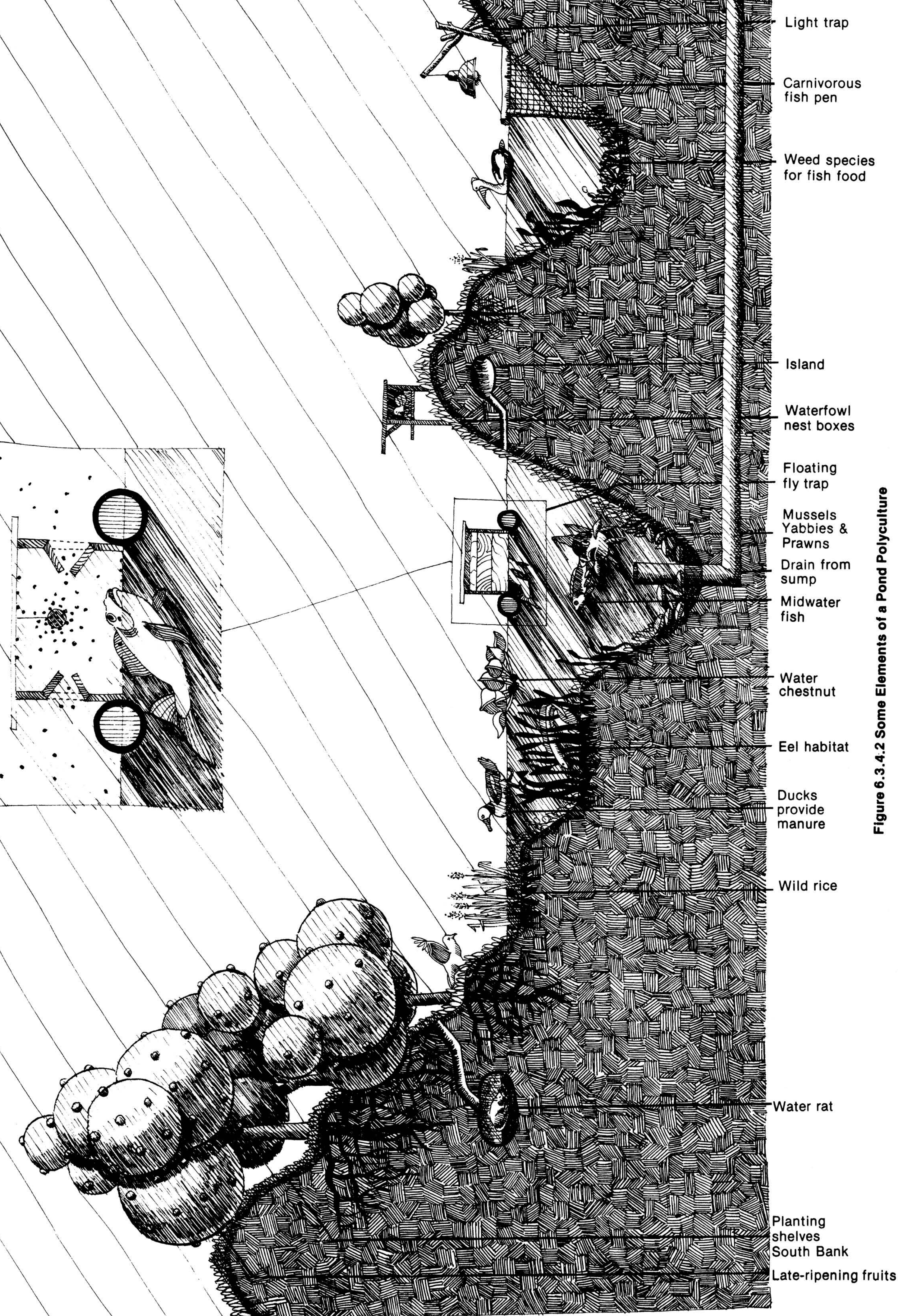


Figure 6.3.4.2 Some Elements of a Pond Polyculture

house-heating unit, saving much of the winter fuel needed in present designs.

The microclimate of north-facing walls is most important. They act in much the same way as does a north-facing forest edge — sheltered from cold southerly winds and reflecting winter sun. In addition, walls store a considerable amount of heat which is radiated at night, thus reducing frost risk. This is especially true of dark-coloured, rough stone walls. On the other hand, light-coloured, smooth walls reflect most of the light which falls on them. In Germany, an experiment with tomatoes and peaches against white and black walls, showed that plant growth was more rapid against a black wall but yield (due to better ripening), was higher against a white wall. [31]

In Tasmania, fruit trees such as oranges are most successful against white, north-facing walls.

6.3.6 Planning with Microclimate

The manipulation of microclimate factors more than anything else allows diversity in plant and animal species. Microclimate planning in cool regions should be oriented towards these aims:

1. The increase of yielding season (summer) radiation available to plants for the ripening of fruit.
2. The increase of average air temperatures, avoidance of frosts and reduction of wind chilling in order to protect sensitive plants (and ameliorate the environment for animals).
3. The development of a more moderate microclimate with reduction of temperature and humidity ranges and the reduction of winds.

The aims are in order of importance for extending the range of species which can be grown. Figure 6.3.6.1 summarizes ways to achieve the first two aims. Figures 6.3.6.2 and 6.3.6.3 illustrate the microclimatic differences between two similar forest/pasture plans.

6.4 Spatial Relationships in Permaculture

The groundplan of zone and sector outlined here is basically an energy conservation plan, designed for the best possible efficiency in the long and short term. Zonation from indoors to horizon is possible, much as a good kitchen layout follows a flow-through principle of least labour. Thus, the zones represent the energy values inherent *within the system,* the needs of plants for control or attention, the need of the household for that particular plant, the energy or vital product yielded by the plant or unit.

By zoning all species (plant and animal) and all structures (pond, fence, shelter, pit), the human labour in the system is most efficiently used.

The sector division is for the efficient control of energies *external to the system* (sun, wind, fire), and these energies can be blocked, channelled, or increased by design. Thus, wind can be screened out, directed to a wind machine, or allowed to enter as a cooling or heating system to moderate temperatures. Fire is, of course, excluded as wildfire, and used as controlled combustion within the system (see Figures 6.4.1 to 6.4.3).

An idealised placement diagram can be made for an isolated settlement but actual site considerations, some size limits on ownership and other practical considerations limit the 'perfect' form as it does in keyline planning. Basically, we have imposed a zone-and-sector plan on landscape, the zones representing intensity of use and the need to visit plants, the sectors concerned with sun, wind and fire factors, and the whole height limited by the need to admit winter sun to the central dwelling complex.

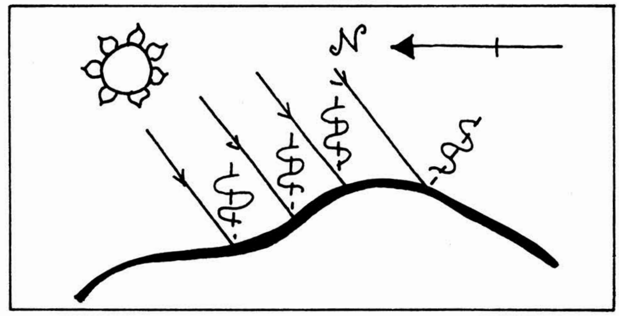
Ideally, one should construct a vast bowl of trees, with water and grass surfaces interpenetrating the system and structures carefully planned to serve several functions.

In planning a whole dwelling/support system layout, or just placing an individual plant, the relationship between accessibility and intensity of use should be recognised. Consider a flat, cleared farm site with no vehicles available. In such a pedestrian situation, accessibility from the dwelling site is a function of distance. Positions near the dwelling (high accessibility) would be used for high intensity activities (that is, activities involving high input and giving high returns). Intensity of use decreases as distance from the dwelling increases. For example, a herb garden is much visited and could be described as very intensive land use. Herb gardens are best sited not far from the kitchen door. A nut-bearing pine forest, infrequently visited, requires little maintenance and is low-intensity land use. Such forests should be a considerable distance from the dwelling site.

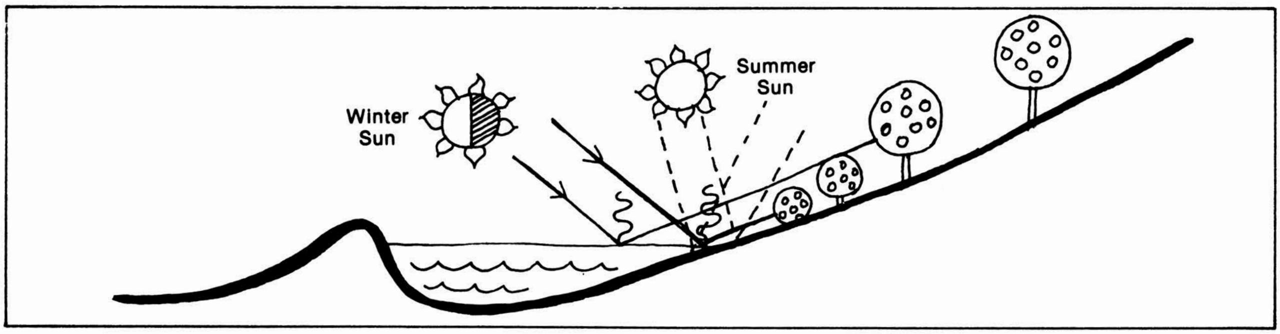
Any traditional farm will exhibit the relationship illustrated in Figure 6.4.4 with vegetable gardens, chicken shed, workshops, etc., near the house. In real situations, distance is not a true measure of accessibility. Land form, vehicles and vehicular tracks alter accessibility.

Figure 6.4.1 can be used as a guideline to assist the rational choice of site for plant species, plant systems (e.g. forests) and all other elements for the support system. The maintenance and species/site/size suitability assessments in Table 7.1.9 can help in evaluating the intensity of use for any species. Other factors to consider are yield per unit area and frequency of use or harvest.

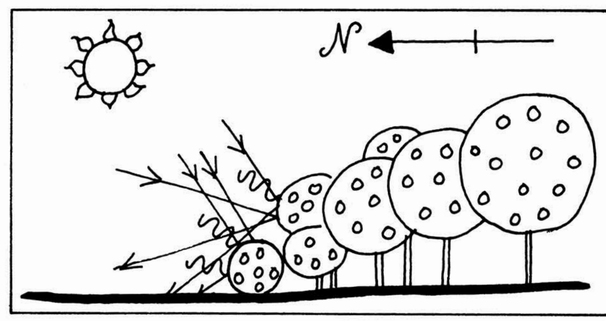
1. ASPECT: The closer to perpendicular to the ground surface the sun's rays are, the greater the radiation per unit area.



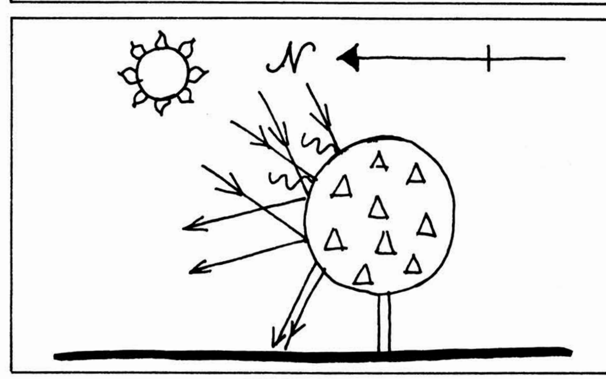
2. WATER: Reflection from water is highest at low sun angles (winter, morning and evening sun).



3. FOREST EDGE: Reflection falls closest to the edge in summer.



4. WINDBREAKS & HEDGEROWS: Act as forest edge.



5. WALLS: (free standing, or buildings). Act as heat stores for cool periods.

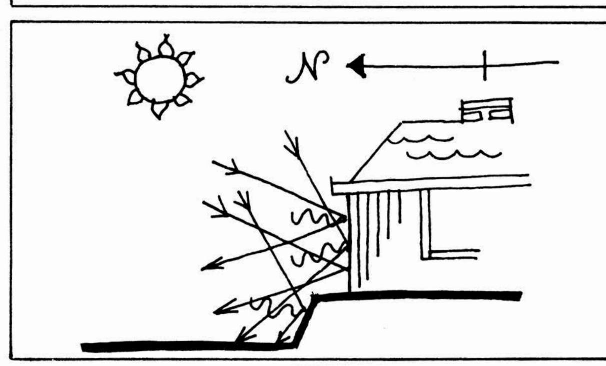
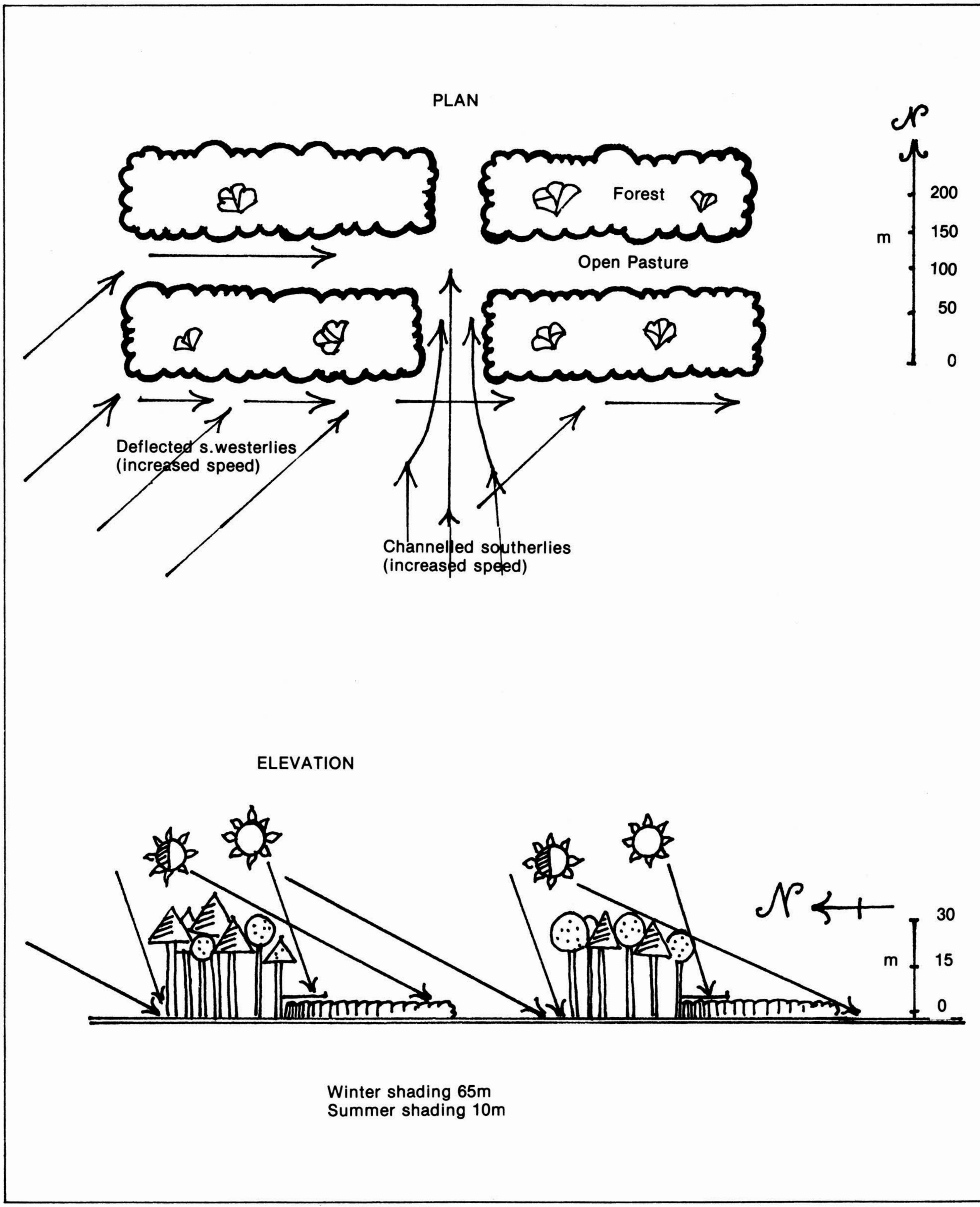
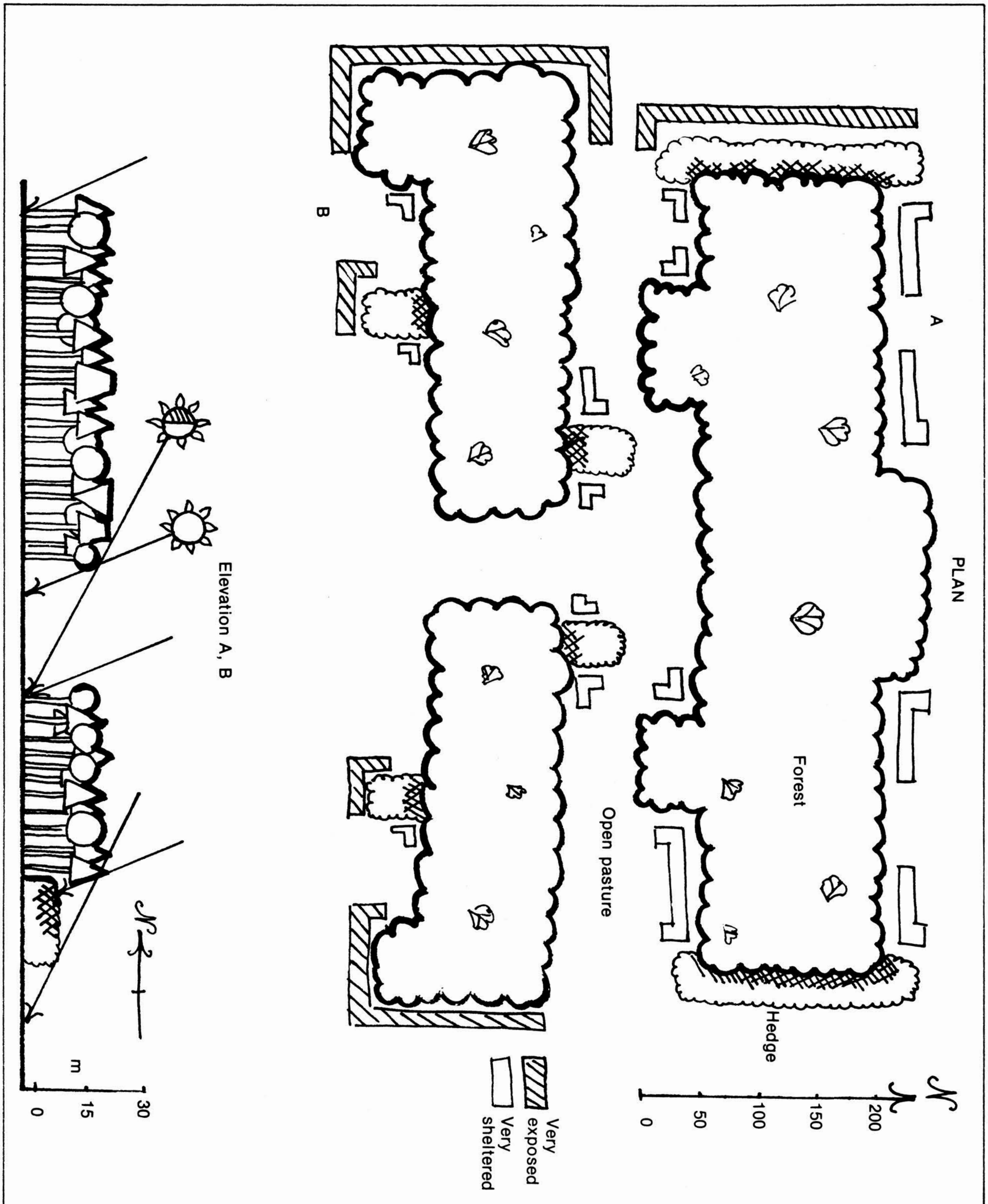


Figure 6.3.6.1 Elements Useful for Increasing Radiation and Raising Temperatures at a Particular Locality
Arrows indicate sun angle and reflection; sinuous lines are radiated heat.



Notes: Sheltered forest environment — useful microclimate.
Sunny north facing forest edges — very useful microclimate.
N.-S. gaps — very bad southerly winds — poor microclimate, possibly wind energy use.
South facing forest edges — shady and windy, due to deflected south-westerlies — very poor microclimate.

Figure 6.3.6.2 Forest/Pasture Layout — Poor Microclimate Planning



Notes: Winds broken by baffle system — no wind channels.
Very sheltered sunny north-facing forest edges — very useful microclimate.
Very sheltered shady south-facing forest edges — useful microclimate.

Figure 6.3.6.3 Improved Forest/Pasture Layout — Good Microclimate Planning

6.4.1 Zoning

It is useful to consider the site as a set of concentric zones (see Figure 6.4.1).

Zone I is the origin of the system. The area surrounding the dwelling, representing the most intensive and controlled land use is the centre of activity. In Zone I, propagation and nurturing, construction and maintenance, experimentation and observation are the characteristic activities. It contains dwelling, workshops, greenhouse and propagating frames, intensive vegetable garden but not animals on range. Mulch can be continuous and re-applied as needed.

Zone II is the intensively cultivated permaculture. Structures include terraces, stone walls, hedges, ponds and trellises. Mulching is extensive or continuous in early establishment, water reticulated and plants generally well maintained (pruning and pest control, weeding and trellising). Planting is dense with few large trees but with a complex herb layer and understorey, especially small fruits. Specimens of a marginal nature requiring special care would be in this zone. Birds, such as guinea fowl, ducks, hens, pigeon and quail, could range through or be encouraged in Zone II. Rabbits would be strictly controlled. It is only Zone I and II species (see Table 7.1.9) that are recommended for urban areas.

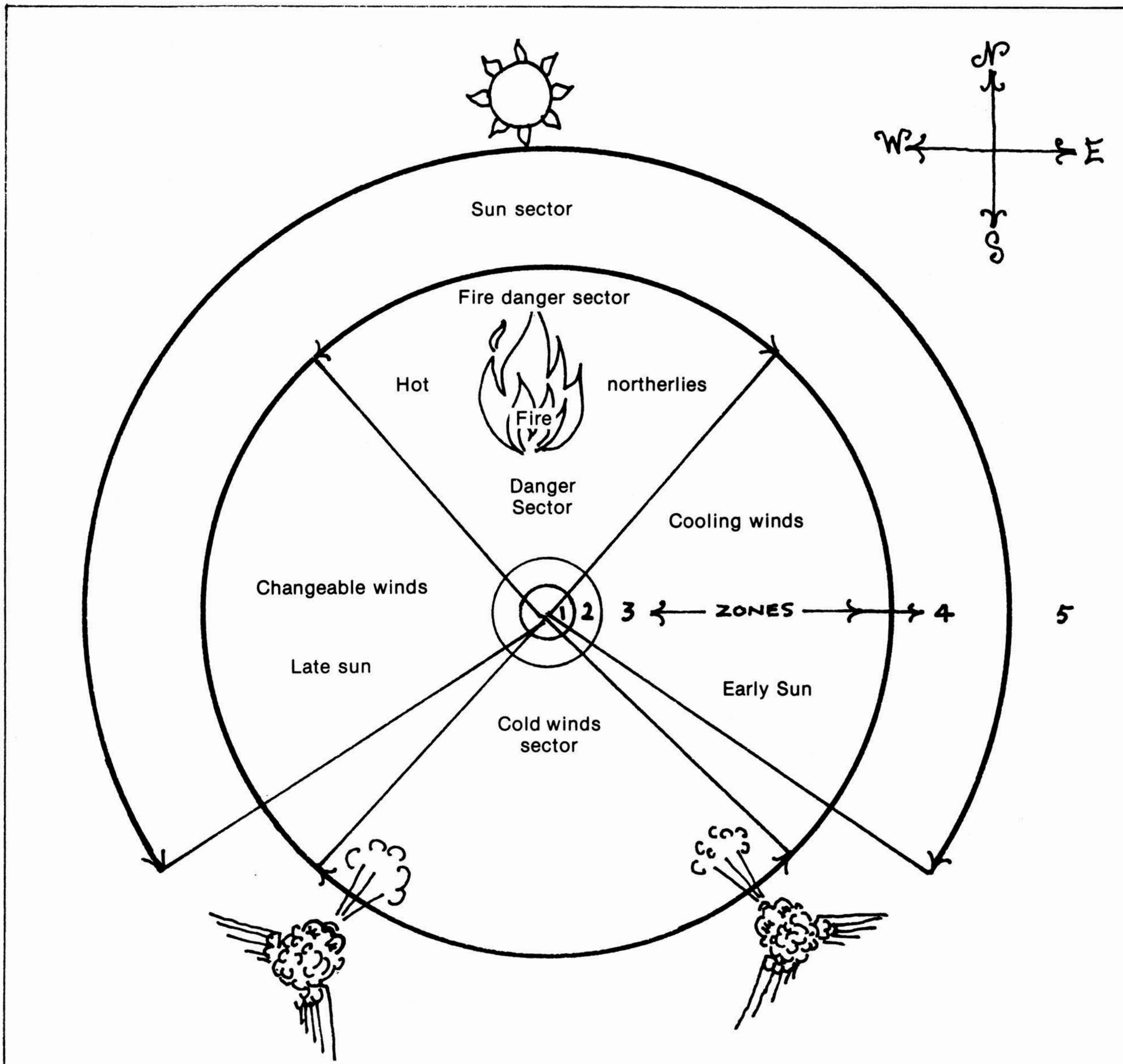


Figure 6.4.1 Zone and Sector Factors Regulate the Placement of Particular Plant Species and Structures

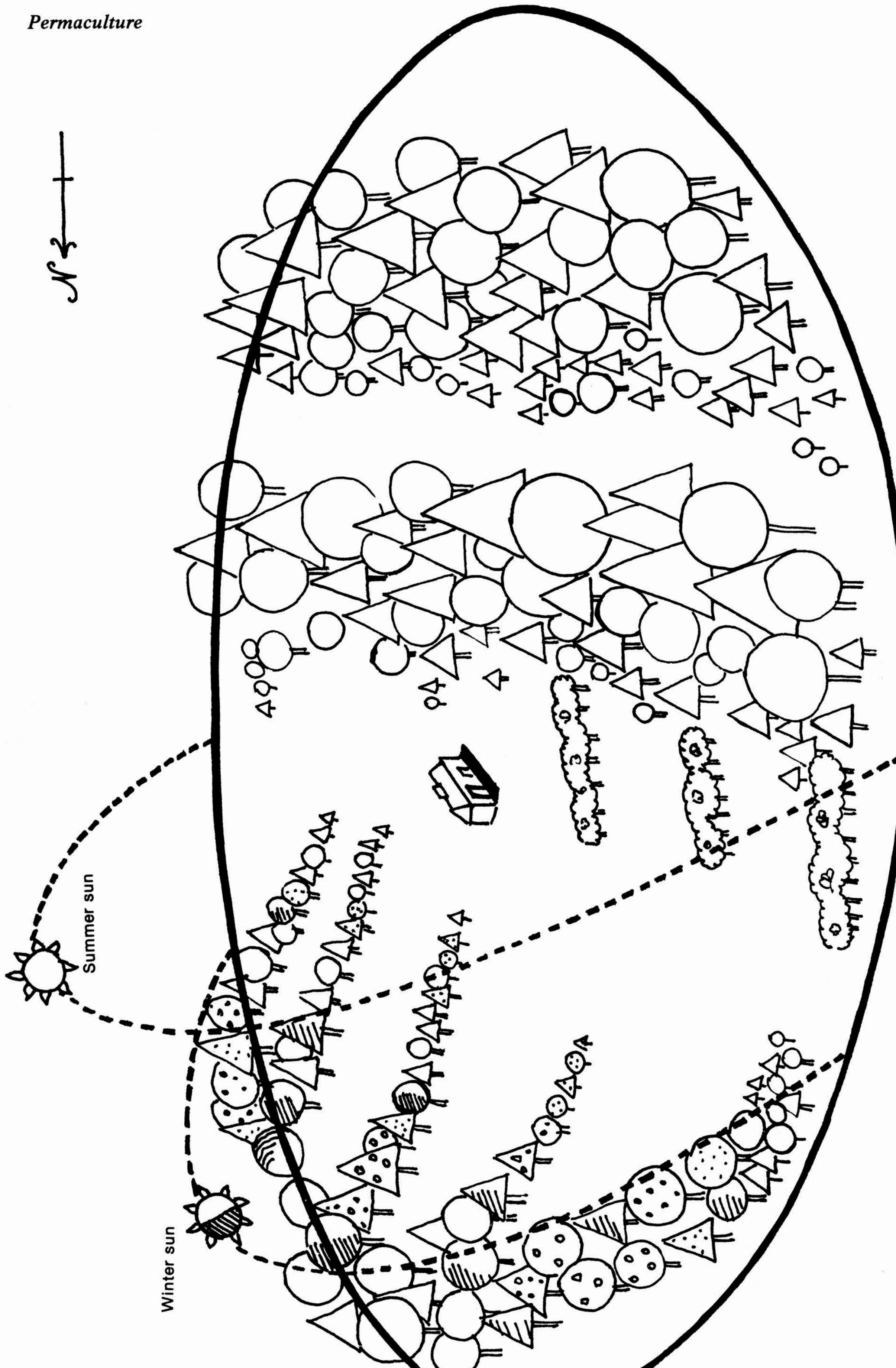


Figure 6.4.2 Winter and Summer Sun Angles Decide Tree Height In Planting. Western Aspect May Be Closed By Hedgerow Against Cold Winds

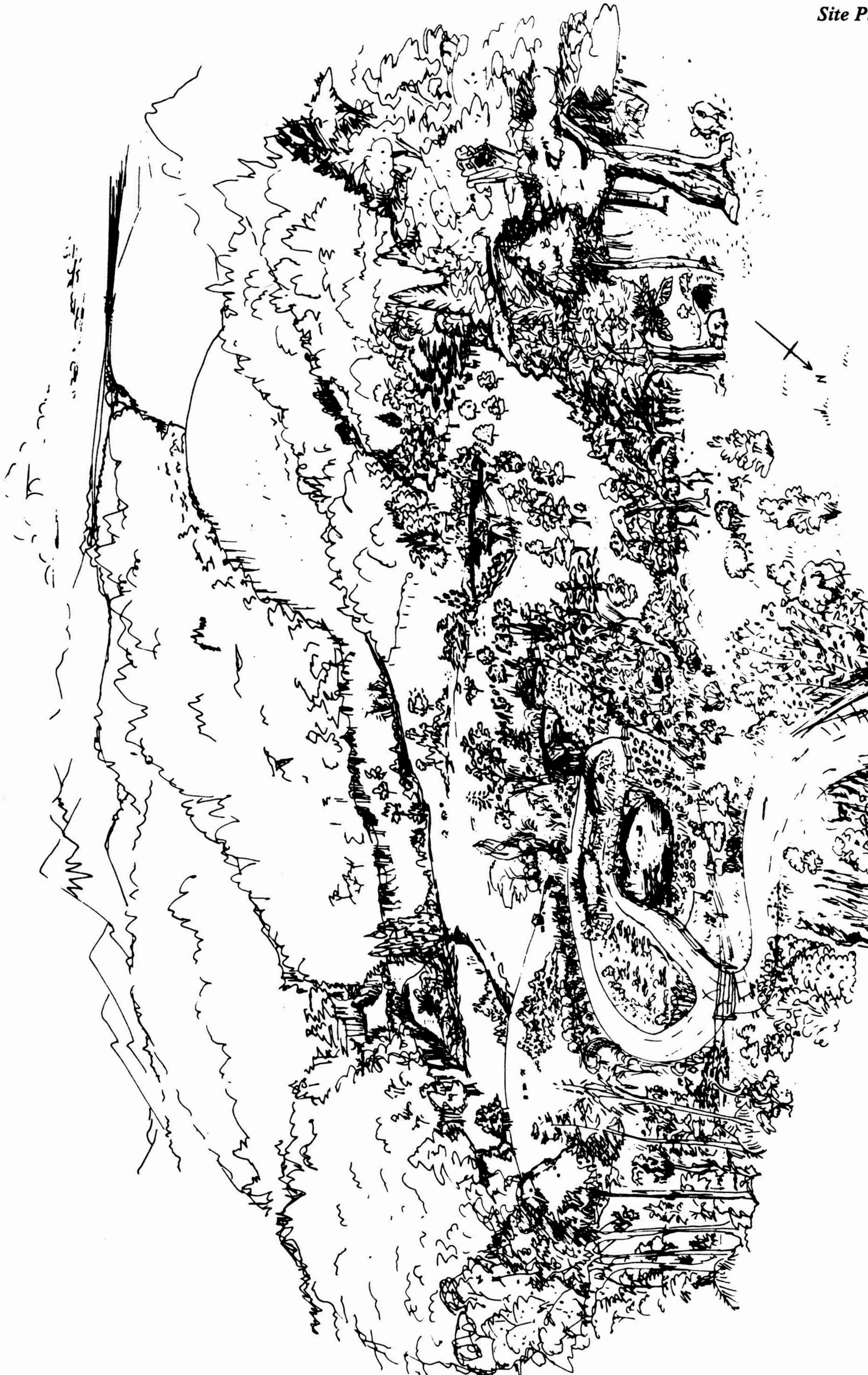


Figure 6.4.3 Appearance of a Developed Permaculture Viewed From Sun Sector

Zone III is hardy permaculture. Products are mainly for animals, both foraged and harvested. It contains only tough understorey and self-perpetuating herb layer or pasture. Plant structures include thickets, hedgerows and windbreaks. Spot mulching is done around some plants, water is not fully reticulated though it is available for animals. Nuts are the main food available directly from plants. Newly-planted trees and shrubs are protected by stakes or cages. Animals could be geese, hens, turkeys, rabbits, sheep and wallaby.

Zone IV is extensive tree culture and open pasture with tough hedge plants, often spiny — for protection. Food yields other than meat are occasional, mainly from seedling trees. Timber is a developed product. Peacocks, cattle, horses, donkeys, deer and pigs would be suitable animals. Sheep, wallaby, turkey and geese would also be suited to this zone. Animals would be mostly self-feeding. Watering, mulching and other maintenance work would be minimal. New plantings would be caged. Possums would be controlled as in Zones I, II and III.

Zone V strictly speaking, is outside the system and can be considered as uncultivated bushland. Direct use would be for hunting and timber. In country over-run by blackberries, gorse, fireweed or bracken goats could be used to clear the area for the extension of the system. Goats (unless staked) are highly destructive and should remain outside the cultivated system, or be penned by secure fencing in Zones II-IV.

The foregoing picture of the homestead and site should not be considered definitive but the zoning concept is basic to any permaculture. The fact that intensity of cultivation is determined by distance from settlement, not soils, is evidenced in the spatial patterns of traditional agricultures.

Blunden[45] quotes a number of writers on the subject of rural land use patterns:—

"Of the situation in Sicily, N. Prestianni (1947) writes: 'The large settlements, where practically all the peasants live, are generally situated on hilltops or hill slopes sometimes dominated by a ruined castle. Around these settlements there is a zone of intensive tree and herbaceous crop cultivation, small fruit and vegetable plots forming a halo of greater or lesser extent, according to the size of the village. Beyond this zone extend the former fiefs or latifundia, generally devoted to cereals and pasture. Interestingly, cultivation is most intense immediately adjacent to the village (on the hill-sides) where land is of poor quality' . . .".

Lannou, writing about Sardinia, is also quoted by Blunden: [45]

"From whichever side one leaves a village, one is struck by the vigorous disposition of the various elements of the countryside into concentric zones.

Table 6.4.1.2 (after Blundell)[45]
Canicatti, Sicily: Percentage of Land Area in Various Uses and Labour Requirements per Hectare in Man-Days.

Distance in kms from Canicatti	Urban	Irrigated Arable and Vegetables	Citrus Fruits	Vines	Arable With Trees	Olive	Trees*	Arable Unirrigated	Pasture and Productive Waste	Coppice Wood per Hectare	Average Number of Man-Days in each Distance Zone
0-1	44.7	. . .	. . .	15.8	. . . .	. . . .	19.7	19.7	. . .	. . .	52
1-2	. . . .	. . .	. . .	18.0	16.7	8.4	41.0	15.9	. . .	. . .	50
2-3	. . . .	. . .	2.6	2.3	21.8	14.4	35.4	23.6	. . .	. . .	46
3-4	. . . .	. . .	2.1	13.3	18.7	0.6	47.2	18.1	. . .	. . .	50
4-5	. . . .	. . .	. . .	5.1	19.2	2.4	28.4	43.4	1.4	. . .	42
5-6	. . . .	1.0	. . .	6.3	4.7	1.6	17.6	64.1	4.7	. . .	41
6-7	1.3	0.7	. . .	3.3	6.7	. . . .	18.3	68.7	0.9	. . .	40
7-8	. . . .	. . .	. . .	4.0	7.7	. . . .	23.6	62.4	0.8	1.6	39
TOTAL	1.0	0.3	0.4	6.1	11.1	2.2	26.3	50.8	1.4	0.4	. .
Average number of man-days per hectare	. . . .	300	150	90	50	45	40	35	5	5	42

* Mainly almond, hazel, carob and pistacchio.
\+ Sometimes sown.
Notes: The location of the small amount of irrigated and citrus lands is determined by the very limited area which is suitable.
The actual diminution of labour inputs from the centre to the outer zones is undoubtedly much greater than indicated, because it is assumed that labour inputs remain the same for each crop irrespective of distance, and arable land left fallow occurs more frequently at greater distances.

Around the village . . . there is a first zone in which the view is restricted, where the parcels of land are small and bounded by hedges of prickly pear, growing vegetables, olives, almonds and vines. But this pleasant labyrinth constitutes only a narrow belt and suddenly there opens out a landscape which is flat and bare, without walls, without hedges, without trees: these are the arable lands . . . Completely cultivated in the area nearest the village, this territory becomes poorer in the distance and the amount of fallow increases".

Similar patterns exist for larger settlements as with the preceding example which also provides some interesting information on the nature of Sicilian agriculture and the labour requirements for different land uses (see Table 6.4.1.2). The data is from the work of Chisholm (1965) (see Blundell[45]) on Canicatti, a settlement of 30,000 people 18 kms from the nearest settlement of similar size.

6.4.2 Sector Planning

The sectors can be planned according to local wind-rose data, now commonly available for most localities. Local knowledge is invaluable, and the history of fire, its speed, direction, duration, and intensity is often available only from older residents. The surviving vegetation may indicate species which retard or survive holocaust, but deliberate choice of fire-retardant species and careful arrangement of structures is essential if efficient fire control is an aim, as it is over most Mediterranean climates (Read Section 6.7, see Figure 6.4.2.1).

Sun elevation data are also available for specific latitudes and sites, so that plant height, trellising, wall cover — and the materials, surface finish, and curvature of walls — can be used to increase, decrease, or direct sun heat. Dams are placed to reflect sun or retard fire, and preferably serve these and other functions. The efficient use of sunlight is also ensured by the preservation of stepped edge sequences in the general planting, much as factory rooftops are stepped to allow maximum light.

We suspect that plants such as *Coprosma,* with shiny leaf surfaces, may be planted as living sun reflectors, giving a diffuse but increased reflection to other species such as citrus, but more work needs to be done on the intrinsic values of leaf shape and surface to elucidate these and other factors.

It is a matter of personal choice and site factors as to how sector-planning is imposed on the site plan; and as locusts have been observed to travel along (not over) linear plantings of tall trees, there may be some value in using more sophisticated zonation structuring than we have envisaged to date.

The aim of sector planning is to channel external energies to serve the internal needs and comfort of an evolved permacultural system.

6.4.3 Access

It is desirable to maximise access to all areas of the system, especially for the purposes of establishment. The transportation of plants, mulching materials, stakes and fencing materials requires access by (at least) good foot tracks. As yields from the system increase, the bulk and weight of produce require easy access for harvesting. Roads, tracks and foot tracks become increasingly important on steep land.

The solution to the transportation problem depends on funds available for vehicles (cars, four-wheel drive vehicles, trucks, tractors, donkey and horse carts, wheelbarrows). However, integral layout of all access ways can be done at little cost and thus maximise access with minimum effort. Layout design will of course, depend on the individual site and resources available but a few principles can be stated:—

1. All-weather roads should, where possible, fulfil other functions such as fire breaks and dam walls.
2. A top bench road should be established if possible, to give access to all areas from above (it's easier to get materials down slopes than up them).
3. Roads should run around contours where possible with no steep slopes which tend to need high maintenance because of erosion. Generally, roads should follow the ridges but this depends on whether primary access is from the valleys or ridges, and the form of the land.
4. Tracks and foot tracks should complement all-weather roads in an integral layout worked out early in the development of the system.
5. The road as water-shed should also be considered and run-off led to the water reticulation system; this is achieved in keyline planning.

6.5 Water Retention and Supply — Aquaculture

Water is important for the establishment of permacultural systems. In Tasmania, water supply is not as great a problem as in drier regions but it can figure as one of the larger initial costs in setting up a permaculture.

Many factors affect the importance of water supply, the main ones being:—

1. Local rainfall, its distribution and reliability.
2. Drainage and water retention properties of soils.
3. Soil cover (mulching, cover crops).
4. Animals (species, age, stocking densities).
5. Plants (species, size at planting out).

The first factor is fixed but the other four can be controlled. The last factor is the main way to control the general level of watering required. (Watering requirement is included in the maintenance assessment in Table 7.1.9).

Fitting species to the site reduces watering needs. For example, olives on dry hillslopes and cloudberries in wet forested gullies require almost no watering once established. Goats, rabbits, sheep and wallaby, survive all but extreme conditions without free water, getting their requirements from night dew. Maintaining plants in a nursery situation in large pots can allow the development of good root systems. After 3 years' growth a tree is much more capable of getting enough water than a one-year-old seedling. Mulching reduces watering needs a great deal, apart from providing nutrients and controlling weeds; this involves considerable input initially but permanently reduces watering costs. Stone-mulching is effective in this respect.

Water retention on farms is usually by dams. In spite of their potential as productive ecosystems, dams are usually considered simply as water storage. In a permaculture, the more dams the better. They:—

— Provide water for rapid and extensive planting activities in the first few years.
— Provide still water for the development of pond ecosystems yielding fish, ducks and diverse plant products.
— Modify the nearby microclimate by light reflection.
— Act as purification tanks for high nutrient water from places such as chicken runs and sewerage outflows.

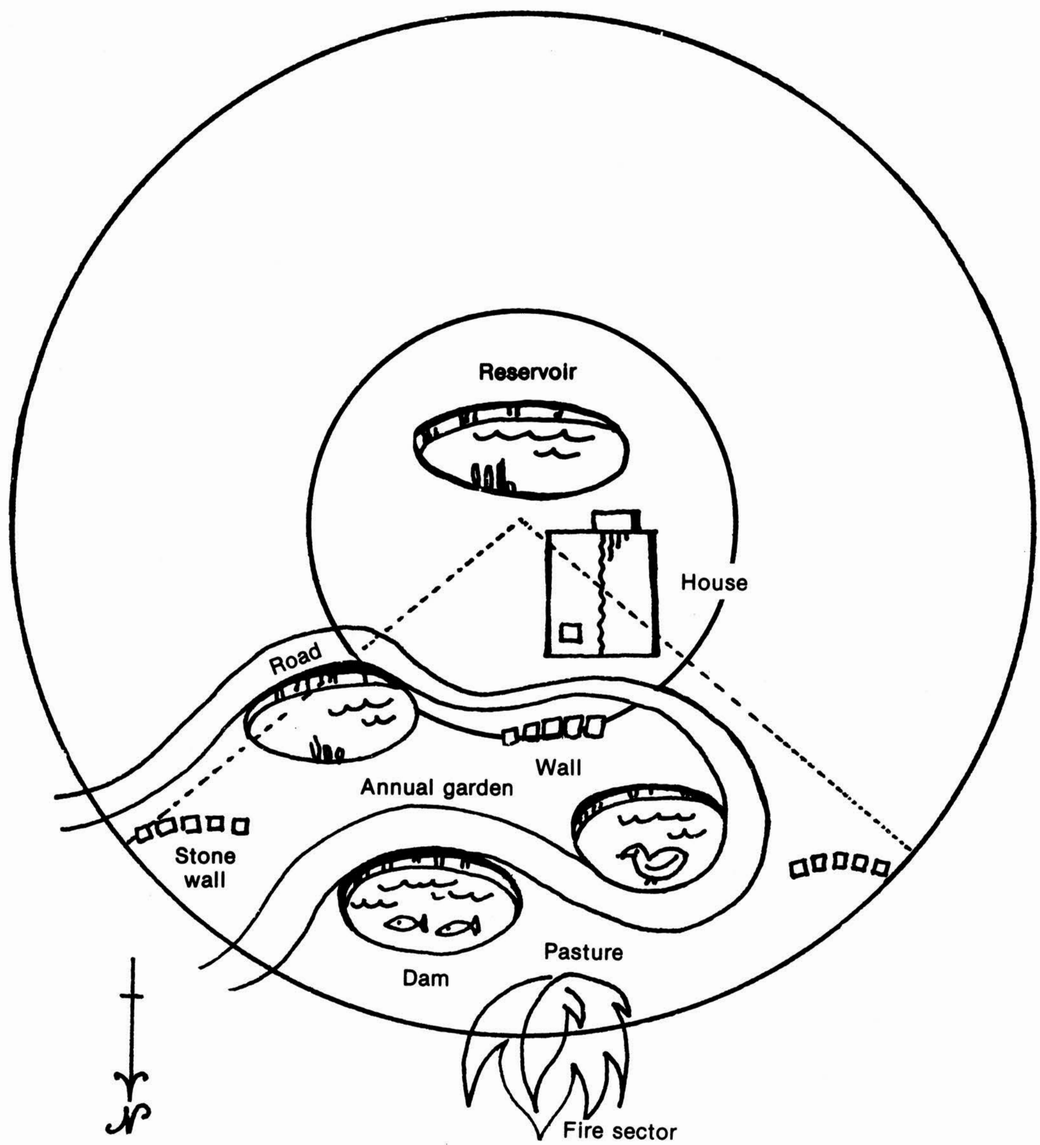


Figure 6.4.2.1 Factors in Siting Structures — Fire Sector

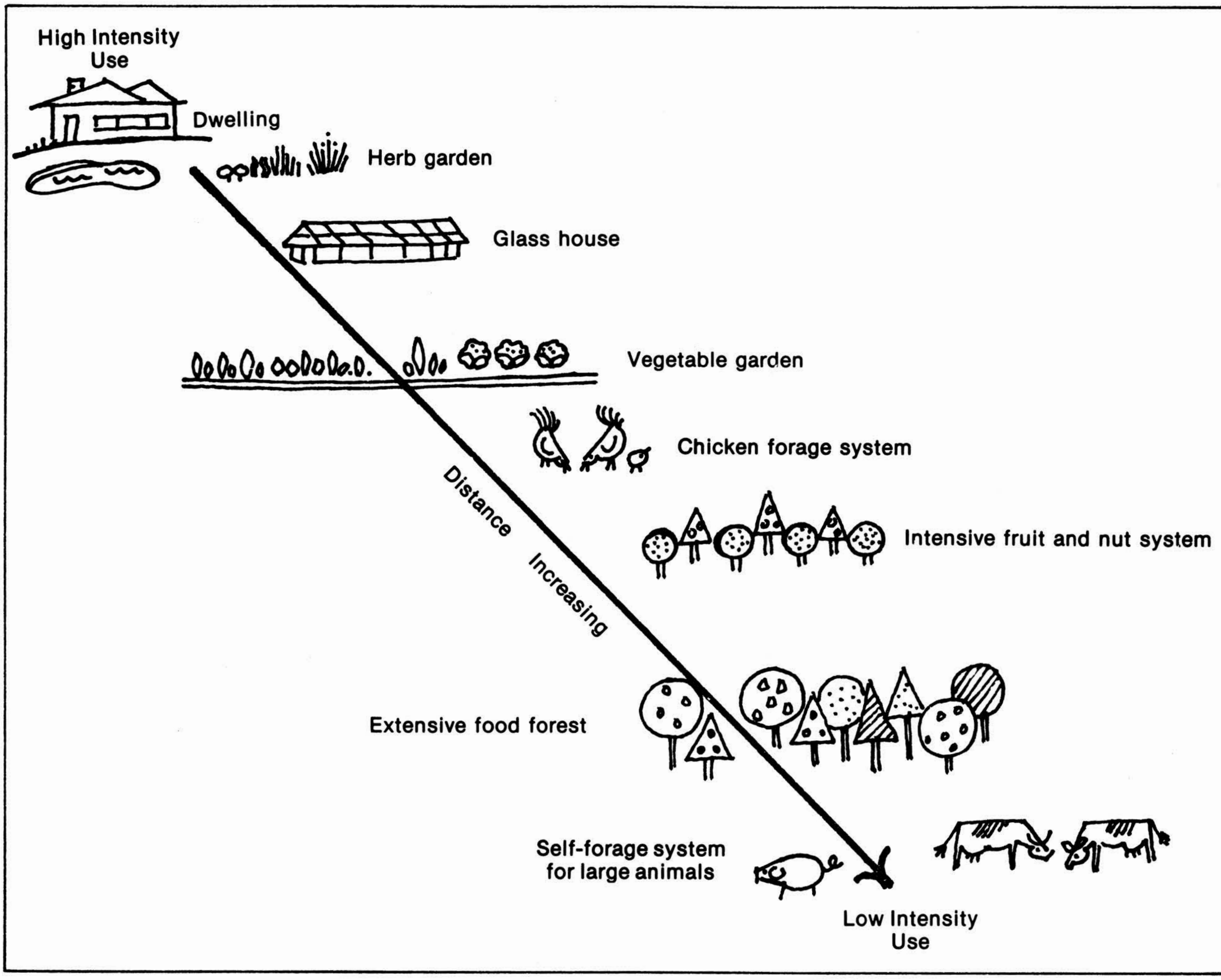


Figure 6.4.4 Intensity of Use/Distance Relationship
(a)

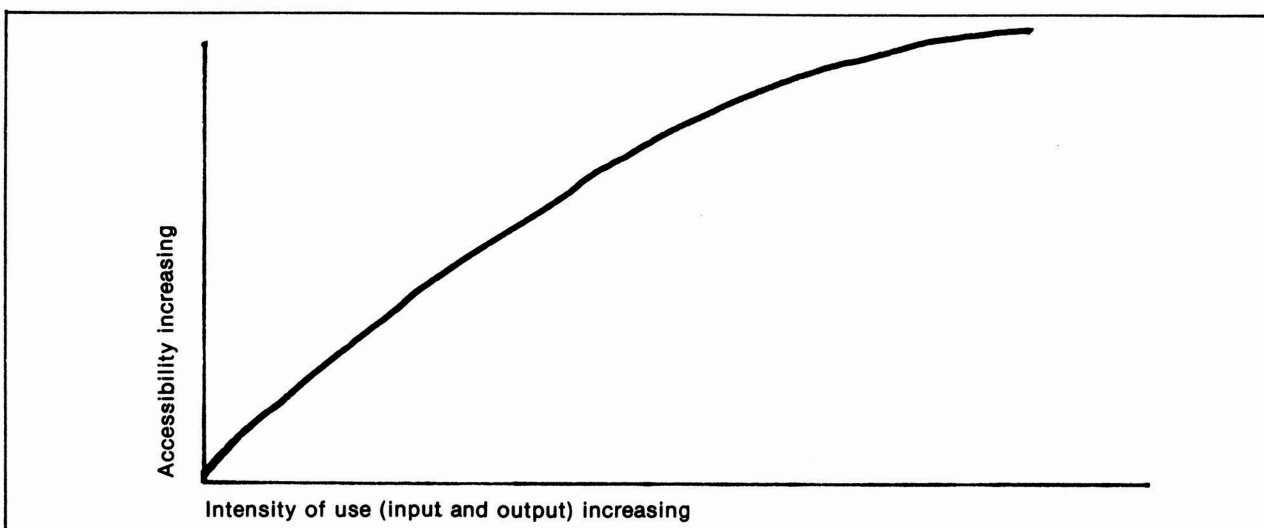


Figure 6.4.4 Relationship Between Accessibility and Intensity of Use
(b)

— Provide defence against fire.
— Allow the development of productive marsh ecosystems in the future.
— Generally diversify the whole ecology in accordance with long-term aims.

In view of their great long-term value, the initial cost of dams to supply water for establishment is very little.

Siting dams is mainly commonsense but should be part of integral site planning rather than isolated decisions. High dams are of great value in that water can be fed to all parts of the site without the use of mechanical equipment. However, dams on steep slopes are costly and of low capacity. Much larger dams can usually be built on near-flat land. Hydraulic rams and other simple devices, making use of the falling water of a creek, can pump water to high dams.

The pioneer work of Yeomans, in his keyline system, decides the placement of dams in larger landscape planning.

As mentioned in Section 6.7 dams on the fire-danger side of a dwelling are an obvious advantage. Dams on north-facing slopes are of great value, due to south bank winter microclimate (see Section 6.3). Evaporation from small dams in warm sunny positions can be high but shelter from winds is usually more critical than shade.

Siting a Dam

Factors to consider:—

Land-form.
Contour level.
Gradient.
Soil, subsoil and base characteristics.
Collection net.
Aspect.
Fire control.
Reticulation area.

See References 21 and 39 for information on dam siting and construction.

6.5.1 Aquaculture

Ponds and streams open up the possibility of aquaculture in the general ecology. A dam built for aquaculture needs more planning than a simple water storage, in that underwater shelves, islands and sumps of deeper water all have a place. Shelves allow shallow-water planting of rushes; islands are ideal waterfowl nesting places and sumps preserve fish in temperature extremes or when the system is drained.

Freshwater mussels can be introduced into the bottom of the dam which then develops a nitrogen-rich mud for manures. Yabbies, or better still, the freshwater marron of West Australia can occupy the mud surface and browsing or plankton-feeding fish from the carp and *Tilapia* group fill midwater niches. *Acorus* and wild rice are planted in the shallows while *Trapa* and ducks utilise the surface of the water. Insect traps, baited or lighted, can provide up to 60% of fish food.

Any water area, particularly if carefully managed, can provide up to 30 times the yield of adjacent land surface, as water is a three-dimensional system and fish need little energy to move in a water medium.

Yields are for the most part additive if species are chosen that do not compete. Biological filter systems, using channels of water-cress and mussels clean silt and suspended solids from road run-off. Small breeding ponds can be established in greenhouses for home breeding of fish stocks. Intensive aquacultural management gives some amazing yields but needs constant water flow or pumping facilities.

Aquaculture in warmer areas allows the introduction of large freshwater prawns and more exotic fish species, while trout (especially rainbow trout) are better suited to cooler sites. By directing manures into dams, the phytoplankton yields can be increased and algael foods for browsing carp encouraged. If a series of dams are contemplated, then the higher dams can provide clean water and the lower parts of the system receive nutrient run-off from animals and man. Dams may also be used as cooling systems for fire gases, or for summer cooling of houses, and the edges provide frogs for insect control in surrounding vegetation. Aquaculture needs special study and only outline suggestions are given here. As on land, fences, or floating nets can be used to keep predatory fish from over-exploiting the system (see Figures 6.3.4.1 and 6.3.4.2).

It is worth noting that about 10% of water caught in tree crowns may run off down bark fissures and stems, so that trees may be regarded as catchment systems and stem run-off led to dams on high sites.

Underground cisterns with concrete pan catchment leading to the water are essential dry-country aids to quail breeding (termed 'gallinaceus guzzlers' by the Americans). The blasting of deeper holes in marshes is yet another way of providing 'edge' as pond and bank, and wet-land management follows much the same principles as permaculture generally, in that many species mixed give much higher yields than monocultures and are more likely to become self-sustaining.

6.6 Soils

In site planning it is necessary to understand the characteristics of the soils. However, soils are not considered to be the limiting factor that many people seem to think. Although the physical character of soils may be a reasonably long-term aspect of the land, the soil ecology which supports plant life is readily changed and improved.

Some elementary survey of soils is necessary. Test holes to examine profile and determine the water table, pH tests and identification of parent rock, are all worthwhile. Observation of water flow and seepage after heavy rains can give information about drainage. Knowledge of both introduced and native flora on the site can give considerable information about types of soils. Local knowledge, often gained over long periods, can indicate specific methods of soil improvement. Detailed chemical testing is expensive, difficult to interpret and of little relevance to the system as a whole. The suitability of the soil for ploughing is largely irrelevant.

All soils can be used, none being totally worthless. Because of the diversity of the plants considered, there is something to suit the most unfavourable sites. For example, gooseberries and olives do well on rocky areas with little soil at all; blackcurrants, pampas and butternuts do well on poorly-drained sites; blueberries thrive in very acid soils; honey locust grow well in the most alkaline of soils. A large range of species in the catalogue are suited to soils of low fertility.

The quotation in Section 6.4.1 from Prestianni on Sicilian agriculture illustrates how soil characteristics are not critical factors in overall site planning. The centre of habitation and intensive cultivation should not be determined by the fertility of the soil, this being only one of the many factors to consider. Within the context of soils, the mechanical structure and thus suitability for construction of buildings is more important than fertility in the location of the homestead site.

6.7 Fire Control

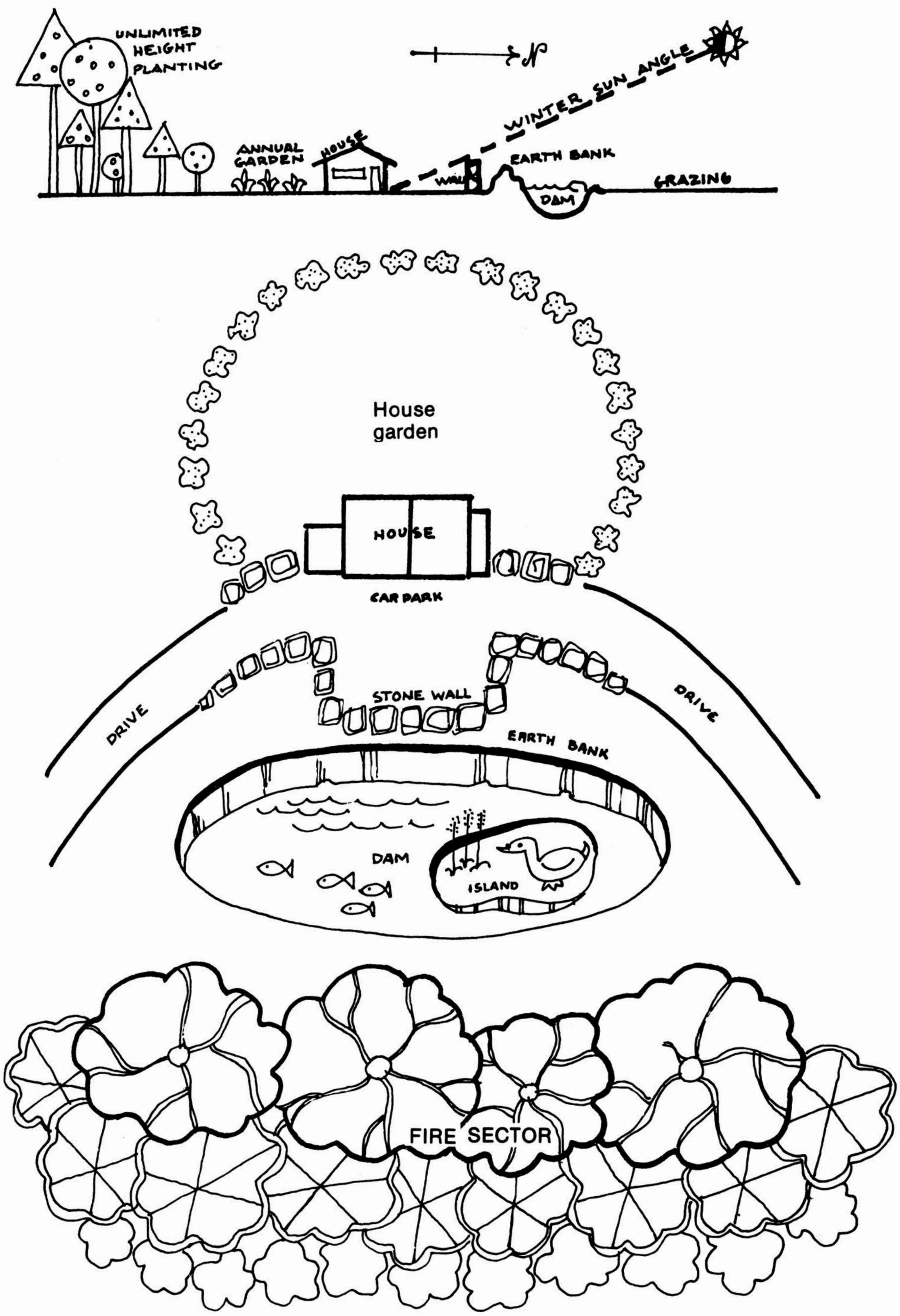
Fire plays a critical role in the development of many ecosystems. In Tasmania, fire maintains the eucalypt forest against successive rain forest. The eucalypt forests accumulate fuel in the form of dead leaves, bark and branches during the summer period. This fuel accumulation can feed frequent ground fires. Long fire-free periods allow the accumulation of large quantities of fuel (up to 50 tons/hectare after 15 fire-free years in stringy-bark forests).[50] Hot weather, backed by dry northerly winds in such forests, can boost ground fires into conflagrations, releasing more than 40,000 kilowatts of energy per metre of fire front. A fire raging through the crown of forest trees releasing more than 20,000 KW/metre is considered uncontrollable.[50] Such fires may be part of the forest ecology but represent disaster to man, his constructions, plants, animals and the fertility of the soil. The frequency of forest fires is difficult to forecast but a permaculture can be expected to be threatened with severe fire at least once in its first 50 years. Permaculture continues to improve productively over a long period and destruction by fire sets the whole system back; the older the system, the greater the loss. Planning against fire can be seen as a form of insurance against catastrophe.

The conventional approach to fire control is regular prescribed burning, to prevent fuel accumulation. The effects on the natural ecology (plants, animals and soil) of such frequent cool burning is not fully understood but in some cases, major and long-term ecological changes have been noted (see Ref. 50). Burn-offs also make a major contribution to air pollution. In Tasmania, areas frequently fired are often covered by post-fire pioneers such as bracken or mosses, which indicate low soil fertility.

Less destructive ways to control fire are available. However, they are much more intensive, relating to the control of small areas rather than large acreages. The planning of structures, plants, water and the use of animals, can all be done to positively reduce fire risk. Table 6.7.1 lists factors which increase and decrease fire risk. Most of these are commonsense and when used with the concept of the 'fire sector', can be very effective in controlling serious fire. Severe forest fires are only likely to come from the north (driven by

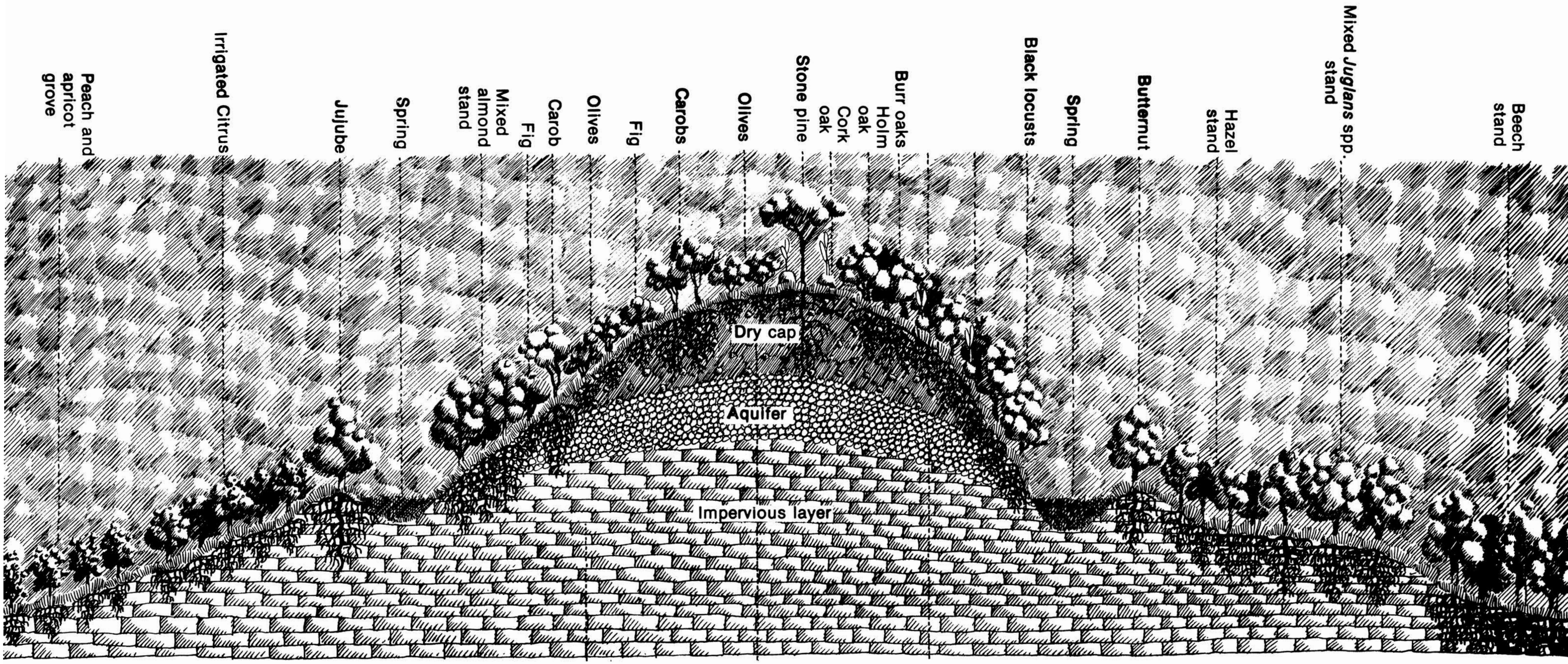
Table 6.7.1
Fire Factors

Increased Fire Danger	Decreased Fire Danger
"Summer deciduous" spp. (e.g. *Eucalyptus*)	Winter deciduous spp.
Dry leaf accumulators (e.g. Gorse, pampas)	Succulent spp. (e.g. Comfrey, N.Z. Coprosma)
Shaggy-bark spp.	Smooth-bark spp.
High volatile-oil spp. (e.g. Pines, eucalyptus)	Trees which inhibit understorey growth (e.g. Walnuts)
	Known species which "steam" in fires (e.g. Silver wattle, willow, blackcurrant)
Long grazers (e.g. cattle, horses)	Short grazers (e.g. sheep, geese, goats)
Trackless	Paths and roads
Waterless	Creeks, ponds, lagoons and marshes
Paling fences, wooden trellises and wooden buildings	Stone walls, earth banks, concrete and brick buildings
Unirrigated	Irrigated or piped
Thick undecomposed sheet mulch	Thin decomposed mulch, rock mulches



— No tall vegetation near house (vegetation profile).
— No fuel-producing spp. in fire sector.
— Fire-retardant vegetation in fire sector, e.g. annual garden.
Animals controlling vegetation in fire sector (chickens, ducks, geese).
— Stone walls and earth-banks in fire sector.
High-risk shelter belt (pampas) at least 100m from house.
Water masses (dam) in fire sector.
— Water supply (gravitating feed from tanks and house pond).
Roadway adjacent to house in fire sector.
Acacias, willows, coprosma and other fire-hardy trees to north.

Figure 6.7.1 Planning Against Fire — Dwelling Site With High Fire Risk from the North



SITES	PLANTS
N. facing upper slope; unirrigated, dry, rocky, warm	**Fig, carob, almond (mixed stand for pollination)**
N. facing spring; wet, warm	Jujube.
N. facing lower slope; good soil, irrigated, sheltered, accessable	Intensive orchard culture — peach, apricot, lemon, grapefruit
Hilltop; dry, rocky, exposed	Stone pine.
S. facing upper slope; dry, rocky, shady	Cork, holm and burr oak, honey locust, black locust, pampas.
S. facing lower slope; wet, shady	Butternut.
S. facing lower slope; shady, moist, cool	Hazel stand, *juglans* (mixed walnut, black walnut, Japanese walnut, butternut).
Lower shelf; very shady, moist, sheltered, cold, deep soil .	Beech stand (mixed European beech and American beech)

Figure 3.7.2 Tree Planting on a N.-S. Hill Profile — example of planning considering factor of soils and drainage, access, aspect and exposure.

hot northerlies). Local site characteristics may change this basic rule in some cases. The N.W.-N.E. sector of the system (see Figure 6.4.1) will carry the fire which will destroy the home and Zone I where maximum productivity is achieved and where losses due to fire would be greatest.

Therefore, the fire sector should be planned to include the elements which decrease fire risk. Elements which pose a high risk, such as pine trees, would be well away from the house site, in the outer zones and in the southern sector. Some of the elements which reduce risk represent intensive land use, such as comfrey pasture; stone walls are appropriate in the inner zones of the system. Other elements, such as belts of wattles, blackwood, willows and grazing for sheep, are suitable in the outer zones. Figure 6.7.1 shows a site plan using many of the factors listed in Table 6.7.1 to reduce fire danger to the house site from the north. Naturally, all fire-risk reducing elements should serve other functions in the system.

After many years, a developed permaculture should, like rain forest, be virtually fire-immune. This would apply to small fires within the system as well as uncontrolled forest fire.

If walls are of stone, they will serve well in the fire sector as additional safety factors, shielding the rest of the system from radiation damage. Such structures as walls and earth banks throw a "fire-shadow" over the system, as do plantations of wattles, willows and *Coprosma*. In the catastrophic '67 fires in Hobart, Tasmania, plants in the "fire shadow" of the houses survived. A prime aim in Australian bush settings should be to reduce fuel and provide fire-shadow systems in any developed permaculture. Fuels can be collected and pit-mulched or burnt for domestic use. "Monsoon" sprays and gravity-fed sprinklers, which need to operate for only a few hours, can effectively dampen mulch and create a fire-proof strip to the north. Fire screens over gutters, windows and vents are the ordinary precautions of householders in fire-prone areas.

For tree planting on a N-S hill profile see Figure 6.7.2.

7.0 System Establishment

(See Section 10.3 for sheet mulching techniques).

7.1 Species Selection

The number of species listed in the catalogue is considerable. Within the species, the number of varieties is often extensive. Many plants not listed would be worthy of investigation. How does one select plants from such a range

As many species as possible should be planted. Such an approach will provide more information on suitability than all the published information on the subject. From this experimentation, certain species and varieties will be found to be of great value, while some will fail completely. The planning of more extensive permaculture in later years will then involve closer selection, based on first-hand information.

Availability will be the main limit on the range of species (see Appendix A). However, many plants not immediately available should come to hand in time.

The nature of the family or community which is to be supported will greatly influence plant selection. Vegetarians would not be very interested in forage plants for animals but the nut trees would be most important. Those with adequate funds would develop a different system from that of a large community with plenty of labour but less capital.

The size of a site (or rather area intended for cultivation) is important in selecting species. For example, it is wasteful of space to plant ginkgo trees for nuts on a site of 2 hectares, since they grow into a large forest tree bearing small nuts. Being dioecious both male and female trees are required. For significant yields, a stand of about eight females and a couple of males would be required. In the assessment of species suited to sites of different sizes in Table 7.1.9, several factors are considered:—

a) The effect of the plant on variety and intensity of use possible, e.g. pines provide unfavourable conditions for almost all understorey plants.

b) The space occupied by the plant, e.g. Kudzu vine will fill whole gullies.

c) The yield per unit area gained, e.g. pistachio trees are irregular yielders giving a low average annual yield.

d) The uniqueness of the species for the use indicated, e.g. olives are unrivalled for oil production and have a place in the smallest of systems.

e) The zone placement of species.

It is interesting that most species (in Table 7.1.9) can be considered useful in areas of less than 0.5 hectares (1-2 acres). This is indicative of the intensive nature of mixed perennial culture.

The nature of the local climate, site and microclimate are critical in species selection. For example, with extensive acid marshy areas, the blueberries could be considered an important fruit. Tables 7.1.1 to 7.1.8 show species suited to particular environmental conditions. The variety of environments which can be used for permaculture is indicated by these tables. Although environmental conditions can be altered considerably (Sections 6.3 and 7.5), it is advisable to make initial selections of species to suit existing conditions if a high success rate is expected.

The number of plants of each species worth planting is extremely variable, depending on many factors including:—

- The yield/plant.
- Yielding habits as affected by deciduous characteristics, biennial yields and similar cycles.
- The quantity required, or capable of being used, of the products available from the species. For example, due to its value as animal and bee forage, fertilizer and fire retardant, comfrey is useable in unlimited quantities.
- The time required for full yielding age to be reached (some species can be overplanted and thinned later as individuals mature).
- The importance or "usefulness" of the species and its products in a subsistence system.
- The availability of information on "usefulness" and culture under local conditions.
- The cost of propagation in time, money and skills.
- The size of the community to be supported.

Table 7.1.1
Plant spp. Requiring Warm and Sunny Positions

Most are unsuited to cool climates but favourable microclimates allow their successful culture. Many of these spp. will grow quite well in less favourable positions but yielding is usually the problem.

Bamboo (some spp.)	Mesquites (?ripening requirements unknown)
Cape Gooseberry	Olive
*Carob	*Orange
Custard banana	Pecan (? ripening requirements not tested)
Fig	*Pistachio (? ripening requirements not tested)
Grapefruit	Prickly pear
*Jujube (? ripening requirements not tested)	Queensland arrowroot
Cumquat	Tree tomato
Macadamia (sunshine not so critical as shelter)	Water chestnut

* Needing high temperatures.

Table 7.1.2
Plant spp. Requiring Shelter From Wind

This usually means a need for relatively constant humidity and no extremes of temperatures, though some, indicated *, need high temperatures.

Banana passionfruit	Loquat
Bunya bunya pine	*Macadamia
Cape gooseberry	Monkey puzzle
Cornelian cherry	Nectarine
*Custard banana	*Orange
*Fig	Raspeberries
*Grapefruit	Red currant
Hops	Snowberry
*Jujube	Sweet cherry (mostly for pollination)
*Cumquat	*Tree tomato
Leatherwood	Ugni
Lemon	Vines in general

Table 7.1.3
Windfast Species

Will thrive in exposed positions; useful for sheltering other plants.

Bay Laurel	Laurel berry
Black locust	N.Z. mirror plant
False tree-lucerne	Pampas grass
Honey locust	Stone pine

Table 7.1.4
Trees With Thin Foliage (Summer)

To allow a range of understorey plants.

Black walnut	Walnut
Black locust	Some oak spp.
Honey locust	

Table 7.1.5
Plants for Moist, Waterlogged Sites

Bilberry	*Earth almond
Black currant	Jujube
Blueberries	Leatherwood
*Blackwood	Mulberry
*Buckbean	*Osier Willow
Butternut	Pampas
Checkerberry	*Snowberry
Cloudberry	*Tupelo — especially *N. aquatica*
Cranberry	*Swamp oaks

* Very wet spots — semi aquatic.

Table 7.1.6
Aquatic Plants

Suitable for pond or stream culture (see also Ref. 68).

Arrowhead	Reedmace
Acorus	Trapa nut
Buckbean	Water chestnut
Common reed	Wild rice

Table 7.1.7
Species for Very Dry Sites

Capable of surviving prolonged drought.

Almond	Mesquites
Black locust	Mulberry
Burr oak	Olive
Carob	N.Z. spinach
Cork oak	Pampas grass
False tree lucerne	Prickly pear
Fig	Pistachio
Holm oak	Rosemary
Honey locust	Stone pine
Lavender	Sweet quandong
Mirror plant	Most aromatic herbs

Table 7.1.8
Shade Tolerant Plants

Suitable as understorey plants for a permaculture in cool climates.

Alpine strawberry	Hazel
Bamboos (*Arundinaria* and *A. graminea*)	Hops
Barberry	Huckleberry
Bilberry	Loganberry
Blackcurrant	Leatherwood
Blueberries	Mirror plant
Bergamot	Mints
Cloudberry	Mulberry
Checkerberry	Oak (dwarf chestnut)
Cornelian cherry	Quince
Elderberry	Snowberry
Gooseberry	Ugni

The assessment of numbers in Table 7.1.9 is arbitrary and should not be considered a definitive guide. Its value is in comparison between species. From the numbers indicated, some species such as lemons or apricots could be brought from nurserymen, but black locusts and oaks would be largely propagated on the site. The space required for the supply of particular products can be gauged; space need for grapefruit production is insignificant when compared with that for beech oil.

Table 7.1.10 can help in assessing the number of plants of different sizes required to fully plant an area. In a multistorey system, it seems that a fully planted hectare could contain from 5-10 thousand plants. Only very small areas (Zones I and II) would ever be "fully planted".

7.2 Plant Propagation

Extensive permaculture requires great numbers of plants. To give some idea, planting trees out at 18ft. spacings, required 134 trees/acres. Smaller shrubs at 9ft. spacings, requires 537 plants/acre and herb layers involve many thousands of individual plant/acre. Of course, many herb layer plants are

Table 7.1.9
Information on Plant Species Relevant to the Establishment of Permacultures

Zone Placement (site unlimited).
1. Near house site.
2. Within 50m of house.
3.)
)
4.) Increasing distance — see Text and Figure, Section 6.4.
)
5.)

Propagation Method.
1. Seed.
2. Root or clump division, runners, suckers.
3. Cuttings and layers.
4. Grafts and buds.

Propagation Difficulty.
V.E. Very easy — tending towards self-propagation.
E. Easy.
D. Moderately difficult.
V.D. Very difficult.

Maintenance Requirement.
L. Low.
M. Medium.
H. High.

Species/Site Size Suitability.
a. All sites.
b. Sites >0.5 hectares.
c. Sites >2 hectares.
d. Sites >8 hectares.

Number Worth Planting.
Categories:—
1.
2-5.
6-20. — Sufficient for a small community.
21-50.
>50.

	Zone Placement	Propagation Method	Propagation Difficulty	Maintenance Requirement	Species/Site Suitability	Number Worth Planting	**Comments**
Acorus	II-IV	2	E	L	a	2-5	
Almond	III	4	D	M	a	6-20	Considered as an important food rather than a delicacy.
Alpine Strawberry	III-IV	2	E	M	a	6-20	Dessert berry.
American beech	IV-V	1/4	E/D	L	d	21-50	To supply oil and/or stock feed.
Apple	II	4	D	H	a	6-10	Allow large quantities to be dried or otherwise preserved.
Apricot	II	1	D	H	a	2-5	Some for drying.
Arrowhead	III-V	2	E	L	a	1	Large clump (or several small clumps).
Asparagus	II	2	E	M	a	6-20	Delicacy vegetable.
Bamboo	II-V	2/3	VE/VE	L	a	2-5	One clump of each spp. selected.
Banana passionfruit	II	1	E	L	a	1	Large vigorous vines yielding almost all year round.
Bay laurel	II	1	E	L	b	1	Ample for culinary needs.
Bergamot	I-III	2	V.E.	L	a	>50	Excellent bee forage.
Bilberry	II	1	E	L	a	2-5	
Black currant	II	3	E	M	a	6-20	Very useful berry
Black locust	III-V	1/2	E/E	L	a	21-50	
Black walnut	II-V	1/4	E/V.D.	L	c	2-5	One grafted variety — rest as seedlings for stock forage.
Blackwood	III-V	1	E	L	c	21-50	

(Swamp) Blueberry	II	3	E	M	b	2-5	
(Sweet) Blueberry	II	3	E	M	a	6-20	Excellent berry.
Borage	I-II	1	V.E.	L	a	>50	Excellent bee forage.
Broccoli (perennial)	I	1	E	H	a	2-5	
Bunya bunya pine	IV-V	1	D	L	d	21-50	Dioecious, and irregular yield.
Butternut	III-V	1/4	E/V.D.	L	c	2-5	
Cape gooseberry	II	1	E	M	a	6-20	
Capuchin	II	2	E	L	a	2-5	Occasional vegetable.
Cardoon	II	1/2	?/E	M	a	2-5	
Carob	III-V	1/2	E/E	L	a	21-50	Only if definitely well-yielding under local conditions.
Castor oil plant	III	1	E	L	a	2-5	Dangerous in large numbers. (Poisonous seeds).
Chequers	II-IV	1/3	D/E	L	b	2-5	
Cherry plum	II-V	1/4	E/D	L	a	2-5	Prolific yield.
Chicory	II-V	1	E	M	a	21-50	Kitchen use and occasional forage.
Chinese artichoke	II	2	V.E.	L	a	2-5	Occasional vegetable.
Chinese gooseberry	I-III	4	D	M	a	2-5	Dioecious.
Cloudberry	II	2	E	L	a	2-5	Occasional delicacy.
Comfrey	I-V	2	V.E.	L	a	>50	
Common reed	III-V	2	V.E.	L	a	2-5	A few clumps.
Cornelian cherry	II-V	3	E	L	b	1	Large numbers if used for hedge-rows.
Coulters pine	IV-V	1	E	L	d	6-20	
Cranberry	II-III	3	E	L	a	2-5	
Custard banana	III	1/3	D/E	L	b	1	Delicacy fruit.
Damson plum	III-V	1/2	E/E	M	a	21-50	Hedgerows.
Dandelion	II-V	1	V.E.	L	a	>50	Excellent bee forage.
Earth almond	II	2	E	L	a	2-5	
Elderberry	II-V	3	E	L	a	21-50	Hedgerows.
European beech	III-V	1/4	D/VD	L	a	21-50	Oil and animal forage.
False tree lucerne	II-IV	1	V.E.	L	a	21-50	Bee forage and hedgerows.
Fat hen	II	1	V.E.	L	a	>50	Generalised seed forage.
Feijoa	II	3	E	M	a	2-5	
Fig	II	3	E	M	a	6-20	Valuable dried fruit.
Ginkgo	IV-V	1	?	L	d	6-20	Dioecious, delicacy nut.
Globe artichoke	II-III	2	E	M	a	2-5	Occasional vegetable.
Good King Henry	II	1/2	E/E	L	a	2-5	
Gooseberry	II-V	3	E	M	a	6-20	
Grape	I-V	3	E	H	a	2-5	Each vine has considerable yield.
Grapefruit	II	4	D	H	a	1	Ample if good tree.
Hawthorns	III-V	1	E	L	b	>50	Hedgerows and bee forage.
Hazel	II-V	2	E	M	a	21-50	As important food.

Herbs

Yarrow	II			L	a	2-5	
Marsh mallow	II			L	a	2-5	
Chamomile	I-III	1		L	a	6-20	Many uses.
Horseradish							
Angelica	II			L	a	2-5	
Fennel	I	1		L	a	2-5	
St. John's Wort	II	1		L	a	2-5	
Hyssop	II	1	E	L	a	2-5	
Juniper	II-IV			L	a	1	Dioecious. Female plant.
Marjoram	I	1		L	a	1	
Mallow	II			L	a	1	
Parsley	I	1	V.E.	M	a	6-20	
Plantain	II-V			L	a	2-5	
Cowslip	II			L	a	2-5	
Rhubarb	II	2	E	M	a	2-5	
Rue	II			L	a	2-5	
Sage	I	1/3		L	a	>50	Bee forage.
Thymes	I	1/3		L	a	2-5	
Nasturtium	I-II	1	V.E.	L	a	2-5	
Coltsfoot	II			L	a	2-5	
Valerian	II			L	a	2-5	
Mullein	II	1	V.E.	L	a	2-5	
Violet	II	2		M	a	2-5	

Squill	I	2	V.E.	L	a	1	
Lemon balm	I	2	E	L	a	1	
Hickories	III-V	1/4	E/VD	L	c	6-20	Some grafted.
Honey locust	III-V	2	E	L	a	21-50	
Hops	II	2/3	E/E	H	a	1	
Horse chestnut	III-V	1	E	L	c	2-5	
Japanese quince	II-IV	1/3	?	L	a	2-5	
Japanese walnut	III-V	1/4	E/VD	L	c	2-5	
Jerusalem artichoke	II-IV	2	V.E.	L	a	>50	Forage crop.
Kudzu vine	III-V	1/2	?/E	L	c	6-20	
Kumquat	II	1/4	D/D	M	a	1	
Laurelberry	III-IV	1/3	E/E	L	b	6-20	Hedgerows.
Lavender	II	3	E	L	a	2-5	
Lemon	I-II	1/4	E/D	M	a	1	Ample for culinary needs.
Lespedeza	II-IV	2	E	L	b	21-50	
Loganberry	II	3	E	H	a	2-5	
Loquat	II	1/4	E/D	M	a	1	
Lucerne	II-IV	1	E	L	a	>50	Bee and animal forage.
Lupins (perennial)	II-III	1	E	L	a	21-50	New edible varieties.
Macadamia	III-V	1/4	E/D	M	b	2-5	Delicacy nut.
Mediterranean medlar	III	1	D	L	a	2-5	
Medlar	III	1/4	?/D	L	a	2-5	
Mesquites	III-V	1	E	L	b	21-50	If climatically suitable.
Mints	I	2	V.E.	L	a	21-50	
Mirror plant	I-III	1/3	E/E	L	a	21-50	
Monkey puzzle	IV-V	1/3	D/D	L	d	6-20	Delicacy nut.
Mulberry (black)	I-V	3	E	L	a	21-50	Valuable forage.
Mulberries (red and white)	II-V	3	E	L	A	6-20	
Natal plum	III	1/3	E/?	L	b	21-50	Hedgerows.
Nectarine	II	1/4	E/E	H	a	2-5	Some dried fruit.
New Zealand flax	II-III	2	E	L	a	2-5	
New Zealand spinach	I	1	E	L	a	2-5	
Oaks	III-V	1	E	L	b	21-50	
Oca	II	2	E	M	a	6-20	
Olive	II-V	3	E	L	a	21-50	For oil: numbers depend on degree of climate suitability.
Osier willow	III-V	3	V.E.	L	c	21-50	Only if creeks are present.
Pampas grass	III-V	2	E	L	a	> 50	Forage crop.
Peach	II	4	E	H	a	2-5	Some dried fruit.
Pear	II-V	4	D	M	a	2-5	High yield/tree. Some dried fruit.
Pecan	III-V	1/4	E/D	M	c	2-5	
Persimmons	II-IV	1/4	E/D	M	a	2-5	Human food — more if used for pig food.
Pistachio	II-V	1/4	E/D	L	b	2-5	Experimental — more if yields.
Pokeweed	I	1/2	E/E	L	a	2-5	
Prickly pear	I-II	3	E	L	b	6-20	Hedgerows.
Queensland arrowroot	II	2	E	M	a	21-50	Animal forage.
Quince	II-III	3	?	L	a	2-5	
Raspberry	II	2	E	H	a	21-50	
Red currant	II	3	E	M	a	6-20	
Rosemary	I	3	E	L	a	2-5	
Siberian pea tree	II-IV	1	E	L	a	6-20	Seed forage.
Sloe	III	1/4	E/D	L	b	21-50	Hedgerows.
Snowberry	II-III	1/3	E/E	L	a	2-5	Delicacy berry.
Sorrel (garden)	I	2	E	L	a	2-5	
Sour cherry	II-IV	1/4	D/D	L	a	2-5	
Stone pine	III-V	1	E	L	d	6-20	
Strawberry	I-II	2	E	H	a	21-50	Excellent berry.
Strawberry guava	II	1/3	E/E	M	a	1	Marginal climatically.
Sweet cherry	II-III	1/4	E/D	H	a	6-20	Some grafted — some seed.
Sweet chestnut	II-V	1/4	D/VE	L	a	2-5	
Trapa nut	I-III	1	D	M	a	6-20	Unlimited in ponds.
Tree tomato	II	1/3	E/E	M	a	2-5	
Ugni	II	3	E	L	a	2-5	
Walnut	II-V	1/4	E/VD	L	a	6-20	Most useful.
Waxberry	II	1/2	E/E	L	a	2-5	Representative.
Wild rice	II-V	1	V.E.	L	a	>50	Unlimited value as duck feed.
Wood millet	III-V	1	E	L	a	>50	Generalised seed forage.

Table 7.1.10
Number of Plants Required to Plant 1 Hectare of Land at Given Distances

Spacings in Metres	Plants per Hectare
1 x1	10,000
2 x 2	2,500
3 x 3	1,111
5 x 5	400
7 x 7	205
10 x 10	100
15 x 15	44
20 x 20	25
30 x 30	11

1 hectare (ha) = 10,000 square metre (m^2) = 10,720 square yards (yds^2) = 2.47 acres.

self generating (such as borage), or are very easily propagated (such as comfrey). On the other hand, most of the nut trees require grafting for good, early and reliable bearing.

Buying all plants, for even a relatively small area, would require a large financial outlay. However, 3-year-old grafted fruit and nut trees for two to six dollars cannot be considered expensive. Unless plant propagation equipment such as greenhouses and related skills are available, it is advisable to buy many of the plants for a small area. Propagation work can be limited to those species easily reproduced by seed, clump division, etc. Bought plants can give a head start of 3 years, or more. At the same time, a propagation set-up can be established to allow expansion and infilling of the system. Even extensive seedling-raising requires reasonable care. As experience increases, grafting can be attempted.

Elements of a good propagation set-up are:—

Site — warm, sunny, sheltered position close to house, fully protected from animals (adequate fencing).
Water — ample supply all year round.
Shed — storage of tools, etc.
Tools — including pots, trays, bottomless flagons, secateurs, mist sprayer, thermostat.
Materials — potting loam, sawdust, river sand, peat-moss.
Greenhouse — lean-to on shed wall or pit greenhouse (see Kern[39]) with heated propagation bed.
Hardening-off shelter — mesh or open slat walls and roof.

Obviously, a greenhouse with heated bed is a considerable expense. Kern's[39] solar frame could be a cheap compromise. Flagons with the bottoms cut out should not be underestimated as a propagation tool. They protect seedling and cuttings *in situ,* keep humidity high and increase internal temperatures. Plants so protected are also free of pests and we use flagons over small seed-beds in late winter.

Although some of the most useful trees require grafting, Table 7.1.9 shows that most of the species can be propagated by seed or division. On a large scale, these simple forms of propagation require a good nursery situation but not the degree of skill and effort involved in grafting. The ease or otherwise of propagation is one of the factors which determines the number of each species worth planting.

Nut and fruit trees which are normally grafted are often useful as seedlings in large numbers for animal forage, so it is very worthwhile to grow seedling walnuts, pecans, etc. If scions for grafting become available at a later date, some young trees can be top-worked, while the rest can be grown in extant stands for the provision of nuts for animals feed. The collection of seed or cuttings to be propagated by commercial nurserymen at low cost should not be overlooked.

Information on propagation:

Jaynes Handbook of N. American Nut Trees (Ref. 12). The best book on propagation of nut trees, including information on selection and named varieties.
Bailey. *The Nursery Manual* (Ref. 38). A classic American text on propagation — excellent, includes detailed information, propagation of species *Abetia* thru *Laurus* to *Zygopetalum* — very comprehensive. Information on seed viability and treatment very good.
Kern, K. *The Owner Built Homestead* (Ref. 39). Information on greenhouse materials; not widely known.
de Vause, N. *Better Vegetable Gardening for Australian Gardeners.* See also Refs. 28 and 58 for special groups of plants.

7.3 Planting and Maintenance

The size or age at which plants are set out in a system is critical in considerations of maintenance. The setback in planting larger plants is greater than for small ones and annual growth in the nursery situation is slight. However, protection and care available to the plant is most important — young plants need careful attention.

All browsing animals such as cattle, horses, donkeys, goats and the destructive possum, should be kept out of areas where plants are being established. Staking of all plants is worthwhile, more for the sake of location than assistance to the plant. Cages made from stakes and wire mesh will keep out most animals. Mesh cages, especially fine mesh, also significantly reduce wind.

Mulching is essential. It retains moisture for long periods, reducing the need for watering, moderates soil temperature, eliminates frosting of the soil, slowly adds nutrients, provides ideal conditions for soil-improving earth worms, stops erosion on steep slopes and reduces weed growth. Stone-mulching over mulch prevents poultry and bandicoots from scratching at the roots. Incidentally, poultry keeps the rocks free of weeds and adds manure. If plants become overcrowded by weeds, it is better to renew mulches (cardboard with a few stones) than to cultivate, which only damages surface roots and encourages more weeds.

Newly planted specimens become the centre of attention for animals and pests, so the first few days are often the most critical. During this period, plants should also be watched carefully to check on water requirements.

The costs of propagation and maintenance of plants during the first few years are the greatest incurred in establishing a permaculture. Maintenance costs include water and nutrient supply, pest and competitor control, protection from animals, pruning and trellising. These costs will vary greatly for any particular species depending on three factors:—

— The suitability of the species for the ecological niche or position.
— The dependence of the variety, on man, for healthy growth.
— The yield which the plant is expected to provide.

Plants in their natural ecological niche grow and reproduce maintenance-free. Such plants are often not of great use and although we should attempt to fit species into appropriate niches in our cultivated system, cultivated plants are in a "deflection state" which is more useful to mankind. This state requires the attention of man if it is to be maintained. Cultivation over long periods has resulted in genetic changes which make plants more adapted to the cultivated rather than the wild state; the need for maintenance becomes critical. The third factor is the most variable. Intensive cultivation, involving high maintenance, can produce high yields. Maximum yield is a basic aim of commercial agriculture but in a subsistence permaculture where total yield is more important than specific yield, little-maintained plants, giving some yields, are important elements of the system. Most species can be considered in both high maintenance/high yield and low maintenance/low yield situations. For example, black currant bushes can be well mulched and fertilized, watered if necessary and pruned annually, for high yield, or set out as an understorey along a creek, in large numbers, as low-yield bushes.

An assessment of the relative costs of maintenance can be made. The assessment of species in the catalogue in Table 7.1.9 shows that most are considered to require only low levels of maintenance. Thus, the species catalogue reflects the concept of a low maintenance agriculture, developed in Section 2. One of the reasons for this is the inclusion of little-selected and wild species which are not as dependent on man as highly cultivated species. Bamboos, black locust, common reed, mirror plant, the oaks and stone pines, are all good examples.

7.4 Structures and Enclosures

Structures such as walls, trellises and fences and plant structures such as hedgerows and windbreaks are important elements of permaculture, being key factors in system diversity. Structures can alter microclimate in a variety of ways (Section 6.3), be of importance in fire control (Section 6.7) as well as in the containment of animals. All constructions should be considered multi-functional. For example, cleared stone can be used for a wall which can reduce fire danger, harbour lizards, contain domestic animals and alter microclimate favourably. Dams, as considered in Section 6.6, are good examples of multi-use structures.

The more intensive the system, the greater will be the number of structures. Zone I is largely a built environment — dwelling, greenhouse, wall trellises, driveway, ponds, sheds, etc. Moving outwards, the amount of construction reduces, the length of fencing and paths per unit area decreases, and stone walls, trellises, and buildings, are less in number.

Many important structures such as dams, buildings and paths are not considered in detail here. Enclosure of animals is a key element in determining the form and function of a permaculture and is considered in some detail.

Good-quality fencing is essential to the establishment of the system. Fencing priorities should be decided early in the planning of a system.

A system boundary should be established first. Although later extensions could be made on unimproved land worked by a single family, not more than 15 hectares need be enclosed. Control of wild-life and exclusion of domestic stock can then be assured. Enclosure of the dwelling site and primary access (Zone I) should occur concurrently. If the system is to develop unimpeded, total control of pest animals — such as possums, rabbit, rat, cat and sparrow, should be exercised within Zone I which can be quite small (0.1-0.3 ha.).

From this inner fence, subdivisional fences and small enclosures can be built. A chicken run and area for the first tree plantings would be priorities. Gradually the subdivisional fences would establish the other zones of the system. Such an approach allows the ranging of animals on the undeveloped remainder of the system, so improving it by clearing undergrowth and manuring. Goats are excellent for this purpose.

Fence lines are important sites which can be used to advantage. In the open country (in the outer zones), they are obvious sites for windbreak trees and in the more intensive zones, collection of stone along fences and the planting of hedgerows is useful. Stone walls and hedgerows can eventually replace some fences in the inner zones. A dense, mixed hedgerow of spiny shrubs with a low freestone wall is virtually impenetrable to most animals. Hedgerows of the species in Table 7.4.1 eventually add greatly to the productivity of the system, either directly or indirectly. Hedgerows have been integral parts of many traditional farming systems, being considered as a productive resource (e.g. prickly pear in Sicily; hawthorn, hazel, sloe and elderberry in N. Europe). They can provide fruit, nuts, wood products (e.g. bamboos), animal forage, bee forage, bird habitat and food. They act as windbreaks and suntraps (Section 6.3). A mixed hedgerow of fast-growing, soft shrubs, such as false tree lucerne; a tough, slow grower, such as hawthorn, and a thicket-forming species such as hazel, is much more useful than a single-species hedge. The false tree lucerne will quickly provide shelter and animal and bee forage. The hazel will provide nuts, increase butterfat in milk and sucker profusely, which will prevent animals from crawling through the hedgerow once the fence has decayed. The hawthorn will eventually make up the tough spiny bulk of the row, provide berries, forage for bees and excellent nesting sites for small birds.

The double fence system is of use in establishing a permaculture on an existing pastoral property with cattle or other large animals on range on open country.

See Section 8 for containment requirements of particular animal species.

For plant species requiring support for proper culture see Figure 7.4.2; for plant systems for double-fenced strips see Figure 7.4.3.

Table 7.4.1
Barrier Plants (Useful in other ways)

A. Tough and resistant to penetration or serious damage by large animals.

- Damson plum
- Honey locust
- Natal plum
- Jujube
- Sloe
- Hawthorns
- Prickly pear

B. Dense shelter plants less resistant to damage.

- Bamboo (*Arundinaria japonica*)
- Elderberry
- False tree lucerne
- Hazel
- Laurelberry
- Lavender
- Mediterranean medlar
- Medlar
- Mirror plant
- Pampas grass

Table 7.4.2
Plant Species Requiring Support for Proper Culture

- Banana passionfruit
- Chinese gooseberry
- Grape
- Hops
- Loganberry

7.5 Soils: Management and Improvement

Refs. 2, 39

Soils are the subject of much discussion, research and dogma. Their improvement, creation and destruction has been instrumental in the rise and fall of cultures throughout the world.

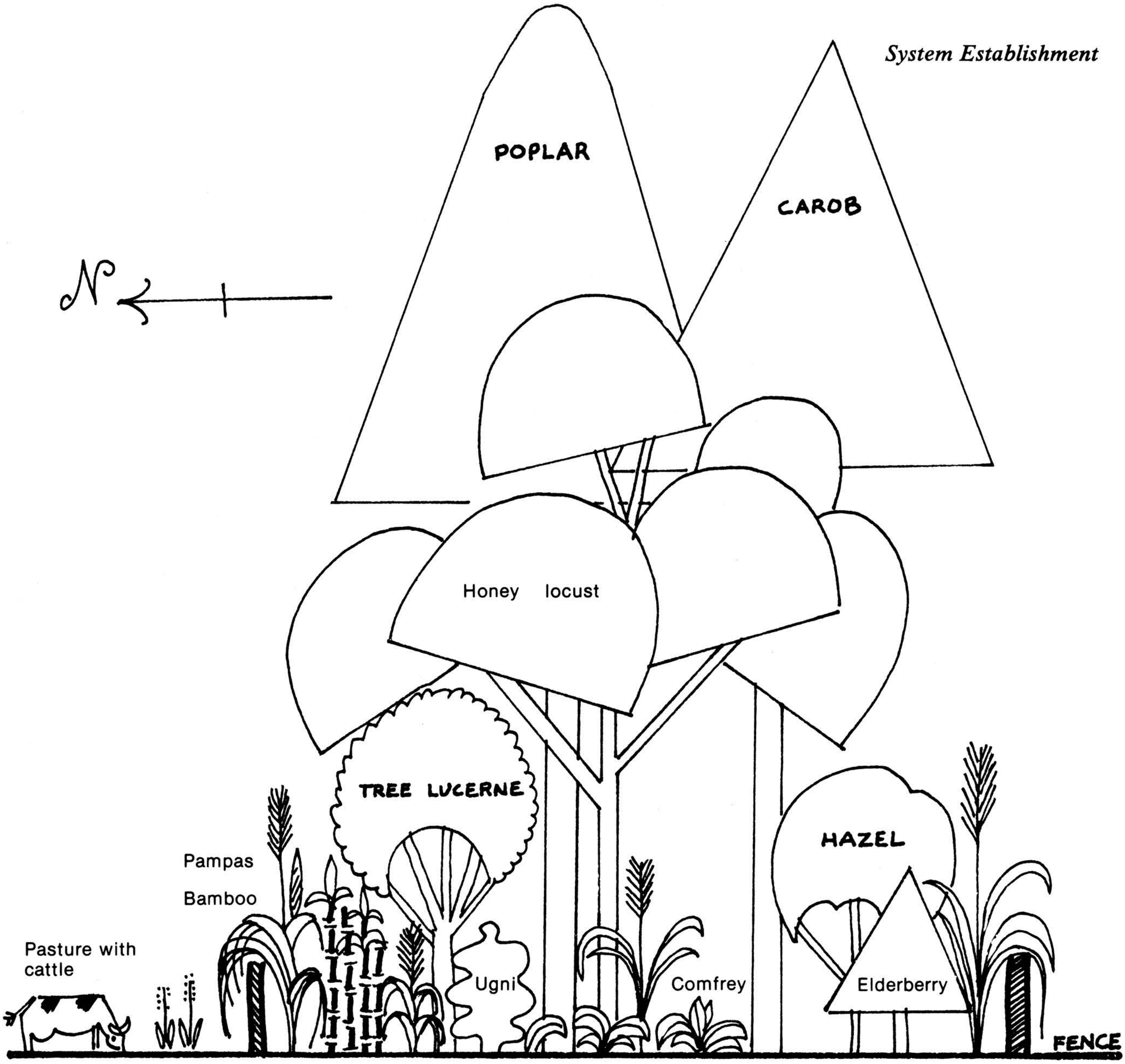
Being a part of the biosphere, soils are complex ecologies, rather than non-living systems. Knowledge of the flora and fauna, their interactions, relationships and microclimatic conditions of soils, is very limited. The soil science of modern agriculture deals mostly with physio-chemical interactions of soils, rather than total ecosystems. However, the fundamentals of soil management, improvement and creation have been known to agricultural man for many centuries.

Permaculture, in developing a mixed flora from trees to herbs and avoiding cultivation, is incapable of destroying soil resources in the ways that crop agriculture has done where not carefully managed. The case against cultivation of the soil in any form is summarized by Kern.[39] For a perennial system cultivation it is even more pointless than for annual crop.

In simple outline, the soil ecosystem is a stratified system of three basic layers:—

a) The mulch/litter layer, 0.5cm-10cm. This is the most complex layer of the system, biologically speaking, and is based on the decomposition of organic matter including foliage, fruit, nuts, seeds, animal wastes and animal remains. The range of bacterial flora and fauna is large, and many species are instrumental in decomposition. Fungi and moulds are the most important plant forms, often being the primary agents of decay. Many lower animal forms live in the litter layer including worms, insect larvae, dung beetles and millipedes. A few higher animals — such as frogs and lizards — also reside there. There is little mineral matter and the whole system is usually acidic, due to organic acids. Some plant roots feed from the litter layer.

b) The topsoil (2cm-100cm) is the next layer. It is part mineral and part organic. The organic material (humus) is highly decomposed and available to the feeding roots of plants which are mostly



NOTES
- Double fencing allows a specialized strip in an extensive grazing area.
- The enclosed space can become a sheltered habitat for birds and animals.
- The mixed strip acts as a windbreak.
- The internal environment of the strip becomes sheltered, moist and shady; suitable for berry fruits and other useful plants thriving in such an environment.
- The strip can provide harvested and foraged yields to large animals in adjacent areas.
- The strip can be the beginning of a long-term plan to establish an extensive permaculture.
- Fences can allow passage of smaller domestic species on range.

EXAMPLE
Plant Species:

Honey Locust:	Large thorny self-maintaining tree with thin foliage — moderate reduction of wind speeds over a wide area. Yield: sugar pods harvested and self-harvested by cattle in paddocks.
Pampas:	Tough self-maintaining hedges — dense low level windbreaks. Forage for cattle through fences.
Bamboo:	Hardy medium height windbreak. Very useful straight canes.
Elderberry:	Tough hardy shade-loving hedge. Berries and flowers.
Ugni:	Compact shade and shelter-loving shrubs. Berries.
Comfrey:	Tough shade tolerant herb — hand fed to cattle.
Structure:	Double fence with 5-15m space. Central row of large trees. Tough plants as hedges against fences. Delicate plants in central sheltered space.

Figure 7.4.1 · Plant Systems for Double-fenced Strips

in the topsoil. Bacteria/plant-root symbiotic associations are common. Moulds and fungi occur and animal populations are considerable — earthworms being common. The mineral matter is chemically very different from the parent material, being changed by complex biochemical interactions.

c) The subsoil (50cm-1,000cm) is mainly mineral matter, physically and chemically broken down from the parent rock. Organic content is low. Deep roots, some bacteria and moulds and deep-burrowing animals are the main life forms.

Plants with deep roots draw water and mineral nutrients from the subsoil, which tends to be a stable source of these elements. The fall of leaves (especially from deciduous species), fruit, bark and other plant matter builds up the litter layer, providing organic materials, mostly carbon, but with some nitrogenous and mineral-rich compounds. Combined with animal wastes and remains, high nitrogen and mineral content, these materials provide the nutrients for plant growth *via* a complex series of decomposers. The litter bed acts as a reservoir of plant nutrients, holds water and protects the topsoil and roots from rapid microclimatic change. The whole ecosystem can take a long period to develop, but once established it is self-maintaining.

Permaculture changes the basic processes of the soil ecology very little. There is a full range of root systems tapping all available nutrient sources. Plants are not removed or cut down in large numbers as in annual crop culture and a deep litter of plant and animal wastes and materials is allowed to develop without disturbance. Planting of large numbers of perennials, watering and mulching, speeds up the processes of soil development. Mulching means that in a surprisingly short time, plants are growing in conditions similar to those in a naturally-evolved soil of considerable age (50 years or more). This is especially so if the mulch is of mixed animal wastes and diverse plant material. With the introduction of animals and the increasing leaf fall from canopy trees, a deep, highly-evolved soil ecology can be created in 5-10 years, on very poor base materials (e.g. heavy clay free of organic matter).

Mulching should be recognised as one of the larger initial costs in developing a permaculture. Although materials such as seaweed, sewage sludge, bean and grain husks, spoiled hay and animal manures are very cheap (or free) transportation and application can be costly, usually as labour. This is because of the great bulk of such materials. For example, 20 cubic metre loads of sawdust do not go far when sheet mulching. Chipping machines — as used by councils to dispose of tree prunings — would be useful for direct mulching, using the scrub vegetation, tree tops and bark from land clearing and timber felling. All vegetation should be considered as resource. In Zones I and II, cardboard, carpets and old clothes can be used as the first layer in a mixed sheet mulch. Such materials suppress weed growth and encourage worm populations, while breaking down quite quickly. A sheet-mulched system can support a dense array of plants, from trees to herbs, which could otherwise compete for a limited nutrient supply. Obviously, such mulching should supply all nutrients and include high N.P.K. substances (animal wastes) and lime or dolomite, to balance the high carbon content and acidity of most plant-waste mulches and provide a full range of trace elements. In the outer zones, individual plants can be mulched to the drip-line, using similar materials.

Established beech forests in Europe and elsewhere actually become mulch-producing systems and their litter provides mulches for poorer soils; similarly, many of the plants grown in permaculture (comfrey, for example) provide nutrients, when wilted, for root crops. See, for details on comfrey as a source of nutrients, Ref. 69.

8.0 PERMACULTURE AND ANIMALS

In considering a permaculture as a complete ecosystem, animals are essential. Their role in vegetation and pest control, as well as the nutrient cycle, is basic. The diverse products which they provide makes them invaluable, despite inefficiencies in protein conversion. Figure 8.0.1 indicates needs, products and functions of animals in the system.

The following section does not attempt to give detailed information on animal husbandry — a vast field. Texts covering most domestic animals are readily available but it should be remembered that such texts are geared to the methods of traditional husbandry — practices which may, or may not, be relevant in permaculture. Animals should not be introduced into a permaculture during the early establishment period and only general understanding of the needs, uses and functions of animal species is necessary during the early design and establishment phase. Kern[39] and Belanger[47] are two excellent references to start with on animals in self-sufficient systems.

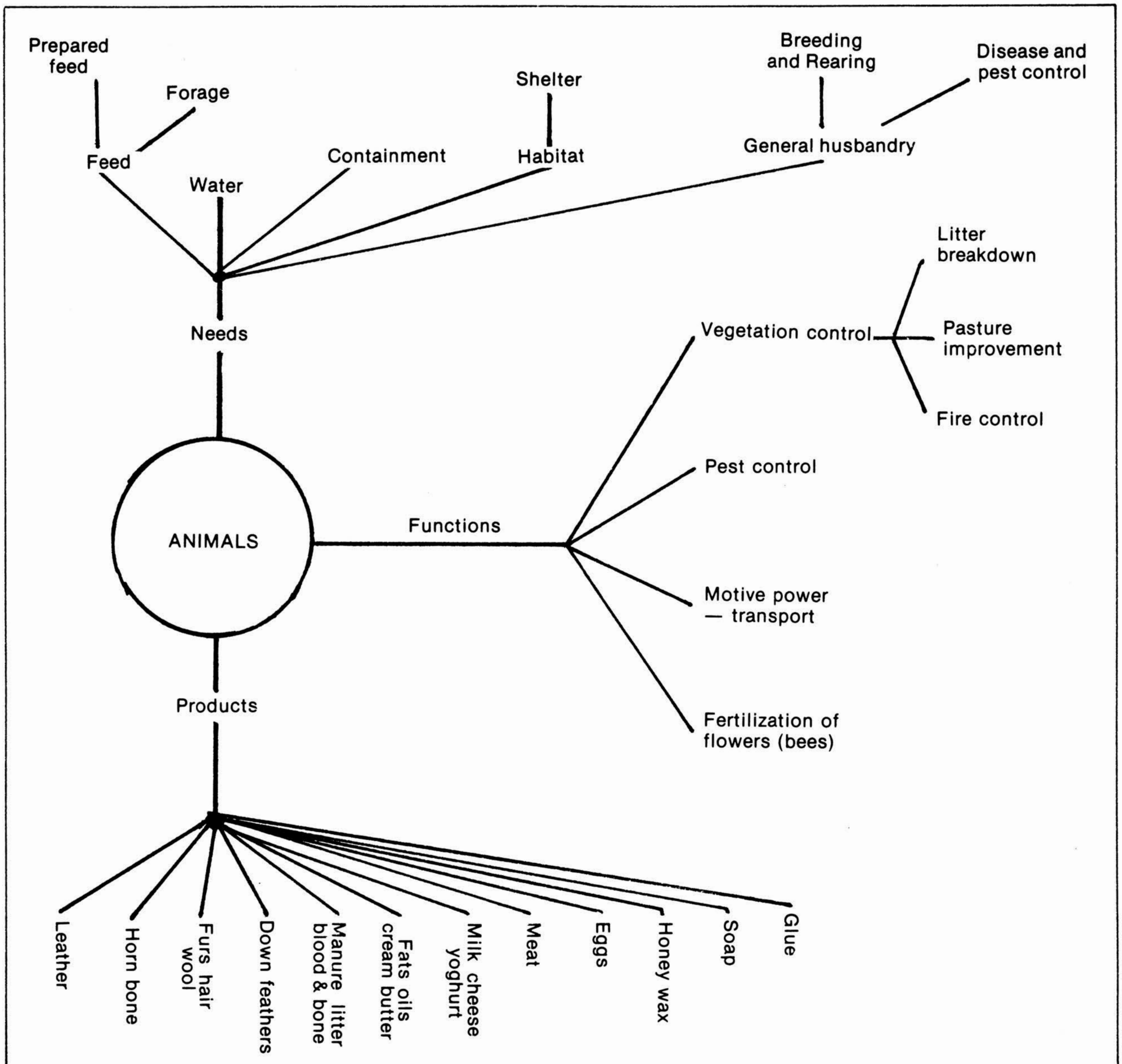


Figure 8.0.1 Animals in Permaculture. Needs, Functions and Products.

8.1 Feeding Refs. 2, 39, 47, 18

For feeding habits and shelter and habitat requirements see Table 8.1.1.

Different animals have different food and feeding requirements and like humans, it is difficult to assess accurately the food needs of a particular animal of a certain age, sex and breed. It is even more difficult to regulate that food supply.

However, feeding of animals can be considered in another way. The free range situation allows the animal to select food. In a complex and diverse system the range of feed (plant and animal) is great. This situation allows for full nutrition. Animals on free range foraging for themselves is the basic feeding mode for all animals species in permaculture. It is by this process that animals perform their other useful functions — manuring, pest control and vegetation control, and how many plant species, which cannot be harvested, become useful (e.g. N.Z. mirror plant). Labour by humans is minimal, mainly control, by moving animals to different parts of the system. The animals put on weight slowly but fat accumulation is less and fats are soft, unsaturated, when compared to concentrate-fed animals in pens. Mineral deficiencies are less apt to occur on a free-range diet than on a saturated, high-energy diet. The diversity and regularity of free range diet is basic to animal health.

In a permaculture the free-range foods include pasture and pond plants and weeds; mulch flora (fungi) and fauna; shrub and tree foliage; roots, tubers and rhizomes; nuts, seeds and pods; fruit and a variety of above-ground fauna, insects, lizards, frogs, etc.

The layout of important forages requires considerable thought if the feeding of animals is to be efficient. The nature of the forage as well as the requirements of the animal must be considered. A mulberry crop for pig forage, for example, needs to be consumed immediately — whereas an acorn crop can lay on the ground for some months. Bamboos (young shoots) and Jerusalem artichokes (roots and tops),

Table 8.1.1
Feeding Habits and Shelter and Habitat Requirements Ref. 2

W = Some drinking
WW = Drinking and dabbling

	Feeding Habits: Graze	Browse	Seed, Nut, Pod Foraging	Root, Scratch, Dabble	Recommended Zone	Shelter and Habitat Requirements	
Birds:							
Ducks	x	—	xx	xxx	II-V	Open housing	Pond
Geese	xxx	x	xx	—	III-IV	Nil shelter	Pond
Hens	xx	—	xx	xx	II-IV	Closed or open housing	W
Guinea fowl	xxx	—	x	—	II-V	Nil shelter — perch in trees	W
Peacock	xx	xx	xx	—	IV-V	Nil shelter — perch in trees	W
Pigeon	—	—	xxx	—	?II-IV	Housing	W
Quail	—	—	xxx	—	?I-IV	Self-serving	WW
Pheasant	x	x	xxx	—	?II-IV	Thicket, trees	W
Turkey	xx	xx	xxx	x	III-IV	Thicket trees	W
Mammals:							
Rabbits	xxx	x	x	x	III-IV	Self-served	—
Pigs	xx	—	xx	xxx	III-IV	Thicket, marsh	W
Cows	xxx	xx	xx	—	IV-V	Thicket and copse	W
Wallaby	xx	xxx	xx	—	III-IV	Thicket — (e.g. pampas clumps)	—
Horses	xx	xx	xx	—	IV-V	Hedge, stony rises for hooves	W
Donkeys	xx	xxx	xx	—	IV-V	Hedge, stony rises for hooves	W
Sheep	xxx	xx	xx	—	III-IV	Hedge, stony rises for hooves	W
Deer	xx	xxx	x	—	IV-V	Copse	W
Goats	xx	xxx	xx	—	* —	Thicket, stony rises	W
Possum	xx	xxx	xxx	—	* —	Self-served	—

* Difficulty in any cultivated system — external (Zone V) or enclosed in pens.

Notes: A well developed permaculture with forest, woodland, marsh, thicket and hedgerow, can provide the shelter needs of most species, without structures.
The milk cow or goat represent a dilemma in location. They are of high productivity and in frequent use, but are destructive in the inner zones. In this case, the zone concept is inappropriate and fencing along tree edges is recommended.

Table 8.1.2
Animal Feed — Plants

	Pod, Nut or Seed A	Pod, Nut or Seed B	Foliage A	Foliage B	Fruit A	Fruit B	Roots, Shoots or Tubers A	Roots, Shoots or Tubers B
Beech (American and European)	X							
Apple						X		
Bamboo (All species)							X	
Bamboo			X					
(*A. racemosa*)	X							
Bamboo (*A. macrospermal*)	X							
Black locust	X							
Carob		X						
Cherry plum						X		
Chicory			X					
Comfrey				X			X	
Common reed							X	
Damson, Sloe					X			
Dandelion			X					
False tree lucerne	X		X					
Fat hen	X							
Hawthorns (Some species)			X			X		
*Hickory	X							
Honey locust		X						
Horse-chestnut	X							
Jerusalem artichoke			X				X	

A Immediate consumption only.
B Harvest and storage possible.
* Nuts are very hard, requiring cracking.

	Pod, Nut or Seed A	Pod, Nut or Seed B	Foliage A	Foliage B	Fruit A	Fruit B	Roots, Shoots or Tubers A	Roots, Shoots or Tubers B
Kudzu vine			X					
Lespedeza				X				
Lucerne				X				
Lupins			X					
Mesquites		X						
Mirror plant	X							
Mulberry					X			
Oaks		X						
Pampas			X					
Pear					X			
Queensland arrowroot							X	
Reedmace							X	
Siberian pea tree	X							
Sweet cherry	X					X		
Sweet chestnut	X							
Walnut	X							
Wild rice	X							
Wood millet	X							

A Immediate consumption only.
B Harvest and storage possible.
x Value varies with tannic acid content.

would be best grown in a patch and harvested every year or two by pigs, penned in. The organization of a self-forage system for hens and ducks can give experience of use in designing layouts of systems primarily aimed at support of larger animals. This type of design-work, has not — as far as we are aware — been developed in any detail. Smith's "Tree Farm" (Figure 2.4.1) is largely developed for animal forage but it is fairly simplistic.

Concentrate feeds do have a place in the system for feeding, during periods of poor forage, for fattening, and maintenance of milk and egg production. The tendency to feed only concentrate feeds for rapid weight increase should be avoided, especially with young animals (see Kern,[39] Chapter 16). Naturally-concentrated foods should come from within the system. Table 8.1.2 indicates plant species with storable yields for animal feed. Most of these are nuts and pods which are high in protein, oils or sugars, as shown in Tables 4.1.1 to 4.1.12.

Some animals can be fed these products unprocessed but generally, the ground product is better; ground nut shells can provide many minerals essential to diet. A small hammer-mill is necessary for grinding — a basic tool in a well-developed permaculture. Seed cakes and similar residues from the expression of oils are valuable feedstuffs, available as by-products from oil production. An oil and juice press is another basic tool in permaculture. Hay and silage from more valuable forages, such as lucerne and comfrey, should not be ignored as a store feed. Sprouting grain and other seed is a process, little used, for animals feeds. Any seed can be sprouted if given moisture and adequate warmth. Sprouting increases the qualities of some vitamins many-fold, starches are mobilized and converted to sugars, while protein remains constant. Weight of feed increases 3-6 times over dry weight, while volume can quadruple. Easily done in an old wash trough, this process should be universally recognised in animal and human nutrition, where bulk grain is available. Grains which sprout at moderate temperatures are most suitable — wheat, buckwheat, lucerne, oats, barley, brown rice, soy beans, mung beans, lentils, peas, garbanzos, pumpkin, cress, sunflower seed, fenugreek, sesame seed, and rye. All can be used for human food.

Since many of the species indicated for animal feeds are not in common use and information is scant, much experimentation is necessary. For example, the seed value of mirror plant seeds and berries is unknown. On the other hand, it is not necessary to work out an animals' diet down to the last calorie or vitamin, due to the diversity of free-range feed available.

Table 4.1.11 gives the species of the catalogue which are useful for animal forage and stored feed. Many, such as almonds, hazels, persimmons and the common reed, would only be considered for animals if there were excesses. For this reason, it is more extensive than Table 8.1.2.

For fencing required for containment see Table 8.1.3; for amounts and fertilizing value of some animal manures see Table 8.1.4; for breeding see Table 8.1.5 and for conversion efficiency of plant to animal protein see Table 8.1.6.

Pig mesh enables geese to browse through a fence and thus keep weeds down along footing.

Considerable savings may be effected by using permanent electric fences. Solar-powered models are now available, and these also serve to exclude possum and cats from protected areas of Zone I.

Table 8.1.3
Fencing Required for Containment
Ref. 2, also see Kern,[39] p. 120

Fencing	Height/Mesh	
Ducks	1m	6cm
Geese	1m	6cm
Hens	2m	5cm
Guinea fowl	1m	6cm
Peacock	Unfenceable — need roofed area	
Pigeon	Not fenced	
Quail	Not fenced or small pens	
Pheasant	Not fenced	
Turkey	2m	
Rabbit	1.5m	5cm
Pig	1m	— String wire or mesh*
Cow	1.5m	— Need top barb or high fence*
Wallaby	1.5m	— Large spp. — need 2m fence
Horses	1.5m	
Donkeys	1.5m	
Sheep	1.5m	
Deer	2m	
Goats	1.5m	— Top barbed
Possum	Unfenceable — need roofed area	

* Need buried netting or stones on turned-over footing, or electric fence.

Table 8.1.5
Breeding Table (from Belanger)[47]

Animal	Age of Puberty (months)	Interval of Heat (days)	Average Duration of Heat (hours)	Average Gestation Period (days
Swine	4-7	18-24	2-3 days	144
Sheep	5-7	14-20	30	148
Goats	4-8	12-25	36-48	151
Cattle	8-12	21	16-20	283
Horses	12-15	21	4-6 days	336

Table 8.1.8
Conversion Efficiency of Plant to Animal Protein (from Kern)[39]

Milk cow	47 per cent
Hen eggs	36 per cent
Chicken	23 per cent
Hog	17 per cent
Beef	7 per cent

Table 8.1.4
Amounts and Fertilizing Value of Some Animal Manures (from Belanger)[47]

Animal	Tons Excreted per Year per 1,000 lbs. Live Weight	Percentage Nitrogen	Percentage Phosphoric Acid	Percentage Potash
Rabbit	6.2	2.4	1.4	0.6
Sheep, Goat	6.0	1.44	0.5	1.21
Swine	1.60	0.29	0.34	0.47
Chicken	4.5	1.0	0.8	0.89
Dairy cow	12.0	0.57	0.23	0.62
Beef steer	8.5	0.73	0.48	0.55
Horse	8	0.70	0.25	0.77

8.2 Animal Interaction and Association

Like the rest of the system, animals are capable of beneficial and symbiotic interaction, as well as competitive, negative association. Design which takes advantage of these relationships comes from experience and observation but some examples can be considered.

Poultry are scavengers and will salvage food that is wasted by other animals. Maggots and other unwelcome life forms are controlled by ranging poultry. On the other hand, chickens can pass on tuberculosis to cattle and thus, humans.[47] Pigs also can be easily infected by chickens — the two should not mix. Ducks, geese, sheep, goats, are relatively resistant to tuberculosis. Ducks are also scavengers and do not scratch mulches. They thrive on parasites which kill sheep, cattle and chickens, such as husk or liver fluke.[39] The excrement of cattle provides nutrients for pigs, which will follow cattle. On ground grains, four yearling steers can support one pig through wastes alone.[47] Ducks will follow pigs, often gaining tid-bits where pigs have been rooting. On pasture, when adequate, sheep, cattle and goats can graze together to advantage. Goats can make tetanus infection in horses more likely and infect sheep with parasites if association is close.[47] Ducks and pigs complement fish culture by provision of excrement for fish food.

Dogs do not interact well with any domestic animal but may well keep possums away to some degree. They will also rid a place of wallaby! Dogs are of little use and do much harm in the system. Cats are totally destructive to small animal life — birds, lizards, frogs, etc., so are a definite disadvantage. It is probably that the insect pests of suburbia would be greatly reduced by frogs and lizards if cats were removed. Both dogs and cats carry parasites harmful to man, especially children. We can see no good reason for keeping either of these "pets". (The pet-food market mainly whale or kangaroo meat, is a modern undesirable product of such practices.)

The brush possum, in Tasmania, is the most harmful wild mammal, breaking trees and taking even immature fruit and nuts. Live-traps are used to transport these to other areas (they must be taken 10 miles or more away or they will return).

8.3 Notes on Animal Species (mostly from personal experience)

Geese Ref. 50.

Tough birds, suitable for free range on wide areas but not on steep slopes. Ample water in a deep container (e.g. bucket) is necessary. A pond or dam, if available, suits the geese best. They do not muddy dams as much as ducks and tend to camp on bare areas around dams, thus encouraging grass growth due to manuring. They roost and nest in the open, requiring no shelter. One gander and three geese, at least four years old (for good breeding), produce up to fifty goslings per year. Being general grazers and browsers, geese must be kept off the delicate zones which have small fruits, herbs, vegetables and young trees. Goslings born in spring can be butchered in December and March, after fattening. Goose-down is a valuable by-product and is used in sleeping bags and quilts. Stocking densities of up to ten geese/acre are possible. Wings are used for bee-brushes when taking honey.

Wallaby

In Tasmania, these animals should be considered seriously as domestic stock. They are easily domesticated and can become very tame (in the absence of dogs). With one male to twelve females, two crops can be taken — December and May. The meat is good and the furs are high quality, especially in May. We estimate a maximum yield of 80lbs/acre/annum, in a mixed forest with complex edge. The carrying capacity of low grade forest and woodland, is one animal/acre. Ideal wallaby country is complex edge with ti-tree swamp, clearing and tall forest on well drained patches. Forest wallaby need dark shelter — as provided by ti-tree or pampas, to prevent blindness. Wallaby can be considered "softer" than sheep in a system and more or less equivalent to geese. They are short herb grazers, feeding on grasses, low foliage and fungi, but rarely reach up to vegetation higher than 0.5m. However, wallaby as domestic animals would be best suited to the outer zones or in undeveloped areas within a boundary fence. Close netting to 1.5m is necessary for containment.

Turkeys Ref. 47

The original wild turkey is a bird of the N. American deciduous forests, living mainly or acorns and nuts. Although the domestic birds are now quite different, it would seem appropriate to keep the birds on free-range under oak and other forage trees in the outer zones of the system. Raising turkeys is quite involved — due to their susceptibility to disease, especially from chickens, and to their stupidity (poults need to be taught how and what to eat, hens lay eggs while standing up, the birds are easily frightened — see Belanger[47]). Free-range birds in dense forage forest (well away from chickens) should be able to survive quite well. Raising poults may need to be done "intensively". Harvest would be late autumn, after the main nut crops.

Guinea Fowl Ref. 47

Medium sized birds, little domesticated, being more suited to semi-wild conditions than most birds.

They do not scratch and are less destructive than chickens. They do not require housing as they roost in trees and need little feeding. They graze, eat weed seeds and insects. As with ducks, one egg should be left in each nest, otherwise the bird will make a new nest. A good guinea hen will lay about one hundred eggs/year but they are poor mothers and the keets (chicks) need careful rearing. A fine flock of guinea fowl is on range in Launceston's First Basin Park (Tasmania).

Ducks

Small birds for eggs and meat, depending on breed; Khaki Campbell and Indian Runner lay up to three hundred eggs/year. Pekin and Muscovies are the main meat breeds — the latter is a free flyer and wings must be kept clipped or birds fed to very tame condition.

Ducks require good scrub shelter or open housing and water to dabble in (e.g. shallow concrete trough fed by piped water). They muddy ponds, so only established ponds or dams are suitable. Ducks lay in the early morning, so can be penned up at night and released in mid-morning to forage. They will eat insects, worms, grass and seed. They cause little damage to plants but occasionally reach up 0.5m, nibbling tender leaves on young trees. However, Zone II could be considered for a duck run. Ducks can be fed all household food scraps and garden greens. One drake to 5-6 ducks, 8 ducks per family of 5.

Goats

The value of the goat as a milk producer is becoming more widely recognised. They are more efficient milk producers than cows, the raw milk is less dangerous (for tuberculosis) and they are easier to handle than cows. However, goats are very destructive to cultivated plants. Apart from browsing, they debark trees. A well established forest of tough trees is the only environment suited to goats. Staking and the use of orchard halters can allow goats into more delicate parts of the system for short periods. The milking goat can fit into the system to advantage but goat husbandry in large numbers is incompatible with permaculture. Goats however are useful in clearing new country. On abandoned pasture with gorse or blackberries — so typical in Tasmania — goats can be used to bring areas under control for future planting. Being browsers, and enjoying pests such as gorse and blackberries, the feeding of goats presents few problems. Some concentrate feed is necessary of course for the milking goat. (See Belanger[47] for general information on keeping goats).

Quail, Pheasants, Pigeons, Guinea Pigs

Are all worth consideration in a permaculture. Quail (in Japan) and pigeons (in Europe) are an integral part of small-scale farms, providing eggs and meat and needing little attention. Guinea-pigs are highly developed for a small domestic meat animal in Peru and Chile, needing greenstuff rather than grain for maintenance.

8.4 Pasture and Browse in Permaculture.

In keeping with the development of edge in the system, and as a measure in fire control, diverse pasture and browse can be developed as sinuous or irregular strips interpenetrating the design. Here again, we envisage perennial species of plants, allowed to evolve over time into a true herbaceous cover comprised of many species, including dandelion, plantain, lucerne, large clumps of pampas (which also acts as dense shelter for newly-shorn sheep, and nest areas for birds), edge aquatics, grasses, and legumes.

Yeomans[20] gives excellent pasture management principles, using his chisel plough and more recently developed shakerator plough in order to aerate soils. The impoverished and soggy turfs of close-trimmed lawns demonstrate a poor soil development, as close-cut monocultured pasture rarely develops deep roots, or permits free water penetration.

As our aim is diversity, many grazing species can be permitted to range on pasture; wallaby eat the plaintain that geese refuse, and cattle and horses the coarse clumps unused by sheep. By observation species balance can be maintained, and special areas fenced off for occasional browse, or as a seed resource for quail and pheasant.

Animals and birds utilise seed missed in harvest, spoiled fruit, windfalls, and trimmings. Wallaby also utilise fungi as winter food, and duck find insects and seed in pasture. The succession of grazing species and their admixture must be regulated by considerations of disease transmission between species as well as by specific pasture condition. Dolomite, foliar seaweed application, and animal manures encourage health in pasture. A mixed species complex ensures efficient utilization, and a more diverse range of products for man.

Vegetarian communities are still able to use animals (one-sex or sterilised populations) as providers of fibres, eggs, milk, in fire control, and to utilize wastes for manures.

8.5 Design for a Duck and Hen Run

The following design should be considered as an illustration of integrated design in permaculture. Note also that the development occurs over a number of years. In practice, design should proceed in the same manner, with only general outlines laid down in preliminary stages. The presence of the animals in the first few years entails considerable problems with which the design attempts to cope. However, these problems should be carefully weighed against the value of egg production and manure.

First year:

Structures:—

The external fence — keeps out predators.
— usually keeps flying birds in.
— reduces winds.

The shed — food storage.
— roosts and nests.
— water catchment.

Pond — built early to allow vegetation cover on banks to establish.

Planting:—

False tree lucerne — windbreak, wind hardy.
— rapid growth.
— seed and leaf forage.

Pond banks sown with mixed pasture seed.
Blackberries removed.

Birds:—

6 hens and 1 rooster.
6 ducks and 1 drake.

Second year:

Structures:—

Fences extended to form small pen.
"A" frame shelter and trough for ducks built.

Planting:—

N.Z. mirror plants — dense windbreak.
(*Coprosma*) — fire retardant.
— shade and wind tolerant.
— seed forage.

Honey locust — wind hardy.
— thin foliage — minimal shade.
— pods for stored feed.

Mulberries — shade tolerant.
— fruit forage.

Black locust — thin foliage.
— seed drop.

Planting seed and fruit-yielding species at the other end of the pen from the shed encourages distribution of birds over the system.

Eucalypts removed — unlimited height
— nutrient and water absorbers.

Wattles left — limited height and age.
— nitrogen fixing.
— low fire risk.
— dense shelter.

Reedmace in pond — stabilize banks.
— duck habitat.

Bamboo — seed drop.

Carobs — warm dry position.
— pods for stored feed.

All plants rock-mulched to prevent hens scratching at roots after cages are removed.

Birds:—

Numbers maintained — birds not allowed to sit — or some killed for meat.
— ducks confined to small pen.

(fully sawdusted) over winter for manuring.

Third year:

Structures:—

Fences — pond enclosed.
— 3 pens formed.
— complete 2m external fence.

The Hen as an Automatic Heater

Greenhouse/Henhouse replaces temporary shed. If hens are provided with roosts and nest boxes in a netted run under greenhouse benches, the body heat of the hens at night and in bad weather provides bottom heat and CO^2 for the greenhouse propagation bed as well as nitrogenous featherdust for manure. Greens from the greenhouse can be fed directly to the hens. The regular attention that the greenhouse requires fits with the daily egg collection and feeding. The rear section stores the increasing yields from the Honey locust, Carob and other storable feeds. A hammer mill can grind pods and seeds for feed mixtures. A trough for wheat and other sprouted seed can be sited in the shed. Feed preparation, feeding and egg collection become indoor activities, all done efficiently and easily. The roof is a catchment for the water tank, serving the birds, the greenhouse plants and sprouting trough.

Planting:—

— Comfrey patch established for stored and fresh feed.
— Manured pen seeded for forage in late summer.
— Bamboo for seed, spread along fence.

In the following years more species could be planted to increase yields and henceforth the number of birds. Wood millet under the trees and wild rice in the pond would be of great value.

In the real situation it is easier to consider all the factors of site, plant species, the birds and available resources. The following list indicates some of the factors considered in the design.

Site — aspect and slope.
— water catchment and drainage.
— winds.
— existing vegetation — resource and liability.

Plants — Forage yields to hens and ducks.
— habitat for birds.
— cultural requirements and particular adaptations.

Animals — Enclosure requirements.
— shelter and habitat needs.

— foraging habits.
— water needs.
— manure and vegetation control.
— damage to plants.
— feeding and egg collection.
— feed storage and preparation.

8.6 Bees. Refs. 5, 16, 28

The usefulness of bees as part of a cultivated system is considerable and unique.

The products are honey, pollen and beeswax. Honey is a complex food consisting of quite diverse sugars in water solution (about 75 per-cent sugar). It contains many minerals, including potassium, calcium and iron. Beekeeping is probably the easiest way to obtain concentrated sugars in large quantities, in temperate climates. Concentrated sugars are not essential to diet but uses in cooking — including preserving — are many. Honey kills all germs immersed in it and has an unlimited shelf life. Its uses in soothing sore throats and as a general health food are well known. Beeswax is a very ductile but high melting-point (145 deg. F) wax. It is used as an ingredient in wax polishes, for candles, as a sealant for canvas, bottles, insulation on electrical coils, for waterproofing cardboard boxes, and so on. Pollen is being increasingly used as a high-protein additive to flour.

The special thing about bees is that they provide these valuable products from sources which would otherwise remain untapped. In the process of producing these yields, bees increase the productivity of the system by pollination of flowers, without in any way detracting from it. Many plants require pollination by insects, for fruiting. For fertilization of the ovary, pollen from the anthers must be transferred to the stigma. Insects moving on, or in, the flower often effect that transfer. Often, fertilization is only possible with pollen from another flower, plant, or even variety. In these cases, insects are frequently essential for a significant rate of fertilization. Individual bees usually confine each field trip to flowers of a single species, thus being very effective in fertilization. The presence of large numbers of bees during flowering has been known to increase the yield of fruit or seed in a huge variety of plant species. Tables 8.6.1, 8.6.2 and 8.6.3 gives plants (including annuals) which are dependent upon, or benefited by, insect pollination.

To keep bees on a site all-year-round, it is necessary to consider the forage available to them for pollen and nectar. Flowering and yields of nectar from most species varies greatly from year to year, depending on many factors, including weather conditions. It is not possible to depend on particular species as certain sources of adequate nectar and pollen. It is also necessary to have at least some forage available in each month and to have some extra rich sources of pollen in early spring.

Table 8.6.1
Bee Forage Plants for Permaculture

Otherwise-useful species from the catalogue, providing large quantities of pollen and nectar for bees.

Almond	Lavender
Apple	Lemon
*Bergamot	*Lime
Blackberry	Loganberry
Blackcurrant	Lucerne
Apricot	Lupins
Black locust	Mesquites
Blackwood	Mints
*Borage	Nectarine
Cherry plum	Osier willow
Comfrey	(and other willows)
*Dandelion	Peach
(large pollen yield in	Pear
early spring)	Raspberries
False tree lucerne	Rosemary
Gooseberry	Sage
Grapefruit	Sloe
Hawthorns	Sour cherry
Hyssop	Strawberries
Laurelberry	*Pride of Madeira

* excellent yielders.

Table 8.6.2
Plants Dependent or Benefited by Insect Pollination (after Ref. 16)

Alfalfa	Macadamia
Almonds	Buckwheat
Anise	Carraway
Apples	Celery
Blackberries	Cherries
Blueberries	Chestnut
Broad beans	Musk melons
Clovers	Mustard
Coriander	Nectarines
Crabapple	Parsley
Cucumbers	Passionfruit
Currants	Peaches
Dill	Pears
Eggplant	Peppers
Feijoa	Persimmon
Gooseberries	Plums and Prunes
Guava	Pumpkin
Jujube	Rape
Chinese gooseberry	Raspberries
Kudzu	Squash
Lespedeza	Strawberries
Lima beans	Sunflower
Loquats	Sweet clover
Grapes	Tung
Cranberries	Watermelons
	Safflower

The first source of forage to consider is the native flora. Many species, including the famous Leatherwood, are worked by bees. Table 8.6.4 shows the flowering periods of Tasmanian natives important to bees. Since bees' maximum range is about two miles, only a certain amount of bush can be worked by any single hive. A huge variety of cultivated plants is worked by bees. However, large numbers of plants are required so the main commercially significant forage is from pastures such as clovers. For small scale production, a relatively small area under permaculture, could provide greatly increased forage. Table 8.6.1 shows plants of the catalogue (mostly useful in other ways) good for bees. Table 8.6.3 shows some of the flowering times. Some of these plants are easily propagated (e.g. Borage, Comfrey and Lucerne) in large numbers for rapidly established bee pasture. The number of hives that a cultivated system could support all-year-round or the number of bees required for optimal pollination are not really known but in a fully developed permaculture the carrying capacity should be in the order of one hive/hectare, allowing for some bush forage. Yields from hives range from ten to fifty kg/hive/season.

Beekeeping is quite an involved practice and requires specific housing and equipment but for the reasons previously given is well worth the effort. See References 5, 16 and 28 for detailed information on beekeeping.

Table 8.6.3
Flowering Times of Some Bee Forage Plants from Table 8.6.1

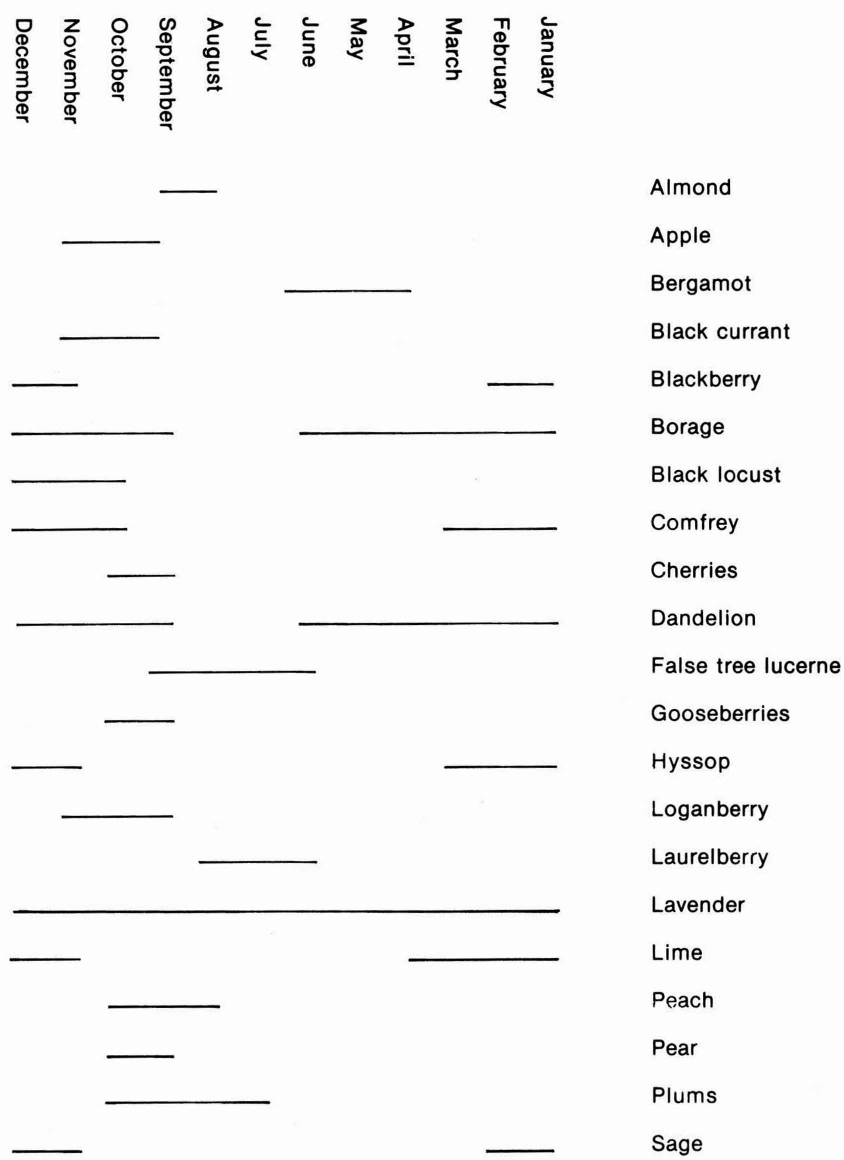


Table 8.6.4
Tasmanian Native Plants for Bee Forage (after Reg. 5)

December	November	October	September	August	July	June	May	April	March	February	January	
												Eucalypts:
X										X	X	*E. mygdalina* (Black Peppermint)
	X	X	X									*E. globulus* (Blue Gum)
X	X	X										*E. pauciflora* (Cabbage Gum)
								X	X	X		*E. obliqua* (Stringy Bark)
								X	X			*E. ovata* (N. Swamp Gum)
X	X	X							X	X	X	*E. viminalis* (White Gum)
												E. linearis (White Peppermint)
									X	X		*E. gigantea* (Gumtop Stringy)
	X											*E. salicifolia* (Black Peppermint)
X											X	*E. sieberiana* (Iron Bark)
									X	X	X	*E. regnans* (S. Swamp Gum)
	X											*Xanthorrhea* spp. (Grass Tree)
												Myoporum serratium (Boobyalla)
	X									X	X	*Bursaria spinosa* (Native Box)
			X	X	X	X						*Banksia marginata*
									X	X	X	*Eucryphia lucida* and *Milligania* (Leatherwood)
												Prosthanthera spp. (Native Lilac)
												Atherosperma moschatum (Sassafras)
X										X	X	*Leptospermum* spp. (Tea Tree)
												Acacia
	X	X	X									*A. melanoxylon* (Blackwood)
	X	X										*A. decurrens* (Black Wattle)
			X	X								*A. dealbata* (Silver Wattle)
				X	X							*A. baileyana* (Cootamundra Wattle)
					X	X						*A. discolor*

9.0 FUNGI IN PERMACULTURE Refs. 57, 58

Edible fungi take many forms, even the unlikely cup-shaped *Peziza* and the pale lilac *Tridioloma* are eaten and are common in mulched areas or associated with specific tree stands. "Mixed woodlands", says Savenius "generally provide the greatest harvest". It is as well to check the edible species using a local reference book.

Tasmania has many chantarelles (*Cantharellus*) in association with fallen logs, parasol fungi (*Lepiora*), rare morels (*Morchella*) and many *Boletus* and shaggy-caps (*Coprimus*). Common field mushrooms of three or four species (*Agaricus*) are the most commonly eaten but not the most prolific in permaculture.

Less edible are the various stump fungi (*Pholiota, Armillaria*) and more plentiful and also edible are the puff-balls (*Lycoperden*). Bracket or stem fungi from native and introduced trees (*Auricularia, Pleurotus*) and many litter species (*Russula, Coprimus, Lactarius*) are also eaten. [*Comprimus* causes a revulsion to, and sickness from alcohol if taken with that substance. It contains "antabuse", a principle reacting with alcohol to cause skin blotching and vomiting].

Some fungi species are excellent dyes, others are used, dried, as punk to catch sparks from flint-and-steel for fire-lighting. Others (the fly agaric) are used as fly poisons. Cautious use and firm identification are needed to select edible fungi from the many species which appear as decomposers in a permaculture. Some species, particularly the *Agaricus* are worth introducing into mulch as an additional food reserve.

In a trial system established by the authors, fungi entered in an unplanned way, but many were then utilized for food. Harris[58] has written a very useful guide to propagating species on a more organized basis, using simple tools to develop cultures indoors. Experimentation in mulch mixes, and the deliberate placement of wood or leaf substrates under mulch may be future strategies for increasing permacultural yields of fungi.

Where fungi do have unique values is in areas otherwise unsuited to crops, particularly in shaded or indoor niches not suited to green plants; they also yield a variety of useful chemicals and products other than food.

10.0 URBAN EVOLUTION, AND THE FLIGHT TO THE LAND Refs. 2, 59-64.

Since 1800 the proportion of the world's population resident in cities of 20,000 or more has been reasonably summarised. The proportion of the world's population that was urban, increased between 1800 and 1950 from 2.4% to 20.9%. By 1970, according to the United Nations, about 28% of the world's population was resident in urban places (of 20,000 or more population).

The United States can be taken as an illustration of the process of urbanisation. In 1790 when the first decennial census of the United States was taken there were only 24 urban places with 2,500 or more persons. By the 19th decennial census in 1970, the number had increased to 7,062. Not only did the number of urban places increase, but so did the average number of inhabitants in each place: in 1790 the average number of persons in an urban place was 8,400; by 1970 the average number was 21,142. In consequence of both these increases, the urban proportion of the population rose from five per cent in 1790 to 73.5% in 1970. (It exceeds 80% in Australia.) Such buildups are not planned to include a basic food resource for the community, and ever-increasing transport energies are required to deliver exotic foods to urban centres, with increasing losses due to handling and storage damage. It is in the suburbs that the potential for permaculture still remains a viable alternative, if plants of direct use to man are exploited.

It is more accurate to regard the suburb not so much as the product of a flight from the city, as the result of the city ever growing and overflowing its boundaries into adjacent territory. The true flight from the cities began in the late 1950's, and is accelerating in Australia, although only a privileged few are able to purchase land under the present restrictions of tenure and local building and access regulations. This is an urgent area for reform of legislation towards positive assistance in rural areas. Rather than the development of city superhighways, aid is needed in the extending public routeways into productive and potentially productive areas close to the cities.

Little thought, and less policy planning, has gone into making the rural-urban dichotomy more rational, with food production within the city; fibre, fuel, carbohydrate, and bulk protein production in nearby rural areas, and an interchange of services, support systems, and expertise. Rational transport services with 'backloading' of fertiliser derived from city waste is an essential future planning strategy, for example. Active support for rural migrants should be part of city policy. In urban areas one finds a conglomerate of people, who through force of circumstance are dependent on slender resources at a great distance, a particularly distasteful state of affairs. Increasingly nowadays their solution involves either being pushed or pulled to embracing a lifestyle in a rural area (Hauser).[59]

In the third world, rural activities are a normal part of city life, and the city farms of London are re-establishing this trend of recent years, actively supported by city authorities.

In every generation some people turn back on conventional lifestyles and try to establish a different way of living — usually a way of living based on co-operation and consent, rather than ambition and acquisition. The last twenty years have seen the growth of the commune movement, in which men and women have tried to grow as individuals and live as a group; where collective responsibility for the community gives its members a feeling of control over their own futures. This is being attempted against the falling support base in rural areas, the deterioration of rural roads, and the increased regulatory and levy costs imposed by local councils and authorities.

In the March 23 edition of *The Bulletin* (1976) Lindblad noted:

> "Retreat to the bush is not a new phenomenon in Australia but it has never before occurred on such a vast, nation-wide scale. Never before have there been so many people permanently dropping out all at the same time and with such a tremendous sense of purpose and co-operation."

What is lacking is planning to assist and make useful the energies of this movement.

The following sample of Tasmanian 'urban to rural' migrants was undertaken by students of environmental psychology, University of Tasmania, and gives some of the characteristics of the 'alternative' community. (Grogan, 1976, Ref. 2).

Eight experimenters selected a non-random sample of 241 urban to rural immigrant subjects. See Table 10.0.1.

Table 10.0.1
Summary of Frequencies and Percentages of Male and Female Subjects Among Urban to Rural Immigrants N = 241

Sex	Frequencies	%
Male	128	53.1
Female	113	46.9

The higher male ratio reflects the pioneering phase of the movements.

The sample was selected in the following manner. Subjects were initially approached because of being friends of the investigators themselves, or through contacts. On other occasions a subject would suggest that the enquirer might contact somebody else as a potential subject, likely to help. Therefore selection was not random, although not purposely biased in any particular direction.

As will be seen from Tables 10.0.2 and 10.0.3, the largest group of subjects were thirty or more years of age and most people were either married or cohabiting. Single people were a minority, as were those under twenty-five. Almost half (46.1%) were over thirty years of age.

Thus, the often-held belief that this is a movement of young people is not true for the sample.

Table 10.0.2
Summary of Frequencies and Percentages of Under 25 Years; 25-30 Years and 30 Years Upwards Age Groups Among Urban to Rural Immigrants N = 241

Age	Frequencies	%
Under 25	45	18.7
25-30	85	35.3
30 Upwards	111	46.1

Table 10.0.3
Summary of Frequencies and Percentages of Marital Stati of Urban to Rural Immigrants N = 241

Marital Status	Frequencies	%
Single	30	12.4
Married	177	73.4
Cohabitation	34	14.1

Table 10.0.4
Summary of Frequencies and Percentages of Numbers of Male Children Born to Urban to Rural Immigrants Before and After Move N = 241

Males Born Before Move			Males Born After Move		
No. of Children	Fre-quencies	%	No. of Children	Fre-quencies	%
0	191	79.3	0	205	85.1
1	32	13.3	1	26	10.8
2	11	4.6	2	8	3.3
3	5	2.1	3	2	0.8
4	0	0	4	0	0
5	1	4.0	5	0	0
6	1	4.0	6	0	0

Table 10.0.5
Summary of Frequencies and Percentages of Numbers of Female Children Born to Urban to Rural Immigrants Before and After Move N = 241

Females Born Before Move			Females Born After Move		
No. of Children	Fre-quencies	%	No. of Children	Fre-quencies	%
0	192	79.7	0	218	90.5
1	33	13.7	1	18	7.5
2	11	4.6	2	5	2.1
3	5	2.1	3	0	0

Table 10.0.6
Summary of Frequencies and Percentages of Lifestyles of Urban to Rural Immigrants N = 241

Lifestyle	Frequencies	%
Solitary	14	5.8
Familial	198	82.2
Communal	29	12.2

Table 10.0.7
Summary of Frequencies and Percentages of Educational Levels of Urban to Rural Immigrants N = 241

Education	Frequencies	%
High School	61	25.3
Matric	24	10.0
Tertiary	57	23.7
Graduate	99	41.1

Table 10.0.8
Summary of Frequencies and Percentage of Occupations of Urban to Rural Immigrants Before and After Moving N = 241

Occupation	Frequencies		%	
	Before Move	After Move	Before Move	After Move
Professional	106	74	44.0	30.7
Administrative	32	24	13.3	10.0
Clerical	22	8	9.1	3.3
Skilled Manual	33	36	13.7	14.9
Semi-skilled	15	22	6.2	9.1
Unskilled	15	38	6.2	15.8
Other	18	39	7.5	16.2

Table 10.0.4 shows the frequency of subjects who had between none and six male children born before and after their urban to rural shift.

Table 10.0.5 shows similar data for female children.

It can be seen from Tables 10.0.4 and 10.0.5 that forty-eight male children (i.e. (26 x 1) + (8 x 2) + 2 x 3)) as opposed to only twenty-eight females (i.e. (18 x 1) + (5 x 2)) were born after the move. This may be compared with eighty males and seventy females born before the move. In fact the percentage of males born has risen from 53.3% before the move to 63.2% after the move. A rise in male births was predicted on the basis of other data available to the research group.

It is evident from Table 10.0.6 that the most usual type of life style is familial.

Table 10.0.7 shows a breakdown of subjects' education, from which it is evident that the group most represented are those of tertiary level — in fact they supply 41.1% of the total sample. This, in fact, represents a remarkable urban to rural brain-drain.

Table 10.0.8 illustrates the occupations of subjects before and after the move from urban to rural areas. It is evident from the table that the largest group taking part in the move are professional people. The other most noteworthy feature is that of change of occupations after the move had taken place. There is a drop from 66.4% in non-manual occupations before moving (i.e. professional, administrative, clerical) to 44% after moving. Thus, more people are becoming involved in primary occupations. Older professional people have more capital, skills, and freedom to move than most other groups in society. They express concern with the quality of life in cities, and argue the benefits to their children of a rural life.

Table 10.0.9 shows the intended political activity of the people who have moved to rural areas. By far the majority — 75.9% — do not intend to take part in any kind of political activity at all, while a fairly large proportion (16.6%) intend to become involved in community affairs. The apolitical drift is in part indicative of the disenchantment of educated people with present "big business" politics, and consequent neglect of life-support systems.

Table 10.0.10 shows a breakdown of the numbers of people with various size landholdings ranging from none at all to "over 10 acres". Very few people have no land at all (only 4.1%) while most people (75.1%) have over 10 acres. A considerable portion of Australia is thus being secured by 'alternative life style' proponents, and may be used in the development of permaculture or like systems, as opposed to traditional forms.

Table 10.0.11 summarises present and future land uses. The most noticeable feature is the definite trend toward further development, beyond the point of food self-sufficiency.

Of the sample of 241 subjects, 111 (or 46.1%) felt that money was important to them, while the remaining 130 (or 53.9%) did not.

Table 10.0.12 gives a summary of the frequency with which difficulties were encountered by people who have moved from urban to rural areas.

The main difficulties encountered by the people interviewed were:—

a) Lack of agricultural/building knowledge.
b) Difficulties with schooling for their children.
c) Remoteness from shops.
d) Remoteness from medical aid.
e) Access and local council regulations.

Here again, it is obvious that rural support systems are not provided by local councils, and the funding of rural areas is lacking.

As subjects were not randomly selected it is not possible to make valid extrapolation from this sample to the total population of urban to rural migrants. However, one can still make useful and interesting comment about this group of people *per se*, if no inference to a wider population is claimed to be entailed.

Lindblad (1976, p.32) stated of these "new pioneers" that (they) ". . . had the best of both worlds — advantages in their choice of technologies as well as a good education sparing them most of the suffering and hardships encountered by the old-timers". This remains true only as long as rural-urban links are sustained, and high energy inputs continue.

Table 10.0.9
Summary of Frequencies and Percentages of Urban to Rural Immigrants Taking Part in Various Levels of Political Activity N = 241

Intended Political Activity	Frequencies	%
None	183	75.9
Federal	12	5.0
State	6	2.5
Community	40	16.6

Table 10.0.10
Summary of Frequencies and Percentages of Subjects Whose Landholdings Range from Nil to Over 10 Acres N = 241

Acreage	Frequencies	%
None	10	4.1
0 - 2	7	2.9
3 - 5	17	7.1
6 - 10	26	10.8
Over 10	181	75.1

Table 10.0.11
Summary of Frequencies and Percentages of Subjects Whose Landholdings Are Currently or Will be in Particular Stages of Development N = 241

Land Use	Frequencies		%	
	Present	Future	Present	Future
Nil Owned	10	10	4.1	4.1
No Development	46	12	19.1	5.0
Partial Development	144	63	59.8	26.1
Self Sufficiency	10	77	4.1	32.0
Full Development	31	79	12.9	32.8

Table 10.0.12
Summary of Frequencies and Percentages of Assorted Difficulties Encountered by People Moving From Urban to Rural Areas N = 241

Difficulties	Frequencies	%
None	65	27.0
Personal	49	20.3
Financial	30	12.4
Occupational	12	5.0
Other	85	35.3

There are those too who seem to be determined to do things the hard way — or the natural way as they see it, and for whom technology is anathema; a symbol of the world they left behind.

10.1 Permaculture in Cities and Towns
("Treeways, not Freeways")

All cities have unused open land; roadsides, corners, lawns, areas front and back of houses, tubs, verandahs, concrete roofs, balconies, north-facing glass walls and windows. And many suburbs are well planted but if one deliberately selected a group of plants useless for man, these are what we see in the city. It is as though a useful tree, shrub, vine or herb is shameful; as though it is a sign of status to grow only unusable plants; a form of conspicuous wealth. The city could, at little expense, provide a great deal of its food and in so doing, use much of its own wastes as mulch and compost. But perhaps the most valuable product of a city devoted to permaculture would be peace of mind; a paranoia pervades cities and it is a product of helplessness in the face of approaching energy shortages and uncertain futures.

By developing private and public permacultures, people could see a food resource allied to the shelter the city over-provides and involve themselves in meaningful tasks, aiding their own (and others) survival.

The sane ethic is to use *all* land close to settlement as permaculture of Zone I and II species; any botanic garden demonstrates the possible rich variety available to city agriculture and could also provide seed, advice and expertise. Similarly, councils and public authorities have small armies of men tending non-productive systems. It is only a matter of public persuasion and responsible decision to direct these activities to useful species, in a multi-dimensional and many-faceted permaculture. Nothing of beauty or variety needs be sacrificed and a year or two of such effort would ensure a long-term resource within the city and at its boundaries, where transport and processing costs are least.

At present, cities are "energy-sinks", hence vulnerable and wasteful. Thus, their very existence is in balance in a future of expensive energy and reduced transport. Cities must act to justify their existence and diminish their parasitic dependence on rural areas. It is only a favoured few who can escape the cities, although recent surveys in Australia show that 80% would like to do so! Our surveys in Tasmania show that, of those who leave, many have tertiary qualifications, most are family people and are over 30 years of age.

This is just the sort of population that the city needs to keep but cannot attract, given the present mindless designs. Any individual with any open land in the city can institute a permacultural system, choosing from the plants in Appendix B those which are most suited to the situation or those most personally preferred.

It has been estimated that cities support more forest than developed rural areas and that suburbs of ¼-acre blocks can produce 28% more food than surrounding farmland. It is a challenge to the city to see what can be done with its unique facilities. Lawns, in most cases, are energy-absorbing systems. The vast, blind, windowed sides of ferro-concrete office blocks are essentially unused glasshouses. If only one firm encouraged employees to use these advantages, there could be a new interest in work and the essential lessons we all need to learn. The foyers of most buildings would grow some of the coffee needed for the morning break and in so doing, would free land in the third world for more essential local agriculture.

Windows can be adapted, as shown in Abrahams,[70] to grow seedlings and clear panels let into northern roofs serve the same purpose. Vines, moderators of summer heat, are a potential crop for warmer districts; scarlet runner beans, grapes, chinese gooseberry, choko, yellow and black passionfruit and hops are only some of the vines that can be used in this way.

Parks, now largely open lawn, can be carpeted with useful and decorative understorey species such as blueberry, comfrey and small fruit. Useful pine-nut species can be planted to replace sterile cypress and pines, useful nuts replace eucalypts and barren hedgerow, and espaliered fruit can occupy walls and fences.

It is not intended nor suggested here that city forests do not at present have an intrinsic and aesthetic value, not that ancient and beautiful trees be removed except by natural die-off. But it is now time to think of useful replacement species, so that the present barren forests can be phased out, as useful species replace them, and their products (timber, fuel and mulch) utilized. After a single 20-minute talk on radio station 3LO (May 24, 1977), we received some 3,500 letters from Melbourne people, including council engineers, horticulturalists, doctors, churchmen and housewives. Postmen volunteered to carry seed and some people announced that they were commencing a permaculture as from that date. Later programmes had even more positive responses, and some councils and planning authorities have decided in favour of permaculture.

We cannot, and must not, overlook the morale-building and unifying factors that a people would develop as the urban permaculture developed; the city would become a far less hostile place for all who lived there. Plants insulate against heat, noise and wind and give summer shade.

Ethnic minorities, often with rural experience, could impart their skills in processing and cooking tree products to the community at large. Even if most of the potential yield was left to rot into the soil, the stored energy of a permaculture would accumulate ever-increasing yields for any future need.

The addition of a glass-house lean-to on existing buildings would greatly increase both the variety and yield of urban systems (see Ref. 24) and a small pond used for the aquaculture of trapa nuts and wild rice would hold species that could, if needed, be released into larger ponds, lakes or swimming-pools.

Tub specimens can occupy bare concrete and asphalt and even small holes dug in such areas will produce a large tree in good health.

Adelaide is one of the few cities which supports useful public plantings (olives) and the olives are gathered by people who use the oil and preserve the fruit.

If some restrictions could be put on cat and dog populations, then quail, pheasant, pigeon and other useful birds could be introduced into the urban permaculture. Even at present, bees would produce from existing flora.

Leaves and clippings from urban permacultures are ideal compost and mulch components for annual crops grown in intensive raised beds in backyards, or on concrete patios and roof-tops. Earthed roofs of concrete are incidentally insulated, and conserve energy as well as producing life-supporting food plants.

Although many streets are tree-lined, few have understorey species, and there are literally hundreds of acres of unused embankments and public open areas.

Windows and heaters provide drying heat for long-storage products such as prunes, apricots, pears, apples and beans. Silvered builders' paper will reflect light into dark corners, as will broken mirrors. Walls can be painted black, or white, to act as heat radiators or reflectors. By sharing techniques, recipes, experiences and plants *via* a journal such as the *Organic Gardener and Farmer,* the people of urban areas can encourage each other with their successes.

The implications for energy conservation are obvious. Direct use obviates transport, packaging and waste due to spoilage. Greater variety in diet and chemical-free food are an added bonus. The oldest and youngest can perform useful work in urban permacultural systems and the 'unemployed' find useful activities in expanding the system. Much of what is now 'garbage' can be returned to the soil, building up nutrients and lessening the waste production of the city.

The educational inferences are also obvious, as students of any age can construct and observe a permacultural system, and in doing so develop skills for use outside the school system, and devise methods of using wastes while practising applied ecology. Almost any discipline can find an application in permacultural systems.

10.2 Urban Strategies

Many strategies are open to urban dwellers apart from the owned land they can now command. In Britain and Holland the embankments and wastelands owned by public authorities are allotted as 1/8-acre lots to those who apply for garden space; these are for the most part used by the lessees for annual vegetable culture and some flowers.

A better-organized system in Holland, near Rotterdam and elsewhere, is the Garden Club. Members buy shares in a large area of land (100 or more acres), and allot sections on which (with local council permits waived) they erect small huts as 'overnight' accommodation; these are very decorative utility rooms made from any sort of materials, but rain-tight and comfortable. Toilets can be central, and public pathways are opened for visitor access (John Boeschoten, pers. comm.).

Club members visit at any time, mostly once a week or so, and grow flowers, vegetables, and fruit. The land is as close to the city as is possible and thus usually accessible by public transport (rail or bus). This is simply a matter of rural council permission and urban organization, and is particularly suited to high rise dwellers. In Australia, such an area can be group-planned to allow for a section of permaculture.

Cluster-title is a more extensive way of group use of land, where 10 or more owners buy (say) 150 acres, and house-sites of ¼ acre are leased for dwellings and garden to the group. Such co-operative organizations already exist near Melbourne. A combination of permaculture, cluster, and garden club would result in a well-developed resource where urban dwellers could have ample garden space on public routeways, and where the permanent residents could keep an eye on the garden-club patches in case of drought or unwanted interference.

The financial resource of people is also taken into account between allotment, club, cluster and "country estate". Our present by-laws in rural areas allow only some of these alternatives, and none in combination, so that people who wish to develop such strategies must first change this impeding factor, if necessary by political action, (although it would be political suicide for councils to attack a well-developed Garden Club!). Most depressed rural areas would welcome the input of people, capital, and skills.

The closure of streets and lanes, the erection of trellis over traffic ways, and the utilization for food production of unoccupied buildings and corners in cities are obvious strategies, which might well become commonplace as transport fuels become scarce. Fortunately, there are many plants which will deal with bitumen and concrete roads! In New York, it is common for flat dwellers to 'adopt a tree' nearby, and keep it in health, with an associated mulch or smaller species planted at the base.

The first essential in commencing a permaculture is a family or group discussion, and consultation with local nurserymen. Some local examples of simple systems will exist, and a visit to the Botanical Gardens will demonstrate several principles. It is a good idea to gather a list of species already yielding in your urban area; some will be rare, and unsuspected. Children and teachers are able to commence demonstration work on schoolgrounds, office workers and factory workers on wasteland, or interiors, at the place of work.

Enquiries to local councils, parks and gardens staff, and State authorities may bring more official action; many authorities are willing to act, and use their plant nursery facilities and staff. Alternatively, advertisements placed for garden club or cluster-title members are the way to gain numerical strength. Any media releases on the progress made encourages action by others.

Membership of gardening societies which publish newsletters or bulletins allows a flow of enquiries and new information to other members.

Intra-urban planning is a matter of new strategy and modification of older areas and buildings, as a form of urban renewal. In central London, some flats of 5 or so levels are aligned in stepped tiers facing the sun (south), so that part of the roof of the flat below is a garden and greenhouse for the flat above. Shopping malls fill the lower rear (shaded) section, and parking space is fitted under, together with storages and centralized facilities. By this means, flat dwellers have kitchen garden, retail facility, storage and a potential for shared resources all grouped in one site. This further allows group waste and fuel usage. A design of similar form is figured in Blackmore's *Nature and Health Journal* of summer 1976, where autonomy in housing is attempted, in design at least.

Similarly, small modifications to new buildings by way of window placement, balcony, roof, and trellis design can give every new building a food production potential. Why this should not be as essential a part of urban by-laws as is the parking-space and garage accommodation we fail to comprehend; the one designs for energy loss, the other for energy gain. Compulsory insulation is a probable future requirement for all dwellings and compulsory provision for at least some food production is at least as necessary. In the stepped apartment concept, the soil of the upper garden insulates the lower flat, again fulfilling the multi-use aims of permaculture. Community solar panels, stills, and waste recovery or methane production then becomes possible. Again, it is a matter of by-law or commonsense planning rather than using the same materials to build an energy-consuming system, a matter of integration of the rural and built environment, and the re-integration of the city with its hinterland on a wider scale.

The willingness of Federal, State and local authorities, schools and firms, to institute permaculture in public plantings, and of architects and planners to incorporate the principles into design is a measure of their public responsiveness, and concern for the welfare of ordinary citizens. The alternative is the exploitation of their fellowman in using barren planning, monocultural forests, and structures that will need unnecessary future maintenance, without future return. The same holds for changes in local by-laws and systems of land tenure, access costs, and city-rural planning. Ordinary people should see to it that their welfare is also considered.

As we see it, the future of broad-scale agriculture lies in producing bulk products for fuels and carbohydrate, rather than in traditional meat-fibre production, and the future of superhighways is very much in doubt, while rural back-roads will always be of value.

Rural and urban permacultures will need an increase in the importation, generation, and dispersal of selected plant species, new small industries to deal with products, and an involvement of all teaching disciplines. There should be an increasing need for people rather than machines, and small rather than large processing units.

The ability, and motivations for people to use inner urban land is often lacking; old, sick, and depressed people often have neither the energy nor the small capital outlay needed to purchase mulch and plants. In Oxford, and elsewhere in the U.K., Friends of the Earth (F.O.E.), have a successful programme running, trying to match up these people with young family people who would like to garden, but who are living in flats or high-rise. This is bringing many neglected urban areas into productivity.

What is useful in cities are dispersed permacultural consultancies, based on the various colleges, schools and institutes, where people can call for advice and assistance. Two such groups are forming, one in Sydney and one in Melbourne (Australia). They are able to use outside expert and practical advisors, and (using maps of the local area) to locate unused land, private and public, for those wishing to garden. Community involvement is a necessary part of the development of city permaculture.

A by-product of irresponsible industry is the heavy lead content of plants along roadsides (*Ecos*, 3 Feb., 1975) in Australia, and no doubt in many urban and rural areas. The addition of 15% alcohol to petrol obviates the need for lead, and it is long past time that Federal laws demanded this changeover. Chemists, and others with access to atomic spectrometers can monitor the levels of lead in food produced along highways, and need to do so now, as many food-producing plants already exist in private city gardens, to test for this factor. By this means, plants which do not concentrate dangerous levels of lead can be selected, and planted for the future. When lead is finally removed from petrol by responsible authority (on public demand?) constant monitoring should record that levels fall as the lead is leached, or measures taken to reduce the lead content of soils.

Similarly, chemists and industry can provide data on the suitability of cardboard and newspaper for mulch. "Government" paper is at present considered safe, and most newspapers use harmless inks, but it is as well to check for this, and the use of mercuric slimicides in your local paper; they can be removed or replaced with less harmful substances if industry will co-operate in making their waste products safe.

We are asking for feedback, at every level, for future editions of this book, and in that way hope to increase its usefulness in practical applications.

10.3 Urban Sheet Mulching

In any establishment system for perennials, weeds of a perennial rampant nature must first be controlled, and over intensive inner zones or urban areas this can be completely achieved by a sheet mulch. Basically, the procedures are as follows:—

A thin scatter of organic nitrogen (poultry manure is excellent, or blood and bone) plus some ground limestone or dolomite is spread on the area to be planted. Otherwise, long grass and weeds are left untouched, and unwanted shrubs slashed and laid flat. Starting from a weed-free edge such as a path or house foundation, the area is "tiled" with bags, cloths, carpet, newspaper, cardboard, broken plaster board, or softboard, so that all long weeds, grasses, and unwanted plants are *completely* covered and tucked under. To tidy up, leaves, sawdust, bark, chips, hulls of rice, straw or some such loose cover is strewn over the whole tiled area. The end result is quite neat.

A bucket of sandy soil is used to make small mounds, and rootlets, seed, corms, bulbs, and small plants are placed, each in soil (about a double handful) at the selected site. For trees, potatoes, or yams, we axe or knife a hole in the sheet mulch below before placing them in the soil mound. Water the whole area well after planting.

In a few days the original grasses and weeds (the thicker the better) yellow and decay. Worms commence work, and the new plants are established as they shoot. There is no digging. Those strong weeds which come through are subdued with dampened paper or cardboard, and loose mulch pulled over the top. So one perennial system replaces another.

In larger areas, a spot mulch of bags, carpet, stones, or plastic is used around trees. Fortunate people with stony soil can mulch 12" deep with stone, starting 18" out from the tree stems of new plantings. The underlying sheet mulch (old cardboard or plastic sheet will do) suppresses weeds. The stones hold heat and moisture and prevent wind and sun damage to roots.

All mulches are extended as needed, and annuals can produce, in early development, between the perennials. Paths of sawdust later turn into soil, and perennials later spread to replace annual yields as the system evolves.

One of the difficulties in permaculture is in keeping the foot of netting fences clear of weeds. This is best achieved on farms by allowing a mesh size that permits animals such as geese and wallaby to put their heads through the lower mesh (pig netting does this) and browse off weeds under such fences. For small runs, flat-iron, plastic, or some such permanent material, weighted with old bricks or stones, and laid flat below the fence line keeps the wires weed-free; strewed loose husks or sawdust keeps it neat.

While in low-rainfall areas, pits may be needed for shade/moisture species such as celery and pumpkin in high rainfall areas, the same species need raised mounds. If plants are scattered at random in niches, they soon indicate which treatment suits them best; the aim of a permaculture is not to evolve a row-crop system, but to develop edges and complexity for later study, and we originally place small plants almost at random, using careful placement for the larger and more enduring species.

An unforeseen result of sheet mulch, after a period of ageing, is that tree and permacultural species seeds germinate readily in such conditions, enabling the system to be duplicated by re-location of seedlings, or by letting people take surplus stock for either direct use or grafting. This is a result of a combination of factors; higher humidity, shade, and protection; it is also possible to germinate seeds deliberately in such a medium, for removal elsewhere, and we use this facility to start germination in nuts and hard-shelled species. We can only presume that the sheet-mulch system is a healthy habitat for new plants.

Sewage wastes are at present contaminated with heavy metals and dangerous chemicals mainly as a result of illegal disposal of industrial wastes in sewerage lines, but also as a result of the elimination of such wastes from the body, again because of unnecessary contamination of air and food by dangerous substances. Contaminated sewage can be used to grow plants, but in the first place should be restricted to plant species yielding fuels and fibres, not food. Thus, over time, natural mulching, dispersal and recovery of metals from fuel systems, or the dissociation of chemicals by destructive distillation can continue until sewage again becomes the safe and valuable fertiliser it was in past times. Any society which has the energy to bring food in has the energy to return dried wastes to food production sites, and back-loading costs are an essential part of the true energy costs of food production.

10.4 Permaculture and Urban Neuorosis

A city or community involved in permaculture is taking an important step towards controlling its destiny; consultancy groups can advise and monitor dangerous substances in the environment; irresponsible industry and public authority is thus identified and can be regulated or replaced. People, seeing a food resource develop nearby, are relieved of a great deal of their anxiety about futures, and can become actively involved in constructive work which assists community survival. It cannot be too much stressed that this factor alone will greatly assist community health, and the medical profession, amongst others, can lend its considerable weight to the aim of establishing a city permaculture, on the policy level and in private example.

City engineers and public landscape professionals have had specific instructions, in the past, not to plant useful trees or shrubs, and this accounts for the curiously barren nature of the public plantings that we see today. But it is past time for change, in this as in other environmental factors, and it is past time to utilise the skills of our older, retired, and "unemployed" community members in a developing resource which makes us much more independent both of fluctuations in climate, energy base, and multi-national control. A permaculture can start at every level, from private garden to national policy, as a matter of simple personal decision. Thousands of Australians have already decided, and have written to the authors for advice.

A little thought will reveal a great many features in permaculture that will lead to an improvement in public health.

10.5 A Concise Re-statement of Concepts, Possibilities, and Principles

- Permaculture planning is first of all spatial (Zone, Sector, Edge, Elevation), and secondly, ecological (Diversity, Multiple Function, Energy-production).
- All processes; planning, planting, building, fencing, controlling, directing, and utilisation are evolutionary, leading to new or alternative strategies in future planning.
- The broad aim is to evolve a sustainable synthesis of settlement, landscape, vegetation, and animal species (including man).
- Energy is conserved and generated within the system, and directed and controlled if it comes from outside.
- Diverse yields over all seasons mean an input of human harvesting and simple technologies, but most of the essential needs of man can be achieved.
- Animals are designed into the system, some loss of direct yield being accepted, as animals harvest and utilise pasture and wastes or products inaccessible to man, as well as giving a unique diversity of yield.
- Every unit is placed for best use of energy, and in accord with the broad principles, so that every structure and species will serve two or more functions.
- Observation of the evolving system should yield ideas of increasing the complexity, stability, and yield. Control and observation are ongoing needs.
- Concepts such as waste land, unused buildings, unoccupied vertical space, unemployment and organic wastes should become obsolete, especially in cities, as all can be utilised in energy production for the community.
- Future settlement can be planned to be largely self-sufficient and productive, and existing settlements modified towards this end.
- Every discipline, trade, and skill can be utilised in the planning, control, and production of the system.
- Biotechnical systems can often replace active mechanical devices used to produce energy or moderate the environments of settlements and buildings.
- An evolving permaculture gives witness to present concern, and builds a beneficial future legacy.
- Involvement in permaculture provokes a philosophical and natural approach to the environment and its products, demonstrates the intrinsic values of complex systems, and generates the basis of a fully-integrated environmental science.
- Regional stability is promoted, and regional trade and exchange evolved, so that reliance on distant ownership or energy is reduced or made irrelevant. Thus individuals and groups begin to assert control over their life style and future.
- There are applications to small and large areas, from indoors to frontier, and potential useful activities for old and young, and the infirm.
- Wide acceptance of permaculture predicates a change in petty regulation and broad planning,

as well as giving a unified goal for the total society of man.

- Beginning can be made by an individual or institution, as a simple matter of decision. Diversity of creative planning is a probable result.
- Products and wastes return to the system, and fertility builds as soil evolves complexity and essential nutrients.
- The energy generated is governed by the efficiency of using photo-synthetic energy, and fuels for mobile systems can be produced.
- Thus, a society becomes involved in producing the essentials of its own existence, and is unlikely to make the gross errors of past fiscally-based and artificial economies; policies based on the simplistic concepts of external free energy.
- We repeat that we are shaping a tool and an idea; how the application of either of these is made is for each of us to decide, and to refine. Feedback is an essential part of the system.

10.6 As a Final Statement

We do not believe that a society can survive if it lacks values, direction, and ethics, and thus relinquishes control over its future destiny. This book is a contribution to the taking of such control. Some of the ultimate in obscene devices can be evolved in machine technologies bereft of value, as when President Ford approved the evolution of a nuclear device which kills living things, but leaves "property" unhurt, using neutrino showers that pass through bricks and mortar and damage only living tissue (A.B.C. news, June 7, 1977; Editorial, *The Mercury,* June 8).

This is the sort of technology which, at enormous cost in human energy and skill, negates life. We must set our face against such insanity, by working for the evolution of living systems that would outlaw such thoughts and objects, and use our energies in constructs that build compatible social-organic systems. Permaculture and other humane technologies can be a local and global co-operative venture, where no 'secrets', competition, or paranoia need exist, and the free interchange of energy, materials, and skills can be achieved.

As in nature, so in society, we can let many varieties of behaviour flower, but we must judge them from their yields, from their inherent stability, and their beneficial effects in interaction. A society that commands energy but has no ethics or goals is like a child with a machine-gun, a potential danger to everyone and everything, surrounding it. We say, let us give the child an education modelled on permaculture; something that needs and returns nurture. It is time to turn the ebbing tide of energy towards useful ends, and develop a permaculture for the society of man and nature.

We might borrow the motto of the University of Tasmania:

INGENIIS PATUIT CAMPUS

"The field lies open to intellect"

It is our responsibility to the future not to leave a barren field.

11.0 The Permaculture Tree (see Fig. 11.0.1)

The patterns and forms of a tree are found in many natural and evolved structures; an explosion, event, erosion sequence, idea, germination, or rupture at an edge or interface of two systems or media (here, earth and atmosphere) may generate the tree form in time and space. Many threads spiral together at the point of deformation of the surface, and again disperse. The tree form may be used as a general teaching model for geography, ecology, and evolution; it portrays the movement of energy and particles in time and space. Foetus and placenta; vertebrae and bones; vortices; mushrooms and trees; the internal organs of man; the phenomena of volcanic and atom bomb explosions; erosion patterns of waves, rivers, and glaciers; communication nets; industrial location nets; migration; genealogy; and perhaps the universe itself are of the general form portrayed.

Feedback is obtained by observation; energies are demonstrated by the shape, speed of growth, and evolution of the system; the detritus of moraines and deltas represent extent and time sequences, as do the growth rings of trees. Particles interweave at nodes (as the xylem and phloem in a tree) to form sinuous and spiralling pathways. Distortions of shape represent intrusive forces, deflections from the perfect pattern caused by uneven structures and elements in the media. Time is the dynamic dimension.

Simple or multiple pathways describe yin-yan, swastika, infinity, and mandala symbols. A torus of contained forces evolves within the energies of the pattern, like the doughnut of smoke that encircles the pillar of the atomic explosion.

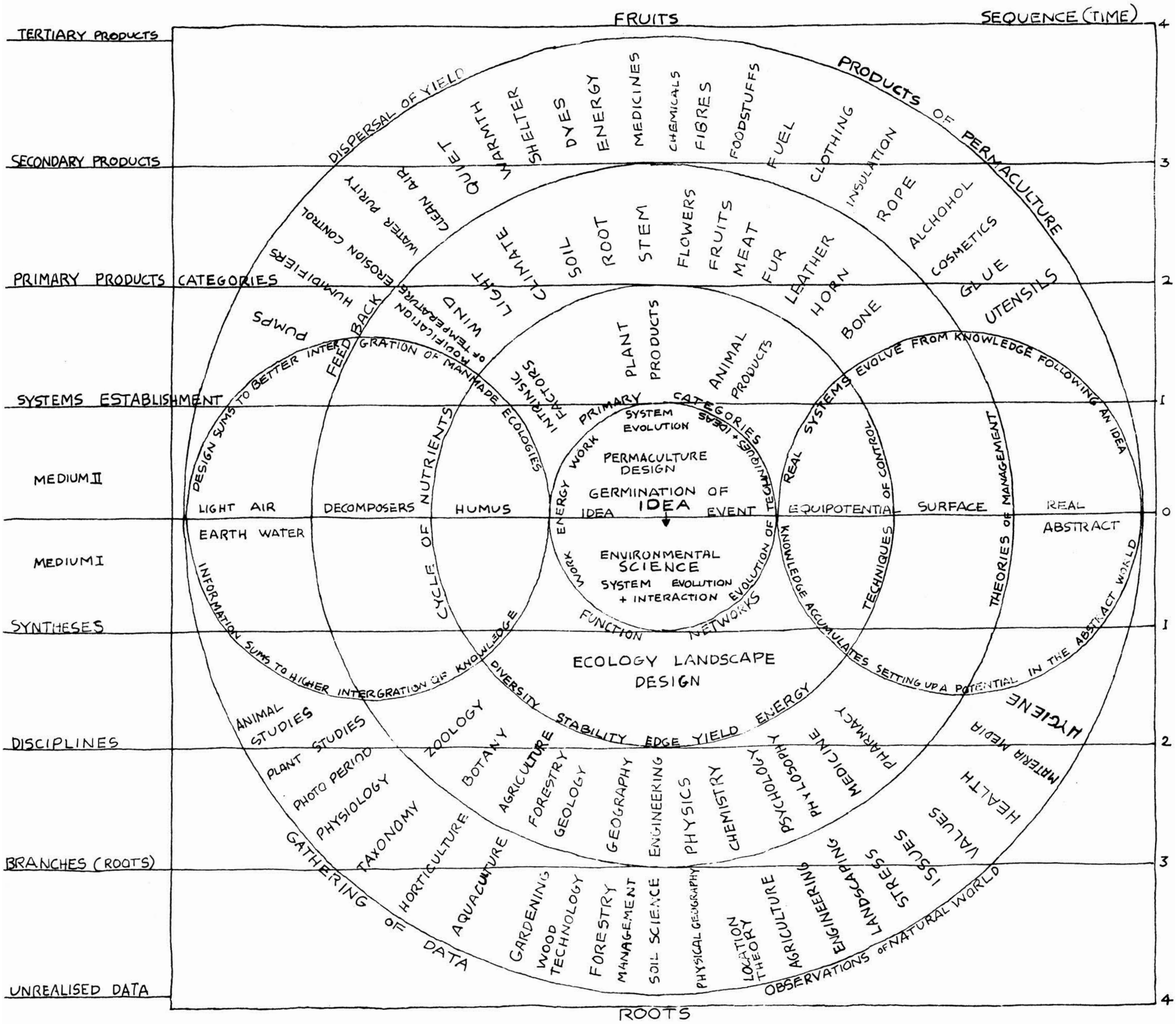
Landscapes and treescapes demonstrate many such patterns. Points to contemplate are the place of the event or idea, surfaces, curvatures and extent in time (the longer the stem, the more material on the move, the greater the englobement potential).

Each event therefore, generates reflections of growth, and gathers new nutrients for dispersal. Knowledge sums to productivity, roots to fruits. Energy gradients are delineated in plan and section, and any interface of systems, real or abstract, presents a location for an event, releasing the accumulated energy and potential in the media. The form is a translation, a conveyance, a resolution of media potential, a generation and a dissolution.

Permaculture, like a tree, is a holistic system, a synthesis of disciplines translated into real effects. Who can say if the idea or the media potential triggers the form? Does it matter? There are infinite pathways and possibilities, roots and fruits.

THE PERMACULTURE TREE

Knowledge flows to Productivity



Appendix A Sources of Species and Information

Many of the species of plants listed in Appendix B are not commonly grown in Tasmania. Seed of most species are fairly easy to obtain, even if it comes from overseas. Some restrictions are placed on seed importation by quarantine authorities but usually fumigation is all that is required. When seed is not useful (e.g. Bamboos) or cultivars of the species are required, every effort should be made to find an Australian source. There is a considerable range of varieties of fruit and nut trees in Australia and many others are plants held by research authorities (e.g. C.S.I.R.O. or Agr. Depts.) or nurseries and may not be available. Importation of trees is a lengthy process; the trees must be grown in quarantine for one, two or sometimes three seasons before they are released. However, with good-quality grafted trees of Black Walnut, Chinese Chestnut, Butternut, etc. available from U.S. nurseries, such imports are well worth the trouble. This is really for the dedicated nurseryman or specialist grower.

Local gardens, parks and roadsides should not be overlooked as sources of seed, cuttings or seedlings. Seed of a range of species could possibly be available from Botanic Gardens, if such seed was not in demand from Botanic Gardens elsewhere (e.g. Acorns).

Eventually, a network could develop, of people interested in little-grown useful plants, propagating and distributing such species. These activities could be extended and selection of local varieties made, to increase the usefulness and range of plants available to the Permaculturalist. Selection of high-yielding sweet acorns, cold climate olives or carobs, for example. This work requires dedication and time but is not costly.

Commercial sources indicated here and in Appendix B are not to be considered superior to other sources, and are chosen for usefulness to Australians in this edition. We welcome other contributions for future editions.

In a sense, permaculture is a "location-free" activity, and materials such as cuttings, roots, and seeds can be sent or obtained by post. An urban or rural permacultural system becomes a resource once it exists, in that the reproductive capacity of plants is enormous. The real difficulty is to gather together the many species needed, and this is what takes time and money in the early stages of establishment.

Aquarium supply houses often catalogue aquatic plants and animals, and again local authorities can be consulted. We do not want to introduce unusable or pest species like the cane toad, sparrow, and fox into an ecosystem designed to yield. Many directly useful species are already available within Australia and New Zealand, and in research institutions.

Some change in the orientation of local authorities is needed to allow (for instance) the breeding of marron in dams and creeks, and the release of quail in urban permacultures; there is a fine line between domestic, or easily harvested species, and feral animals (wild cats are on the debit side, rabbits can be a plus-or-minus quantity, and pheasant and some waterfowl a benefit).

Truly domesticated cultivars or variants, unlikely to survive without our assistance (Belgian Hares in the rabbit, the larger varieties of table pigeons) are therefore unlikely to present any difficulties and could be encouraged as domestic species; as are fruit cultivars (Boysenberry *versus* blackberry). There are also miniature cattle, such as the U.K. Dexter (an old breed near the Welsh black) and the Nepalese small humped dairy cattle which are suited to very small backyard operations, and are not so damaging as the large breeds now in Australia. Import of sperm of such breeds can be organized.

Exotics such as the alpaca may also suit montane or dry areas where sheep are limited in value, and there are many varieties of sheep suited to specific habitats and uses, such as the Soay breed of the U.K. offshore islands, which eat kelp.

Finally, we would like to stress that the more limited the area available for permaculture, the more strictly plants and animals should be chosen for maximum yield, and thus local experts must be consulted. Some cultivars and grafted forms of comfrey, chestnut, carob, walnut and so on may yield 10-20 times the crop of unselected plants, and for the single tree or very small garden this is a most important consideration. Large domestic varieties of quail, pigeon and guinea-pig are available, and selected hybrid fish species, yielding one-sex or infertile progeny for known stocking rates in dams can also be obtained. Aquarium Societies are able to assist in advising on the fish species suited to a local area.

Australian Sources

Forestry Commission Nursery, Perth, Tasmania (and other States).
  Some useful tree seedlings — small, cheap.

Goodwins International Seed Merchants, Bagdad, Southern Tasmania
  Wide range of seed available.

New Gippsland Seed Farm, Silvan, Victoria.
  Mostly vegetable seed. Also herbs and some other useful plants. Excellent quality.

Beaufort Herbs, Cootamundra, N.S.W.
  Seed and plants.

Chandler's Nursery, Sandy Bay, Hobart, Tasmania.
  Good quality plants. Will order a wide range of plants, especially fruit trees from mainland growers.

Allen's Nursery, Launceston, Tasmania.
  Wide range, helpful — will order unusual plants.

Fleming's Fruit Tree Nurseries, Monbulk, Victoria.
Large wholesale nursery. Wide range of varieties.

W.A. Sheppard and Sons, Moorooduc, Victoria.
Nut and fruit trees.

Frank Lucas, Boronia, Victoria.
Seedling nut trees. Bulk orders only (min. 100 trees). Very cheap.

John Bruning and Sons, Somerville, Victoria.
Wide range of nut trees.

David Noel, Shenton Park, Perth, West. Australia.
Rare seedling nut trees. No forwarding service.

Other and International Services

Thompson and Morgan, London Road, Ipswich, England.
Seed of some unusual, useful species. Mainly vegetables and ornamentals.

Last Whole Earth Catalogue.
Names, addresses and comments on American Seedsmen and Nurserymen.

New Zealand Whole Earth Catalogue.
New Zealand Nurseries, addresses, etc.

Organic Gardening and Farming Society, (quarterly publication), $6.00.
Magazine Editor, David Stephen, 12 Delta Avenue, Taroona, Tasmania. Address: Box 56, P.O., Sandy Bay, Tas., Aust. 7005.
Medium through which material and information can be exchanged.

Western Australian Nutgrowers' Society (W.A.N.S.), Newsletter "Quandong",
Editor, David Noel, P.O. Box 27, Subiaco, W.A. 6008.
Information on sources of nut trees and related information.

International Association for Education, Development and Distribution of Lesser Known Food, Plants and Trees.
Publishers of *Good and Wild,*
P.O. Box 599, Lynwood, California, 90262. U.S.A.
These people are listed by the *New Alchemy Newsletter,* Fall, 1976.

In England, there is a National Seed Development Organization at Newton Hall, Newton, Wittlesford, near Cambridge.

The National Institute of Agricultural Botany,
Huntingdon Road, Huntingdon, Cambridge, U.K.

The Henry Doubleday Research Association (and Lawrence Hills).
Australian Secretary is Ms. June Fear, Greggs Road, Kurrajong, N.S.W. 2755.
Head office is at Convent Lane, Bocking, Braintree, Essex, U.K.
[Director, Lawrence Hills, of comfrey fame, also interested in tree crops for the third world].

Appendix B Catalogue of Plants

Plants species listed alphabetically by common name. All are considered useful in temperate permacultures but are not necessarily readily available or fully tested at present. Many other plants, especially common agricultural pasture plants and weeds (mainly of medicinal value) could be considered and we would like to hear of useful species located by others.

Although all are 'permanent plants', many listed are not considered as perennial shrubs, trees, vines or herbs. Other types of plants are self-seeding annuals, rhizome and bulb plants, which die down each year, root and other plants harvested completely but re-seeded immediately (e.g. Oca, Common Reed) — that is to say, the specimens themselves may not be permanent but the species are permanently part of the system with no need for annual sowing (apart from leaving a few roots in the ground after harvest).

References used: 3, 4, 5, 7*, 8*, 9*, 10*, 11*, 12*, 13, 14, 15*, 16, 17*, 18*, 22, 23*, 30, 32, 33, 34, 36, 37*, 38*, 39, 40*, 41, 43, 46, 48*, 49, 51*, 52, 53*, 54*, 55*, 56*, 57, 58*. Those starred are the most important ones.

Other references are indicated in the Appendix or consist of nursery catalogues and lists.

Plants are listed under the following number system:— (where a number is missing, we have no data)

1. *COMMON NAME*
2. *Family*
3. *Genus*
4. *Species*
5. Varieties.
6. Other names.
7. Physiology.
8. Propagation.
   Note: Where "stratification" or chilling of seed is mentioned, autumn planting in mulch is often effective.
9. Origin, distribution.
10. Uses and functions.
11. Climatic limits, sites and soils.
12. Availability
13. References and other information.

1. *ACORUS*
2. *Araceae* 3. *Acorus calamus*
6. Sweet Flag, Myrtle Flag, Calamus.
7. Aquatic reed, flower December-January.
8. Root division in early spring.
9. Native to S. Asia and Central and S. America.
   Ornamental plant in France.
10. Rhizomes — aromatic vinegar.
    — Candy.
    — Gin and beer flavouring.
    — Digestive stimulants.
    Leaves — flavouring.
    Essential oil — cough inhalations.
    Two or three year old rhizomes are gathered in autumn and dried. These do not keep very long.[48]
11. Probably suited to most cool climates. Pond and river banks, damp, muddy soil.

1. *ALMOND*
2. *Rosaceae* 3. *Prunus dulcis*
5. *amara and* VAR. *dulcis* — many cultivars.
7. Small deciduous tree, yields late summer-early autumn after four years (grafted).
8. Bud or graft on to almond seedling — sometimes peach.
9. Near East. Naturalised in S. Europe and W. Asia. Widely cultivated commercially — California, S. Australia and S. Africa.
10. VAR. *dulcis* — culinary nuts.
    amara — bitter almond used to express almond oil cooking, etc., plus essential bitter almond oil — medicinal.
    Bee forage in spring.
    Maximum yield (of nuts) after twenty years — over 700 lbs/acre.
    Nuts are knocked from trees.
    Often self-sterile, requiring two cultivars for pollination.
11. Spring frost kills flowers and young fruit. Frost-free areas for reliable crops, occasional yields elsewhere.
    Deep well-drained soil for heavy crops. Heavy or alkaline soils are not suitable. Dry, sandy soils 'O.K.'.
    Sunny, warm site is preferable. Almond can stand neglect and low-nutrient levels and still yield.
12. Nurseries will order trees — up to a dozen cultivars available.
13. See Howes[9] and Jaynes[12] for more information on culture.
    See wholesale nursery catalogues for information on varieties.

1. *ALPINE STRAWBERRY*
2. *Rosaceae* 3. *Fragaria fresca semper-florens*
7. Clump-forming herb.
8. Division.
9. Europe.
10. Desert fruit — small, very prolific, long-bearing season.
    Birds do not take fruit.
    Plants do not runner.
11. Well suited to Tasmania and cool areas.
    Moist, rich soil best. Moderate shading is 'O.K.'.
12. Through some nurseries, seed from Thompson and Morgan.

1. *APPLE*
2. *Rosaceae* 3. *Malus pumila*
5. Hundreds of named varieties, many cultivars.
7. Small deciduous tree to about seven metres.
8. Root grafting or budding. Seedling rootstocks are often difficult to raise. See Bailey[38] on germination techniques.
9. Forests of temperate Europe and Asia. Long in cultivation.
   Tasmania is a major producer and exporter of apples.

10. Fruit — fresh, cooked, dried, cider, pig forage.
    Bee forage.
11. Well suited to cool areas. Wide range of soils and sites are suitable for apples but sandy loam over clay subsoil is considered perfect.
12. Wide range of varieties available from nurseries.
13. Some unusual local varieties exist in Tasmania.

1. *APRICOT*
2. *Rosaceae* 3. *Prunus armenaica*
5. Many cultivars.
7. Small deciduous tree to seven metres. Yields Nov.-Jan. depending on variety.
8. Budding on to plum or peach stocks.
9. W. Asia. Probably first cultivated by the Chinese about seven thousand years ago.
10. Fruit — fresh, dried. Fruit should be picked when fully ripe for full flavour.
    Bee forage.
    Kernel — cooking oil.
    — medicinal uses.
11. Blossoms are susceptible to frost damage but most cool areas are suitable for apricots. Mulching and watering are necessary in summer. Apricots love lime. Well-drained friable loam is necessary for healthy, high-yielding trees.
12. Most nurseries. A dozen or so varieties are available from wholesale nurseries.

1. *ARROWHEAD*
2. *Alismataceae* 3. *Sagittaria sagittifolia* and *S. chinensis*
7. Small aquatic plants.
8. Division.
9. Cosmopolitan — Europe, Asia and N. America. Extensively cultivated in China. Food to Japanese and N. American Indians. *S. chinensis* sold in San Franciscan Chinese stores.[37]
10. Starchy roots boiled or roasted. These are dug out of the solid earth below the mud in ponds or marshes.
11. Probably well suited to cool conditions. Ponds, dams, marshes and slow-moving streams.
12. Unknown to authors.

1. *ASPARAGUS*
2. *Liliaceae* 3. *Asparagus officinalis*
5. Several cultivars. Mary Washington 500 now popular.
7. Perennial rootstock with new aerial shoots each season.
8. Crown division.
9. Europe — wastelands and dunes. Cultivated by ancient Greeks.
10. Young shoots or spears eaten, also medicinal uses. Harvested in late spring. Yields after three years for at least twenty years.
11. Hardy; deep mulch needed. Salt in all but coastal soils helps. Most sites suitable.
12. Ordered in nurseries in one or two-year-old crowns.

1. *BAMBOO*
2. *Poaceae* (*Graminaceae*) 3. *Arundinaria, Phyllostachys, Bambusa, Sasa, Chusguea, Shibateae* 90-100 species.
7. Evergreen clump, forming grasses with tall woody stems.
8. Division of clumps, rhizome cuttings, basal cane cuttings. Seed is rare, if produced at all, in many spp.
9. Asia, S. America, N. America and Africa. Most spp. are tropical but some are very hardy even to mountain climates.
10. Canes — huge number of uses. Structural as stakes, building framework, concrete reinforcing, spears, arrows, etc. Also utensils, musical instruments, paper. Shoots as food and low-value pig forage — very high water content.
    Clumps as windbreaks, steep bank stabilisers.
    Foliage and seed of some spp. as forage, poultry food.
    Clumps are hilled to produce large, tender shoots.
11. All species listed will grow in U.K. climate so should do well over most cool areas. Site not very important except that most species require plenty of water. For growth of canes a soil rich in organic matter and nitrogen is best.
12. Very few useful species available locally. Encouragement of importation of the most useful species would be worthwhile.
13. See following list for species information. Mostly from Lawson.[15] Species which are invasive could become a pest if introduced. Canes dried carefully over six or twelve months give best timber. Shoots, if bitter, should be soaked in two to three changes of water. Spreading types will not cross running water — drain 60cm wide will prevent their spread.
    1. *Arundinaria ancepts.* Smooth cane 12' x ¾". Used for commercial cane production in U.K. Running rootstock. Hardy.
    2. *A. falcata.* Needs warm and sheltered site 20' x ½". Edible shoots from November on. Does not sucker, grows slowly in clumps.
    3. *A. falconeri.* Warm site, part shade 30' x 1¼". Does not sucker. Canes for baskets, fishing rods.
    *4. *A. fastuosa.* Stiff canes 25' x 1¾", ramrod straight. Edible shoots. Canes split easily for weaving.
    5. *A. graminea.* Hardy shade spp. Ideal canes for garden use 10' x ¾". Runs freely. Shelter belt spp.
    6. *A. hindsii.* As above, thrives in shade. Canes 10' x 1". Runs freely.
    7. *A. hookeriana.* Warm site 18' x1". Slow increase.
    8. *A. japonica.* Best hedge spp. 20' x 1". Hardy, "arrow" bamboo.
    *9. *A. macrosperma.* Large cane Virginia and Kentucky. Produces an abundant crop of seed from heads like those of broom corn — similar to wheat, used by Indians,[37] probably good poultry forage.
    10. *A. niitakayamensis.* Hardy 30' x 1½". Edible shoots. Free running.
    11. *A. pumilia.* Hardy dwarf 2½' x ¼". Used to stabilise loose soil. Very fast-moving, invasive.
    12. *A. racemosa.* Hardy. Foliage as cattle fodder 15' x 1½". Runs but easily controlled.
    13. *A. spathiflora.* Sheltered sites, 15' x 1". Conspicuous nodes, used extensively in small manufactures (handles, etc.). Clumps, no runners.
    *14. *Phyllostachys aurea.* The "fishpole" bamboo, stiff canes 12' x 1½". Very hardy (to 0 deg. F in U.S.A.). Edible shoots, slow-moving runners. Grows in Melbourne Botanical Gardens, to 20'.

15. *P. castillonis.* Hardy 15' x 1½". Edible shoots, slow-spreading.
*16. *P. mitis.* Hardy. Can grow very large (to 40'). Normally 20' x 1½". Prized for sweet, edible shoots. Good quality wood from mature canes.
17. *P. nigra.* Rich black canes 20' x 1". Hardy. Used in small manufactures. Edible shoots, does not run.
18. *P. pubescens.* Sheltered warm sites. 15' x 1½" (to 60' x 24" in warm climates). Edible shoots, fragrant and delicious when cooked in two changes of water.
*19. *P. quilioi.* Largest and commercially, most valuable bamboo in Japan. Very hardy. 20' x 1½" — good timber, thick walls at bases of canes. Edible shoots.
20. *P. sulphurea.* Very hardy. 30' x 1¾". Edible shoots.
21. *P. verdi glaucescens.* Very, very hardy. 18' x ¾". Thin-walled canes. Suits the coldest areas and sites.
22. *Sasa* spp. Dwarf forms, free running, used as water-fowl cover on islands.
23. *Chusquea culeou.* Hardy and drought resistant 18' x 1½". Solid, sturdy canes. Edible shoots. Clumps, does not run.

N.B. Sizes given are for U.K. Larger specimens should grow in parts of Tasmania.
Starred (*) species show the most potential for Permaculture.
John Isaachsen's Bamboo Nursery, West Coast Road, R.D., Oralia, Auckland, New Zealand.
and: New Zealand Department of Agriculture, Research Division, Ruakura, Hamilton, New Zealand.
[Ref. N.Z. Whole Earth Catalogue].
The abovementioned would be two places to enquire about Bamboo species after Australian sources have been checked out.

1. *BANANA PASSIONFRUIT*
2. *Passifloraceae* 3. *Passiflora mollissima*
5. No named cultivars.
7. Large vigorous sub-tropical climber.
8. Seed. Seedlings come true to type (Ref. 2).
9. Andes.
10. Fruit — fruit salads.
Long-yielding season, mainly summer/autumn.
11. Well suited to cool conditions. Most soils and sites suitable if not very exposed. Rampant nature demands plenty of room such as an old dead gum tree. Grow on living acacias, as a trellis.
12. Commonly available from nurseries. Many vines have seedlings growing around them.

1. *BAY LAUREL*
2. *Lauraceae* 3. *Laurus nobilis*
5. No named cultivars.
6. Sweet Bay, Grecian Laurel.
7. Small dense evergreen tree to seven metres, sometimes much taller.
8. Seed or cuttings or half-ripe shoots.
9. Mediterranean — the laurel of laurel wreaths and crowns.
10. Leaves — bay leaves — culinary herb.
— medicinal for pain relief.
Essential oil of leaves and berries used as a perfume.
11. Well suited to cool areas, though it can be cut back by very severe frost. Suited to seaside and very shady positions. Not particular about soil.
12. Commonly available from nurseries. Widely planted in gardens.

1. *BEECH*
2. *Fagaceae* 3. *Fagus grandifolia* and *sylvatica*
5. No named cultivars for nuts.
6. American Beech and European Beech.
7. Large spreading park tree or tall forest tree to thirty-five metres. Dense foliage allowing little understorey. Very long-lived — up to one thousand years
8. Seed. Needs to be protected from drying-out to remain viable. Conditions under Beech trees are ideal for germination of Beech and other deciduous tree seedlings. Good-bearing trees could be grafted.
9. *F. grandifolia* — native of N. America — little cultivated.
F. sylvatica — N. Europe — natural food of squirrels, mice, pigeons, pheasants, rooks, jays and pigs. Used as mast (forage) and oil.
10. Nuts — good flavour but small — treated as chestnuts to prevent drying.
— roasted in France as coffee.
— oil is pressed in parts of Europe (Beech Butter).
— animal forage.
Wood — excellent charcoal for furnaces.
— tough — good for pulleys, tool handles, clothpins, etc.
Crops of nuts may not come for up to 16 yrs. and are then irregular. Heavy crops usually every 3-5 years, sometimes 8-12 years. Nuts usually fall with first frost.
11. Well suited to cool areas, including cold, inland, high country. Soil — well drained but well watered, very rocky soils 'O.K.', lime-loving trees. Tolerant of shaded forest conditions when young.
12. Not widely planted in Tasmania. Goodwins have seed.
13. Beech produce very dense shade with few plants growing as understorey but provide ideal conditions, due to leaf humus and shade for deciduous forest seedlings (Oak, Beech, Lime, Walnut, Chestnut, etc.). Mixed Oak and Beech woods eventually become pure Beech stands if left untended (climax forest).

1. *BERGAMOT*
2. *Labiatae* 3. *Monarda didyma*
6. Bee balm, Oswego tea, Red Bergamot.
7. Herb with spreading perennial rootstock. Flowers in summer.
8. Seed, or more usually root division.
9. Native of N. America — tea of the Oswego Indians.
10. Leaves and flowers for salads and other culinary uses.
Leaves as tea — sleep inducing.
— antiseptic for sore throats.
Excellent bee forage.
11. Probably suited to all temperate areas. Grows well at 1,400 ft. at Mr. Arthur, Tasmania. Rich moist soil will produce rapidly spreading rootstock. Shade tolerant — good understorey herb.
12. Herb seedsmen and nurserymen. Do not mistake for Bergamot Mint.

1. *BILBERRY*
2. *Ericaceae* 3. *Vaccinium myrtillus*
5. No named cultivars.
6. Blaeberry, Whinberry, Whortleberry.
7. Small deciduous shrub. Berries ripen January-February. Not long lived — maximum 28 years.
8. Seed in late winter.
9. N. Asia, Europe, N. America. Widely gathered, but little cultivated. Moors and heaths are natural habitats.
10. Fruit — jellies, tarts, etc.
 — treatment of scurvy, urinary complaints and dysentery.
 Leaves — tisane for diabetics.
11. Should be well suited to cool areas, including alpine areas. Dependent on soil fungus *mycorrhiza,* so could be difficult to cultivate. Acid, peaty and dry sandy soils — moorland or woodland sites.

1. *BLACK CURRANT*
2. *Grossulariaceae* 3. *Ribes nigrum*
5. Many varieties cultivated in Tasmania.
7. Multi-stemmed, deciduous bush to 1m.
8. Cuttings of 8-10" sections of preceding season's wood, in autumn and early winter.
 Very easily propagated.
9. Europe and N. Asia. Cultivated commercially in Tasmania, mainly for juice.
10. Berries — culinary uses.
 — juice as medicinal source of concentrated vitamin C.
 — dye.
 Bee forage.
 Short ripening season. Some varieties do not drop fruit and can be picked when all fruit is ripe.
11. Well suited to Tasmania up to 3,000 ft. elevation. In bad frost areas late flowering varieties are better.
 Exposed sites are unsuitable. Wet soils and partial shade are tolerated by Black Currants.
12. Common in Tasmanian gardens. Nurserymen.
13. See 'Berry Fruit Culture' (Ref. 11) for more information.

1. *BLACK LOCUST*
2. *Leguminosae* 3. *Robinia pseudoacacia*
5. No named varieties except ornamental types.
7. Deciduous tree 10-20 metres, thin foliage. Lives up to 200 years. Flowers late spring-early summer. Grows rapidly and forms thickets, suckering.
8. Suckers profusely — rooted suckers probably best.
9. Eastern U.S.A. — Forest edge is natural habitat.
10. Seed for poultry forage — may be poisonous to humans.
 Pasture improver on very poor country — nitrogen fixer.
 Excellent bee forage.
 Timber — very long lasting in ground (22 years untreated).
11. Very hardy — well suited to cool areas. Most sites — does well on the poorest soils and under the most adverse conditions.
12. Relatively common as a park and farm tree. Some nurserymen.

1. *BLACK WALNUT*
2. *Juglandaceae* 3. *Juglans nigra*
5. Jaynes [12] describes seventeen major cultivars.
7. Large deciduous forest tree to 40 metres, spreading to 20 metres if open-grown.
8. Stratified seed (nuts) which should not be allowed to dry or be cracked artificially.
 Cultivars are grafted — difficult.
9. Native of thirty-two states of U.S.A. Widely cultivated throughout the U.S.A.
10. Nuts — very concentrated flavour — low in starch and sugar, high in proteins.
 — cultivars generally have thinner shells, are easier to crack and have higher kernel weight (over 5 grams).
 — most cultivars give yields of dry, hulled nuts around 12 lbs./tree at 10 years and 35 lbs./tree at 20 years.
 — forage. 2-3 mature trees (seedlings) in Kentucky, feed 1-2 doz. hens the three winter months — cracked, but not separated from shell.
 Timber — durable and beautiful, very high prices paid for Black Walnut.
11. Should do well throughout Tasmania. Good specimen in Hobart Botanic Gardens. Until recently, sold by the Forestry Commission as a farm tree. A deep, well drained, fertile soil with ample water is necessary for high yields and good timber production. Seedlings are relatively tolerant of forest conditions.
12. Seed from some seedsmen or local trees in autumn. No cultivars are known to be available in Australia.
13. Separate male and female flowers as in all *Juglandaceae.* Self-fertile but sequences of male and female blooming called dichogamy make numerous trees necessary for assured nut production. Black Walnuts cast light shade and have deep roots so good for understorey growth, including pasture. However, some plants, including Lucerne and Apples, are inhibited by root excretions of Black Walnut (*Juglans*).
 See Jaynes [12] and Smith [18] for more information.

1. *BLACKWOOD*
2. *Leguminosae* 3. *Acacia melanoxylon*
5. No named cultivars.
7. Evergreen forest tree from 6-60 metres. Long-lived Acacia.
8. Seed.
9. Native to Tasmania, Victoria, N.S.W. and South Australia. Only small areas of large trees, of good quality timber, remain in Tasmania.
10. Fire retardant — little fuel accumulation, burns poorly.
 Timber — excellent hardwood.
 Bee forage.
 Nitrogen fixer.
 Trellis for vine fruit (living tree).
11. Suited to all cool areas. Size and form varies according to soil moisture and fertility. On moist (even wet) fertile sites, large, straight timber trees will result. On poor dry sites, the form and size is more like an olive.
12. Forestry Commission Nursery, Perth, Tasmania.

1. *BLUEBERRY*
2. *Ericaceae* 3. *Vaccinium corymbosum, V. pennsylvanicum*
5. Many named cultivars of these and other species.

6. High bush blueberry or swamp blueberry and low bush or sweet blueberry.
7. Deciduous shrubs, *V. corymbosum* ro 3m, *V. Pennsylvanicum* to 0.5m.
8. Seed — stratified in autumn for spring planting.
9. N. America. Not cultivated before this century. Widely cultivated today.
10. Fruit — excellent berries.
The latest of the berry fruits in ripening.
11. Probably well suited to colder, wetter parts.
A constant water supply is necessary for good fruiting but swamp conditions are not tolerated. Moist, acid soil, (pH 4-5) rich in humus and thick mulches are ideal.
Blueberries can tolerate a little shade but do best in full sun.
12. Some nurseries. Possible commercial production in Tasmania, were a range of cultivars available.
13. See Rodale[51] for complete information.

1. *BORAGE*
2. *Boraginaceae* 3. *Borage officinalis*
5. No named varieties.
7. Self-seeding annual. Flowers November-thru' summer till first hard frost.
5-6 weeks flowering from germination.
8. Seed sown in spring.
9. Native of Mediterranean region.
10. Excellent bee forage — long flowering season.
— ease of propagation in large quantities.
— attendance of bees is almost constant.
Culinary herb — leaves and flowers in salads.
— flowers candied.
Medicinal — anti-inflammatory.
Rich in potash and calcium — compost potential as with comfrey — breaks down very quickly.
12. Well suited to cool climate. Adaptable to most conditions but best in loose, stony, well-watered soil in a sunny position. If frosts are mild, seed set early in a season will germinate in autumn, grow and flower through the winter.
12. Herb seedsmen. Relatively common — survives in abandoned gardens.

1. *BROCCOLI — PERENNIAL*
2. *Cruciferae* 3. *Brassica oleracea botrytis asparagoides*
5. Nine Star Perennial.
7. Perennial vegetable, yielding for three to four years.
8. Seed sown mid-October.
9. Recent cultivar of British origin.
10. Vegetable — produces 6-9 heads per season.
11. Rich, well-manured garden soil — normal cultural requirements.
12. Thompson and Morgan.
13. See Organ, J., 1960. 'Rare Vegetables', Faber.
Ref. 52.

1. *BUCKBEAN*
2. *Gentianaceae* 3. *Menyanthes trifoliata*
6. Bog Bean, Water Trifoil, Marsh Trifoil, Marsh Clover.
7. Aquatic, perennial herb, flowering mid-summer.
8. Division of creeping roots into 30cm lengths, each with terminal bud in soft mud.
9. Marshy areas of N. America, N. Asia and Arctic Europe.
10. Leaves — suitable for hops in beer.
— roots boiled as vegetables by Lapplanders.
— wine or infusion for rheumatism, debility of liver and skin diseases. Externally for glandular swellings.
11. Should do well in very cold, wet areas. Wet, peaty soils or shallow water.

1. *BUNYA BUNYA PINE*
2. *Araucariaceae* 3. *Araucaria bidwilli*
5. No named cultivars.
7. Large, symmetrical dome-shaped tree 30-50m. Slow growing at first.
8. Seed or cuttings of leading shoots (from seedlings).
9. Queensland. Nut highly valued by aborigines.
10. Large nuts in cones — generally roasted.
Resin from trunk.
Timber — white softwood, highly valued.
Huge pineapple-like cones form at top of female trees every few years. Each segment contains a nut. Cones weigh up to 30 lbs. with nuts larger than almonds.
Trees are slow to yield.
11. Although a sub-tropical tree, the Bunya grows well in cool climates. A few large specimens grow and bear occasionally in the Hobart Botanic Gardens, Tasmania. Well-drained, deep, rich soil is probably necessary for large, good-bearing trees. Shelter from wind is necessary.
12. Seed from park specimens or seedlings from specialist nut-trees nurserymen.
13. Grown in a grove with other *Araucaria* species, male trees could be thinned for timber, leaving a few for pollination.

1. *BUTTERNUT*
2. *Juglandaceae* 3. *Juglans cinerea*
5. Jaynes[12] mentions seven named cultivars.
6. White Walnut.
7. Deciduous, with short bole and few stout limbs up to 30m.
8. Seed, stratified. Improved varieties propagated by grafting which is difficult. Transplants well.
9. N. America. Not much cultivated due to difficulty in cultivar propagation.
10. Nuts — rich, pleasant flavour — hard to crack.
Timber — good for cabinet work and wood carving.
11. Hardiest of the Walnuts — probably well suited to cool areas, including alpine areas. Found naturally on dry, rocky sites but can tolerate a high water table. Trees develop and yield best in rich, moist loams.
12. No source of nuts or trees known though grafted cultivars are readily available in U.S.A.
13. See Bush[10] and Jaynes[12] for more information.
J. cinerea is susceptible to the prevalent Walnut Fungus. (*Melanconis juglandis*).

1. *CAPE GOOSEBERRY*
2. *Solanaceae* 3. *Physalis peruviana*
5. Named varieties not known to authors.
7. Tender, creeping bush.
8. Seed sown in glasshouse or frames July and August. Treat like tomatoes. Self-seeding to some degree.

9. S. America. Grown at the Cape of Good Hope in the last century.
10. Fruit — fresh or stewed.
    Ripen late summer — early autumn.
11. Easily frost-damaged but established plants survive all but hard frosts. Limited in Tasmania to warmer parts. Most soils suitable. Protected, warm, sunny site for good yielding.
12. Some nurseries and seedsmen.
13. See Raphael[11] for more information.

1. *CAPUCHIN*
2. *Tropaelaceae* 3. *Tropalaeum tuberosum*
5. No named cultivars known.
6. Mayua (Peru) Anu.
7. Tuber-forming perennial, branching plant to 3 ft.
8. Tuber, rarely seed.
9. Peru. Related to nasturtium.
10. Tubers eaten raw, dried, dig in autumn and replant immediately.
11. Probably all cool areas. Fairly rich soil.
13. See Organ.[52]

1. *CAROB BEAN*
2. *Leguminosae* 3. *Ceratonia siliqua*
5. Named varieties in Mediterranean countries but none available locally.
6. St. John's Bread, Sugar Pod.
7. Small evergreen tree, 5-10m. Very long lived.
8. Seed or layers.
9. Mediterranean — cultivated for centuries.
10. Pods as stock food — energy and protein concentrate
    — ground as meal or fed whole to large animals.
    — meal as human food — carob coffee or chocolate.
    Seeds — 35% gum — has industrial uses (Ref. 32).
    Seedlings yield after 7-12 years. Budded trees in Limpopo Valley and Algeria yield after 4-6 years.
    Yields in Mediterranean climates are in the order of 100-500lbs/tree but individual trees have been known to yield up to 2,000 lbs.
11. Climatic limits are similar to the orange. A large tree in full, dense shade in Melbourne Botanical Gardens, Victoria, yields a few pods. Young trees in Hobart Botanic Gardens, Tasmania, do not yield as yet. Withstands high salinities in soils.
    Frost damages flowers and young fruit but not the trees.
    Humid, wet weather in autumn can rot the ripening pods.
    Probably very marginal in Tasmania. However, its value makes attempts to cultivate varieties which fruit in Tasmania well worthwhile. Dry, rocky sites are good. Carobs are totally drought-resistant. Any soil except compacted clay. Sunny, N.,-N.N.W. slopes or against north-facing wall.
12. Seed from Goodwin, trees from nurseries.
13. See Smith [18] for all full treatise.

1. *CASTOR OIL PLANT*
2. *Euphorbiaceae* 3. *Ricinus communis*
5. Cultivars do exist.
7. Open bush up to 4m; short lived, treated as an annual in commercial oil production.
8. Seed.
9. Grown commercially in India, Brazil, Manchuria and Mexico. A common weed of wasteland sites around Perth, W. Australia.
10. Expressed seed oil (35-55% oil) used medicinally — laxative; lubricant. The dehydrated oil is used industrially in paints, varnishes. Other uses are in the plastics, cosmetics, textile and printing industries. Used as a hydraulic fluid.
    Seed cake contains toxin ricin — suitable for fertilizer but not stock feed.
    An insecticide is extracted from the leaves.
    The stems are pulped for newsprint, cardboard and wallboard.
11. Grows well in Hobart, Tasmania. Probably suited to warmer parts of Tasmania. Drought resistant. Dry, rocky and alkaline sites are suitable. A sunny, warm, north slope would be the best site.
12. Some nurserymen.

1. *CHEQUERS*
2. *Rosaceae* 3. *Sorbus terminalis*
5. No known fruit cultivars.
6. Service berry.
7. Small, deciduous tree up to 10m and living as long as 200 years.
8. Seed — takes 2 years to germinate.
    Cuttings.
9. Europe — forest edge species.
10. Berries — used like medlar — desserts, conserves, etc.
    — rich in vitamin C.
    Hedgerow tree.
    Berries ripen in winter.
11. Well suited to cool areas. Shady, southerly slopes. Clay soils are best.
12. Some nurserymen.
13. *S. domestica* (True Service Berry) also gives edible berries when very ripe — common garden tree.

1. *CHERRY PLUM*
2. *Rosaceae* 3. *Prunus ceraifera*
5. Many wild varieties, cultivars and crosses with other plums.
7. Deciduous tree to 10m or more.
8. Cultivars are grafted but self-sown trees often bear good fruit.
9. Western Asia.
10. Fruit — prolific yield of small red or yellow plums — dessert fruit.
    — wine, jam, etc.
    — animal forage (pigs) eaten as they fall, before fermentation sets in.
    Yielding period can extend over 3 months.
    Bee forage in spring.
11. Well suited to cool areas. Most sites and soils suitable.
12. Wild trees — seedlings around mature trees.
    Cultivars — nurserymen.

1. *CHICORY*
2. *Compositae* 3. *Chichorium intybus*
5. Some named cultivars.
6. Witloof.
7. Perennial herb.
8. Seed.
9. Long used as a vegetable in Europe and the Orient — cultivated only in the last few hundred years.

10. Vegetable — leaves used in salads, blanched leaves of cultivars as a cooked vegetable.
 Roots — dried, ground and roasted as coffee substitute.
 — diuretic, tonic and laxative. Decoction used for rheumatism, gout and jaundice.
 Forage crop — leaves 3-6 tons/acre.
 — roots 5-12 tons/acre.
11. Well suited to Tasmania. Rich, well-drained garden soil for vegetable plants or high yield forage crops. Most positions as medicinal herb or occasional forage.
12. Herb seedsmen.

1. *CHINESE GOOSEBERRY*
2. *Dilleniaceae* 3. *Actinidia sinensis*
5. Many cultivars — few locally.
6. Kiwi fruit.
7. Large, woody, deciduous climber to 30m, forms bramble. Dioecious (male and female plants).
8. Seed.
 Grafts for cultivars, cuttings also, but tend to be weak-rooted. Male and female may be grafted on the one vine.
9. China. Grown commercially for export in New Zealand.
10. Dessert fruit ripening May-June.
11. Should yield in most parts of southern Australia. Not particular about soils but higher yields on fertile, well-watered soils. Sunny, sheltered position for ripening of fruit.
12. Some nurserymen.
13. See N.Z. Agr. Dept. booklet (from Govt. bookshop) on details of varieties, culture, etc.

1. *CLOUDBERRY*
2. *Rosaceae* 3. *Rubus chamaemorus*
5. No known cultivars.
6. Avrons, Maroshka.
7. Small bush to 0.2m.
8. Seed or division of rhizomes (easy).
9. Moorland of N. Hemisphere as far as 65 deg. N. Widely collected but little cultivated.
10. Berry — fresh, jam tarts, etc. — excellent, large, yellow, sweet berry.
11. Climatic limits unknown but should do well in alpine and high country areas. Cold, moist, frosty spots — suitable for bogs.

1. *CHINESE ARTICHOKE*
2. *Labiatae* 3. *Stachys sieboldii*
6. Chorogi.
7. Perennial plant to 0.5m.
8. Any piece of tuber or root.
9. China, Japan. Also cultivated in Belgium and France.
10. Tubers — vegetable — can be left in the ground until needed.
 — pieces replanted on harvest.
11. Lighter soils. Climatic range unknown but probably well suited to Tasmania and southern Australia.

1. *CHINESE CHESTNUT*
2. *Fagaceae* 3. *Castanea mollissima*
5. A few cultivars in the U.S.A.
7. Large spreading deciduous tree.
8. Seed as for sweet chestnut. See Bailey.[38]
 Budding or grafting — very difficult.
9. China.
10. Nuts — dried slightly for storage.
 — culinary nuts, flour.
 — animal forage.
 — bears in 5-8 yrs. from seed or 2nd year from grafting.
 — some trees have yielded over 65 lbs of nuts at 12 yrs. old.
 Varieties are self-sterile but seedling plantings pollinate satisfactorily.
 Trees should be less than 200ft apart for good pollination.
11. Should be well suited to cool areas.
 Well drained, light soils best.
12. No known source of nuts or trees in Australia.
13. The Chinese Chestnut is resistant to the blight fungus, *Endothia parasitica* and is now the main Chestnut species grown in the U.S.A. See Jaynes[12] for information on culture, varieties and propagation. Its blight resistance and early bearing make the Chinese Chestnut worthy of introduction and establishment in Australia.

1. *COLTSFOOT*
2. *Compositae* 3. *Tussilago farfara*
5. No named cultivars.
6. Coughwort, British tobacco.
7. Perennial herb with thick, creeping rootstock.
8. Division of rootstock.
9. Europe, N. Africa, N. and W. Asia.
10. Flowers and leaves. Medicinal — astringent, demulcent, emollient, expectorant. Most useful for bronchitis, asthma, coughs and throat catarrh.
 Smoking tobacco from dried leaves.
11. Should grow well in cool areas. Grows in a variety of soils, from moist loams to dry, rocky soils.
12. See Refs. 40, 48 and 53 for further information.

1. *COMFREY*
2. *Boraginaceae* 3. *Symphytum officinale*
 x peregrinum],
 x uplandicum]
5. Various types; cultivars locally. Some white-flowered forms.
6. Russian comfrey, Blue comfrey.
7. Perennial herb with tuberous crown to 1m. Dies down in winter.
8. Root division — any part of root crown will grow. Hoeing or ploughing through a patch in winter should result in large increase in plants.
9. Europe and W. Asia. Widely used medicinally.
10. Forage — very high yields on fertile, well-watered country — with 5-8 cuts per year, yields of 50-100 tons wet weight/acre have been reported.
 — 20-25% crude protein (dry weight).
 — roots as pig forage.
 Excellent bee forage.
 Medicinal herb — leaves or roots. Roots are most valuable — may be dried, powdered and used in ointments, tea, poultices. Very useful for bruises, swellings, arthritis,

rheumatisms, gout, broken bones and wounds.
Tea as cough mixture in more severe lung disorders — pneumonia.
Arrests internal bleeding of lungs, stomach or bowel.
Also for dysentery and internal ulcers.
Vegetable source of vitamin B12.
Culinary — leaves and flowers (sweet) in salads.
— blanched stems similar to asparagus.
— roots for thickening.
11. Suited to all cool areas. Does not die back in mild areas. Well-watered site, rich soil for large yields.
12. Relatively common in old gardens, some nurseries and herb suppliers.
13. *S. xuplandicum* does not die back in winter.
Comfrey will not spread but is very difficult to eradicate unless used for pig forage.
Reputable nurserymen can supply named varieties for best yields. See Ref. 69 for full information.

1. *COMMON REED*
2. *Gramineae* 3. *Phragmites communis*
5. No known cultivars.
6. Common marsh grass.
7. Aquatic reed with large, terminal, plume-like panicles to 4m.
8. Division — spreads by rhizomes.
9. Cosmopolitan. Naturalized along rivers, lakes and dams in Tasmania.
10. Rhizomes made into flour.
Stems and leaves (60-120") for thatching, etc.
Sugar (gum) extracted from leaves and stems.
Young shoots as vegetable.
11. All cool areas. Like spreading bamboos, can get out of control. Marshes, pools, dams, riverbanks.
12. Along rivers where it grows, e.g. Derwent (Hobart, Tasmania).

1. *CORNELIAN CHERRY*
2. *Cornaceae* 3. *Cornus mass*
5. No known cultivars.
6. Cornel-cherry.
7. Small, long-lived, slow-growing deciduous tree to 8m.
8. Cuttings.
9. Europe — cultivated for centuries. Natural habitat is forest edge and scrub. Commonly grown, ornamental in cool temperate areas.
10. Fruit — preserves, etc. — picked, then kept to develop full flavour.
Hedgerow.
May be 10-15 years before first flowers.
11. Should grow well in most cool areas. Moist, sheltered position.
12. Some nurserymen.

1. *COULTERS PINE*
2. *Pinaceae* 3. *Pinus coulteri*
5. No named cultivars.
7. Large pyramid conifer to 30m.
8. Seed, cuttings.
9. American pine. Seed collected by Indians.
10. Nuts — larger than those of *P. pinea.* Can yield only after 6 years.
Mature cones present on tree all year; may be gathered and dried to obtain nuts.
11. Mature tree at 'Native Point' in the Midlands, Tasmania. Should do well in most parts of Tasmania. Probably any well-drained site.
12. Specimen trees, no commercial source known.
13. Heavily armoured cones. 25cm x 10cm, may cause damage when falling.

1. *CRANBERRY [AMERICAN]*
2. *Ericaceae* 3. *Vaccinium macrocarpon*
5. Several American cultivars.
6. Trailing Swamp Cranberry.
7. Creeping vine — marsh plant.
8. Cuttings or layerings of stems in summer.
9. Temperate N. America. Gathered and cultivated commercially at suitable locations.
10. Berries for cooking — large.
11. Should grow well in cool areas but cannot stand very hard frosts without damage. Commercial culture is on peat or muck land over hardpan clays at 15" below the surface and a layer of grey sand 2-3" deep on top. pH should be 3.2 to 4.5. Probably best as occasional plants in suitable acid bogs.
12. No known local source.
13. See Rodale[51] for details of varieties and culture.

1. *CUSTARD BANANA*
2. *Annonaceae* 3. *Asiminia triloba*
5. Two wild types; large-fruiting type is desirable one. No cultivars.
6. Poor man's banana. American pawpaw.
7. Hardy, long-lived, deciduous tree 5-10m.
8. Seed, stratified, planted in spring, shaded seedbed. Germinates late summer. Growth only 1ft for first 2 years.
9. S.E. U.S.A. Gathered wild.
10. Fruit — rich banana-like flavour. Fruit ripens in autumn, can be picked half-ripe.
11. Grows as far north as New York. Should do well in southern Australia, even if fruit do not ripen fully. A rich, well-drained, neutral soil is best. A warm, slightly shaded position is most suitable. Custard Bananas grow well as an understorey tree.
12. No local source known. Seed from American seedsmen possibly.
13. See Simmons[17] and Rodale[51] for details of culture.

1. *DAMSON PLUM*
2. *Rosaceae* 3. *Prunus instilia*
5. Many varieties and cultivars.
6. Sloe, Bullace.
7. Spring deciduous tree.
8. Seed or suckers.
9. Parent of European cultivated plums, along with *P. domestica.*
Naturalized hedgerow plum in England.
10. Fruit — quality of seedlings can be good.
Bee forage.
Hedgerow tree.
11. Well suited to cold areas. Most sites.

1. *DANDELION*
2. *Compositae* 3. *Taraxacum officinale*
5. Cultivars locally, seedsmen.

7. Small perennial herbs with yellow flowers early spring to late autumn.
8. Self-seeds. Root division.
9. Widely distributed, extensively cultivated in France — several cultivars.
Long in use but cultivation is modern.
10. Bee forage — early and long flowering, high pollen yield — very important in early spring.
Vegetable — blanched leaves of some varieties.
Leaves and roots used medicinally — juice removes warts, improves liver function. Active substances, vitamins, sugar, protein, fat, mucilage, saponins, choline, wax and rubber, mineral of K, Ca, Mg, Na, S and Silicic acid, alkaloids, glycocides and tannins.[48] Also used for rheumatism, arthritis, blood diseases, eczema and dropsy.
Roots roasted as coffee.
Forage crop — improves milk quality and quantity.
Latex (rubber) from roots — commercial crop in Russia.
Flowers as dye.
11. Well suited to cold areas — common weed. Does best on rich, well-watered soil. Good pasture with lucerne, under fruit.
12. Common weed, cultivars from some seedsmen (e.g. Thompson and Morgan).

1. *EARTH ALMOND*
2. *Cyperaceae* 3. *Cyperus esculentus*
5. No named varieties.
6. Tiger Nut, Chufa, Zulu Nut.
7. A water-edge sedge grass.
8. Crown division.
9. S. Europe and N. Africa. Long in cultivation — at least 4,000 years.
10. Tubers — sweet dessert — much esteemed in Mediterranean countries.
— rich in oil.
— made into beverage in Spain, "Horchata".
Seeds used as coffee substitute in Hungary.
Crops of up to 3 tons/acre are obtained in N.E. Nigeria, Africa.
11. Runs wild on riverbanks from Pennsylvania to Carolina, U.S.A. and is cultivated in Germany, so should grow in southern Australia. Marshes, riverbanks and wet spots.

1. *ELDERBERRY*
2. *Caprifoliaceae* 3. *Sambucus nigra*
5. No cultivars.
7. Multi-stemmed, deciduous shrub to 6m.
8. Cuttings — very easily propagated.
9. Europe and W. Asia. Once cultivated in Britain for wine.
10. Berries — wine.
— dye.
— conserves, etc. — should not be eaten raw.
— medicinally for neuralgia, migraine.
Flowers — fermented with lemon juice and peel as beverage.
— infusion for respiratory inflammations.
Hedgerow shrub.
Hollow stem used as tubing, etc.
11. Well suited to cold areas. Semi-shade is best, but full shade 'o.k.' — good understorey. Any soil.
12. Common in Tasmanian gardens.

1. *FAT HEN*
2. *Chenopodiaceae* 3. *Chenopodium album*
5. No cultivars.
6. Pig weed.
7. Self-seeding; annual herb.
8. Seed.
9. Widespread in temperate and tropical regions. Remains found in pre-historic lake villages in Switzerland. Used by American Indians. Relatively common weed in Tasmania, especially on seashore.
10. Vegetable — young plants as leaf vegetable.
Seed — relished by poultry and birds.
— can be ground as flour.
Beneficial to neighbouring plants by raising mineral nutrients in the soil.[48]
11. Well suited to cool areas. Responds to nitrogen-rich soils. Salt tolerant.
12. Not available commercially. Weeds.
13. Also see Good King Henry.

1. *FEIJOA*
2. *Myrtaceae* 3. *Feijoa sellowiana*
5. No cultivars locally.
6. Pineapple guava.
7. Large, evergreen shrub 4-6m.
8. Seed in early spring at 13 deg.-16 deg.C, germination takes 2-3 weeks. Leafy cuttings in summer (gentle bottom heat helps).
9. N. Argentina to S. Brazil. Cultivated in many subtropical areas. Grown commercially in N.Z., where relationship between round leaf tip form and heavy fruiters was discovered.
10. Fruit — dessert, jellies, etc. — sugar content 6%.
Petals of flowers used in salads — very sweet.
Yields 3-4 years from cuttings.
11. In England, fruit only ripen in hot summers, but probably good in most cool areas. Very hardy to frost. Yields at 1,400 ft, Mt. Arthur, Tasmania. Common in Launceston, Tasmania, area. Sunny, sheltered position for best yields.
12. Most nurseries.
13. Round tips on leaves in nursery beds indicate large-fruited forms. Quickly improved by selection of round-leaved forms.

1. *FENNEL*
2. *Umbelliferae* 3. *Foeniculum vulgare*
6. Sweet fennel, Wild fennel.
7. Upright self-seeding biennial or short-lived perennial. Flowers Jan.-April.
8. Seed.
9. Native of Europe. Naturalized in most temperate regions. Widespread along sheltered roadsides and waste places in Tasmania.
10. Seeds and Roots — medicinally — antispasmodic, aromatic, carminative, diuretic, expectorant, galactagogne, stimulant, stomachic.
Seed — culinary.
Foliage — fresh herb with fish, etc.
11. Thrives in cool areas in sunny, sheltered sites. A well-drained loam soil is best.
12. Seedsmen. Seed from wild plants.
13. See Refs. 40, 41, 48, 53.

1. *FIG*
2. *Moraceae* 3. *Ficus carica*

5. Many cultivars.
7. Deciduous shrub or tree to 8m.
8. Cuttings 4-5" hardwood, cut just below a bud in autumn. Planted deep so tip just shows above surface.
9. W. Asia. Now widespread in warm, temperate regions. Naturalized as far north as Britain. Important subsistence and commercial crop from Portugal to Asia Minor.
10. Fruit — fresh.
    — dried, 50% sugar.
    — mild laxative.
    Up to 3 crops/year in warm climates but only one in cool climates.
    Figs for drying are left to dry on the tree.
11. Grows and yields successfully in Hobart, Tasmania. Most cool areas are suitable but degree of ripening will vary from site to site. Sunny, warm, sheltered site most suitable. Does well on poor, thin limestone soils.
12. Most nurseries.
13. Figs are fairly disease and pest free.

1. *GINKGO*
2. *Ginkgoaceae* 3. *Gingko biloba*
5. No known cultivars.
6. Maiden-hair tree.
7. Large, deciduous, slow-growing, long-lived to 30m. Many live more than 1,000 years.
8. Seed, slow-growing, transplants easily.
9. E. China. Nuts long used in China.
10. Nut — fleshy covering is fermented, then seeds are boiled or roasted — sweet. Raw, they are mildly poisonous.
    Ginkgos are dioecious. Grove of trees with a few males would be required for significant yields.
11. Very tolerant of climatic extremes. Grows in Hobart Botanical Gardens, Tasmania. Should do well throughout Tasmania. Deep, rich soil best but any well-drained soil is 'o.k.'. Most sites.
12. Most nurseries as an ornamental. May be male or female.
13. Disease and pest resistant.

1. *GLOBE ARTICHOKE*
2. *Compositae* 3. *Cynara scolymus, C. cardunculus* (cardoon)
5. Several varieties, including Purple Globe, Green Globe.
7. Spreading, clump-forming bush with flower heads to 2m.
8. Seed, then select good plants for division. Take offshoots in June for October planting — only a few roots needed.
9. Southern Europe.
10. Flower buds boiled as vegetable. Blanched stems also eaten. Remove flower heads first season, crop thereafter.
    Down from leaves of Cardoon used like rennet (as infusion) in cheese-making (Spain).
    Yield over a long season.
11. Sensitive to heavy frost but generally well suited to cool areas. Nitrogen-rich, moist, well-watered soil.
12. Nurseries, seedsmen.

1. *GOOD KING HENRY*
2. *Chenopodiaceae* 3. *Chenopodium bonus-henricus*
5. No known cultivars.
6. Lincolnshire asparagus.
8. Seed in November. Normally by root division as for Comfrey.
9. Once grown in Britain.
10. Young shoots peeled and used like asparagus.
    Young leaves in spring used like spinach.
    Tender flower buds eaten.
    Antiscorbutic.
    Production increases annually.
11. Should grow well in southern Australia.
    Flourishes in poor soils, poor sites.
12. Thompson and Morgan.
13. See Ref. 52.

1. *GOOSEBERRY*
2. *Grossulariaceae* 3. *Ribes grossularia*
5. Many old and modern cultivars.
7. Small deciduous shrub.
8. Hardwood cuttings taken in autumn — roots easily.
9. Europe — widely grown in Tasmania.
10. Fruit — grown for stewing, or ripe used fresh. Yield from October to February depending on variety and use. First fruit second or third year.
    Bee forage in early spring — summer. Goose forage.
11. Well suited to Tasmania. Cool, southerly slopes best. Well-drained position. Gooseberries grow quite successfully in rock crevices. Good understorey bush.
12. Nurseries, older gardens.
13. Varieties — Crown Bob — most extensively planted in Tasmania.
    Select — high-yielding, thin-skinned, sweet, good flavoured — considered the best gooseberry.
    Seagreen is the earliest cooking variety.

1. *GRAPE*
2. *Vitaceae* 3. *Vitis vinifera, V. labrusca, V. rotundifolia*
5. Many cultivars world-wide. *V. labrusca* and *V. rotundifolia* are American species.
7. Deciduous, woody climber. Long-lived (up to 100 years).
8. Cuttings 8-14", previous years wood with bud at either end, tied in a bundle and buried within 2" of tops, in a damp spot. Plant out in spring.
9. Probably Asia Minor. Cultivation very ancient.
10. Fruit — dessert.
    — wine.
    Yields can be affected by virus infections. Grapes often yield in three or four years.
11. Grapes are hardy to sub-freezing conditions when dormant but need warmth for ripening of fruit. Spring frosts can cause harm. Suitable varieties exist for most parts of Tasmania. Sunny, sheltered position, very well-drained soil.
12. Some nurseries. Agricultural Dept. may be able to supply stock.
13. See Rodale,[51] Simmons[17] for information on culture, etc.

1. *GRAPEFRUIT*
2. *Rutaceae* 3. *Citrus paradisei*
5. Several varieties.
7. Dense evergreen tree to 10m.

8. Seed, or budding onto Seville orange stock. Seeds, like those of the orange and lime, are sometimes apogamic, so some seedlings come true.
9. Origin obscure — may be a variant of *C. grandis* or a hybrid of citrus species.
10. Fruit — fresh.
 — juice.
 — marmalade.
 Bee forage.
 Wheeny varieties ripens November-March.
11. Grapefruit are less cold-resistant than Sweet Orange but resistance increases as they grow older. Fruit will ripen more readily than Sweet Orange. Most of Tasmania would be suitable if a good site is available. Rich, moist soil (or manuring and watering) is necessary. Sunny, sheltered, frost-free position is best. Shelter from wind is more important than warmth.
12. Ordered through nurseries. Seed from fruit.
13. Wheeny variety is most suited to Tasmania and is commonly available. It fruits well at Lalla, in the N.E (Tasmania) at 500ft elevation in open situation.

1. *HAWTHORNS*
2. *Rosaceae* 3. *Crataegus monogym [oxycantha], coccinloides, ellwangeriana, "smithiana", douglasi, azoroles* (see Med. Medlar), *tanacetifolia*
5. Some ornamental varieties.
7. Thorny, deciduous trees and shrubs 2-7m. Long lived (100-300 yrs.). Slow growing.
8. Seed stratified.
9. Europe, Asia and N. America.
10. All species bear edible berries — jellies, conserves.
 Bee forage.
 Hedgerow plants — very tough.
 Bird nesting, habitat and food.
 Some species are good stock food — foliage relished by horses.
 C oxycantha — dried flowers or haws reduce blood pressure — vasodilators after stroke.
11. Hawthorns are hardy and most do well in Tasmania. Not particular about soils or site, some are partially drought resistant.
12. *C. oxycantha* from Forestry Commission. Some others from nurseries.
13. *C. oxycantha* is the common hawthorn grown in hedgerows throughout Tasmania — fruit is not as good as that of other species listed.

1. *HAZEL*
2. *Betulaceae* 3. *Corylus avellana, C. maxima*
5. Many varieties and crosses.
6. Cob, Filbert (*C. maxima*).
7. Small, decidous tree, shrub or thicket-forming plant to 6m. Lives as long as 150 years.
8. Seed. Improved varieties by suckers, layers or grafts.
9. Asia Minor and Europe. Widely gathered by Mesolithic people of Europe. Most cultivars are of recent origin. Natural habitat is both open scrub and forest, hillsides. Major commercial production in Spain, Italy, France, Turkey.
10. Nuts — Culinary uses.
 — animal forage (low grade or small nuts).
 Coppice growth — good hedgerow tree.
 — poles, stakes, etc.
 Peak nut production about fifteen years after propagation. Cross-pollination between appropriate varieties is sometimes necessary for good yields which can be up to ½ tons nuts/acre for intensive orchards.
 Can yield as early as third or fourth year.
11. Well suited to cold areas. A well-drained, deep, fertile soil is best, but clay soils are better than sandy ones. Hazels can be easily sun-scalded and tolerate shade, so are well suited to shady, southerly slopes or gullies. Good understorey shrub or tree. Yields best on an edge.
12. Some nurseries. Old orchards and trees for large numbers of suckers.
13. Kentish Cob, Gosford, Cob's Red Skin, were varieties grown in Tasmania in the past.

1. *HICKORIES*
2. *Juglandaceae* 3. *Carya ovata, C. laciniosa, C. tomentosa*
5. Many varieties and crosses including X with *C. illinoensis* (Pecan). Several named cultivars.
6. Shellbark (*C. laciniosa*), Shagbark (*C. ovata*), Mockernut (*C. tomentosa*).
7. Large, deciduous trees. Form upright, cylindrical crowns when open grown. Yield nuts through winter to spring.
8. Seed stratified as soon as ripe. Husks removed but nuts not cracked. Seedlings have long taproots and are difficult to transplant. Cultivars are grafted, usually cleft and shield budding. See Ref. 38. Grafting is difficult.
9. Eastern and Central N. America in mixed hardwood forests. Important timber trees in U.S.A. Pecan is the only important nut tree of the genus.
10. Nuts — cultivars and crosses with Pecan (Hicans) for culinary uses.
 — seedling nuts for animal forage (cracked and fed to poultry).
 Timber — excellent charcoal.
 — smoking hams (imparts flavour).
 — strong and tough — the best wood for tool handles.
 Trees yield only after 10-15 years from seed but grafted trees can yield in 3-4 years from grafting.
11. All these species mentioned should grow well in cool areas. *C. ovata* is very hardy. *C. ovata* and *C. tomentosa* are upland species and will grow on poor soils. *C. laciniosa* is a lowland species, growing naturally on seasonal inundation river lands but will grow and thrive under a wide variety of conditions. Hickories are relatively intolerant of forest conditions as young seedlings.
12. No source of nuts or trees known to authors. Grafted varieties available from American nurseries could be imported but require quarantine by Agriculture Dept. Breeding of local cultivars with high quality nuts would be well worth-while.
13. See Jayne[12] and Smith[18] for more information.
 Yields from Hickories are often irregular; several varieties ensure adequate pollination.

1. *HONEY LOCUST*
2. *Leguminosae* 3. *Gleditsia triacanthos*
5. A few named cultivars.
7. Open, evergreen tree to 40m. Very thorny when young.
8. Seed — must be filed, a notch in side to allow hard case to open. Grow in full sun, late winter after soaking in hot water. Transplants easily. Grafting or root suckers (easy) for improved varieties.
9. N. America — New York to Nebraska, Louisiana to Minnesota. Occasionally grown locally as ornamental.
10. Pods — high in sugar (27-30%), pod and seeds 10% protein.
    — stock feed, ground or whole. Feed value equivalent to oats.
    — ground meal mixed with cornmeal for sweet bread.
    — yields up to 20 bushels/tree and very reliable in yield.

    Eight-year-old trees in Alabama, some trees produced over 250lbs/tree. At 35 trees/acre, this is 8,750lbs/acre. Timber is durable and beautiful. Shelter belt and hedgerow tree (large thorns protect trees from stock).
11. Very hardy to frost and drought. Pods have ripened in London and U.K. Should do well throughout Tasmania. Any soil or site including very alkaline soils. Does best in well-drained, sunny, open positions. Best survival rate for tree species in the 'Prairies Shelter Belt Plan' of 1934, in the U.S.A.
12. Seeds from Goodwins or local trees.
13. Honey Locusts have few diseases or pests. Pods can be mixed with bran through a hammer mill to absorb sticky sugars.
    See Smith [18] for further information.
    Smith mentions the Honey Locust being used in Australia for stock feed.

1. *HOPS*
2. *Cannabiaceae* 3. *Humulus lupulus*
7. Dioecious climber up to 7m.
8. Cuttings or suckers from healthy female plants.
9. Central European forests. Used in brewing since the eighth century.
   Major industry in Tasmania.
10. Female cones (inflorescences) — brewing.
    — sedative, mild diuretic, baclinocide.
    — tea used for insomnia.

    Leaves and immature cones — dye.
    Young shoots in spring — used as vegetable like Asparagus. Male plants are not necessary since the female cones do not need pollination to produce resin.
    Used as pillow-stuffing for insomnia.
11. Well suited to lowland cool areas. Rich, moist soil and sheltered site.
12. From commercial hop growers.

1. ***HORSE CHESTNUT***
2. ***Hippocastanaceae*** 3. ***Aesculus hippocastanum***
5. No named varieties.
6. Buckeye.
7. Large, deciduous tree to 25m.
8. Seed, stratified, sown in spring.
   Layers, buds and grafts also.
9. Balkans. Long used as deer forage.
10. Nuts — stock forage.
    — culinary uses (bitterness removed by boiling crushed nuts).
    — contain saponin — used for soap in Britain in World War One.

    Leaves — medicinal — astringent, expectorant. Used to treat varicose veins, leg ulcers, haemorrhoids.
    Fruit — bronchitis and respiratory catarrh.
    Bark and leaves — dye.
    Timber — soft, light, even-textured.
    Seedlings often take twenty years to bear nuts.
11. Well suited to cool areas. Requires a rich soil for good growth.
12. Forestry Commission Nurseries.

1. *HORSE RADISH*
2. *Cruciferae* 3. *Armoracia rusticiana [lapathifolia]*
7. Perennial herb, with long, white tap root. Flowers November-January.
8. Root division. Like Comfrey, all pieces grow. Seed.
9. S.E. Europe and W. Asia. Long used in Europe.
10. Roots — culinary, condiment.
    — diuretic, rubefacient, stomachic. Used fresh for rheumatism, gout, bladder infections, intestinal problems. Also for coughs, asthma and lung catarrh. Other medicinal uses.
11. Well suited to cool areas. Rich garden soil is best.
12. Herb nurseries. Old gardens.
13. See Refs. 40, 48, 53.

1. *HYSSOP*
2. *Labiatae* 3. *Hyssopus officinalis*
5. No named cultivars.
7. Evergreen semi-shrub with blue flowers December-February.
8. Seed, cuttings or root division.
9. Origin uncertain due to long history of cultivation. Naturalized from Spain to Caspian Sea.
10. Flowering tops — medicinal — astringent, carminative, emmenagogue, expectorant, stimulant, stomachic, tonic. Used as for sage.
    — culinary herb.
    — bee forage.
11. Best suited to warmer areas. Grows naturally on dry, rocky, limestone slopes in full sun but most soils are suitable. Sunny position.
12. Seedsmen and herb nurseries.

1. *JAPANESE QUINCE*
2. *Rosaceae* 3. *Chaenmeles speciosa,* and other species.
5. Many ornamental cultivars and hybrids.
6. Japonica.
7. Spring, deciduous, spreading shrub to 3m high (5m wide).
8. Cuttings in summer, layers in autumn, or spring and autumn suckers.
9. China and Japan. Cultivated as ornamentals as well as for fruit.

10. Fruit — rich, aromatic, lemon-like juice, used for cooking with other fruits — jellies, conserves, etc.
11. Well suited to cool areas. Any soil, most sites. Sunny position for good fruiting.
12. Common in gardens. Also nurseries.
13. Some ornamental varieties do not fruit well.

1. *JAPANESE WALNUT*
2. *Juglandaceae* 3. *Juglans sieboldiana*
5. *J. cordiformis.* Several cultivars.
6. Siebodl Walnut. Heartnut (variety).
7. Fast-growing, spreading, deciduous tree.
8. Seed. Cultivars grafted — very difficult, occasionally layered.
9. Japan, mountain areas. Not widely grown.
10. Nuts — culinary.
    Bark and fruit as dyes.
    Often bears as early as 4-5 years from seed. Heavy bearers Heartnut is easy to crack.
11. Very hardy. Should do well in cool areas. Most sites and soils, from heavy clays to sand, are suitable.
12. No local source of nuts or trees known.
13. See Jaynes[12] for further information.
    Hybrids with Butternut have resistance to *Melanconis* fungus as with the Japanese Walnut.

1. *JERUSALEM ARTICHOKE.*
2. *Compositae* 3. *Helianthus tuberosus*
5. No named varieties.
7. Tall perennial which dies back to roots. Up to 3m tall.
8. Any tuber will grow — pieces left in ground at harvest.
9. N. America. Cultivated vegetable of the Indians.
10. Roots — vegetable.
    — animal forage (mainly pigs).
    Tops — animal forage — relished by goats.
    Yields are often four to five times that of potatoes.
11. Hardy. Well suited to cool areas. Highest yields on rich soil but is very tough when compared with most cultivated vegetables.
12. Common in Tasmania. Buy tubers in green-grocers'.

1. *KUDZU*
2. *Leguminosae* 3. *Pucraria thunbergiana*
7. Woody, ground-covering vine.
8. Seed or root division (easy).
9. S. Japan. Naturalised in S. U.S.A. Forage crop in U.S.A.
10. Forage crop, hay.
    Seeds for poultry; leaves for cattle and goats.
    Nitrogen fixer — excellent.
    Fibre from stem for rope.
    Japanese arrowroot extracted from roots.
11. Probably only suited to the warmer areas. Good soil — gullies, steep slopes under forest. Can fill whole gullies.
    Understorey forage.
12. Goodwins, N.Z. sources.

1. *CUMQUAT*
2. *Rutaceae* 3. *Fortunella japonica, F. margarita*
7. Small evergreen tree or shrub two to three metres, closely related to citrus.
8. Seed. Soon after removal from fruit under warm conditions. Shield budding.
9. China. Long cultivated in the East. Grown commercially in many places.
10. Fruit — fresh, or more usually, preserved in syrup.
11. Best suited to warmer areas. Not damaged by frosts. Sunny, sheltered site.
12. Some nurseries.

1. *LAURELBERRY*
2. *Rosaceae* 3. *Prunus lauro-cerasus*
6. Cherry Laurel.
7. Dense, spreading, evergreen tree to 5m. Long lived. Fast growing.
8. Seed, cuttings.
9. E. Europe, Asia Minor.
10. Fruit — jam.
    Bee forage.
    Hedgerow and shelter tree.
11. Well suited to cool areas. Widely planted in north and northwest.
    Tolerates fully shaded sites and positions.
12. Nurseries, seedlings and cuttings from established trees.

1. *LAVENDER*
2. *Labiatae* 3. *Lavandula L. dentata, L. vera [officinalis]*
6. Old English Lavender (*L. vera*], French Lavender (*L. dentata*).
7. Small, woody shrubs.
8. Cuttings — easy.
9. Mediterranean region — mountain areas.
10. Bee forage — excellent.
    Flowers and leaves — medicinal herb, antispasmodic, carminative, tonic, cholagogue, diuretic, sedative, stimulant, stomachic. Oil distilled from flowers used for flatulence, migraine, fainting, dizziness. Also for stomach problems, nausea and vomiting. Oil is powerful germicide and insect repellant. Dried flowers to keep moths out of stored linen and clothes.
    Cosmetic herb.
    Hedge plant.
11. Well suited to cool areas. Well-drained, alkaline soil is most suitable. Sunny position. Drought resistant.
12. Nurseries, garden specimens (very common).

1. *LEMON*
2. *Rutaceae* 3. *Citrus limonia*
5. Many cultivars.
7. Small, evergreen tree to 3m.
8. Seed — sometimes more than one seedling results (polyembryonic) and seedlings can come true to type (apomictical). Seedlings are hardier trees than grafts. Budding on sour orange stock, cuttings of mature wood.
9. Possibly from Central Asia. Cultivated for thousands of years.
10. Fruit — many culinary uses —keeps well.
    — astringent, refrigerant used for colds, coughs, sore throats.
    — facial astringent.
    Bee forage.

Lemons tend to bloom continuously and in warmer areas will give an all-year-round yield. Seedlings yield after eight years.
Budded trees after three to four years.
11. Suited to most temperate areas. Meyer variety is best suited to colder areas. Frost hardy, -2deg.C kills flowers and young fruit. Well-drained soil, water essential in hot weather.
Sheltered, sunny position.
12. Nurseries.

1. *LESPEDEZA*
2. *Leguminosae* 3. *Lespedeza L. sericea* and other species.
6. Japanese clover.
8. Seed, then division of clumps.
9. Himalayas through to Japan.
Grown in the U.S.A. for hay.
10. Stock feed — forage.
— hay — up to two and a half tons/acre in Alabama — being 11.0% water, 13.8% protein, 39.0% C/hydrate, 3.7% fat, 8.5% ash.
— cut before flowers bloom.
Good nitrogen fixer.
Soil conservation — used to stabilize slopes.
11. Should suit cool areas. Any soil which is well-drained is 'o.k.'.
Drought resistant.
12. Seed from American seedsmen, e.g. Shumway.

1. *LINDEN*
2. *Tiliaceae* 3. *Tilia T. europea, T. cordata, T. Platyphylbos* and others
5. No named cultivars.
6. Lime.
7. Deciduous tree to 25m, living 500 years or more.
8. Seed, stratified and sown in spring.
Layers — occasionally cuttings.
9. Temperate regions of the Northern Hemisphere — over eighty species.
10. *Excellent bee forage* — 20-80 years to flowering from seed.
Leaves and flower bracts — Medicinal — antispasmodic, diaphoretic, diuretic. Infusion for colds, sore throats, influenza and mild bladder and kidney disorders. Not to be used over long periods.
Inner bark — applied to wounds, sores, etc. Cholagogue, emollient. Lime and charcoal, powdered, mixed with milk will assimilate poisons in the digestive tract — food poisoning, intestinal infections. The charcoal will also absorb toxins from festering wounds.
Lime flower tea as after dinner drink.
Bark of *T. americana* used for binding grafts and buds and weaving mats.
Wood is excellent for carving.
11. Well suited to cool areas. Moist loam is best. Cool, shady sites satisfactory.
Comes into leaf late and early to loose foliage — understorey growth in spring and autumn.
12. Seed from park trees — usually in great heaps under the trees.
Also some nurseries.

1. *LOGANBERRY*
2. *Rosaceae* 3. *Rubus loganbaccus*
5. Many varieties and hybrids.
7. Trailing, thorny canes.
8. Tip layering in early autumn.
9. Possibly a hybrid of raspberry and blackberry.
10. Fruit — dessert. Harvest when fruit and vines are perfectly dry.
Bee forage.
11. Well suited to cool areas. Wide range of soils and sites available.
12. Nurseries, possibly commercial growers.
13. Boysenberry, Veitchberry, Phenomenal berry and others, have similar appearance and parentage to Loganberry. See Raphael.[11]

1. *LOQUAT*
2. *Rosaceae* 3. *Eriobotrya japonica*
5. Many cultivars.
6. Japanese medlar.
7. Small evergreen tree to 7m.
8. Seed — very slow to develop.
Layering in spring.
Grafting or budding onto Loquat, Pear or Quince stock.
9. China and Japan. Widely cultivated also in India and Mediterranean.
10. Fruit — fresh. Little fruit in early years with good crop by 6th year.
Peak in about 15-20 years. Yields in spring.
11. Suited to most cool areas. Frost-hardy, but needs reasonable warmth for fruiting. Any soil, but loquats are gross feeders.
Sheltered, sunny position.
Relatively common around Hobart, Tasmania.
12. Some nurseries.
13. See Simmons[17] for further information.

1. *LUCERNE*
2. *Leguminosae* 3. *Medicago sativa*
5. Many agricultural varieties.
6. Alfalfa.
7. Upright, perennial herb. Life expectancy up to 10 years as pasture.
8. Seed.
9. Europe and Asia. Common fodder crop in many countries. Usually grown under irrigation in Tasmania as high-value feed.
10. Bee forage — next to sweet clover, the most important bee forage in the U.S.A. — blooms just after sweet clover.
Animal fodder — excellent hay. Yields up to 6 tons/acre (dry weight) giving 1-5 tons protein. As forage graze in spring and autumn.
Soil improver — the best nitrogen fixer, draws up subsoil nutrients.
Tender leaves used as vegetable and seed for sprouting in China.
Foliage as Alfalfa tea.

11. Well suited to cool areas. Grows well on poor, alkaline soils but not acid soils.
12. Agricultural suppliers.

1. *MACADAMIA*
2. *Proteaceae* 3. *Macadamia M. tetraphylla* and *M. integrifolia*
5. Many named cultivars mainly of *integrifolia.* Some hybrids.
6. Queensland Nut.
7. Upright, slow-growing, evergreen tree in forests to 7m; spreading tree to 20m in open situations (hot climates).
8. Seed — germination rate drops to less than 50% after 6 months.
   Grafting, budding, cuttings, or air layerings for cultivars.
9. Queensland. Cultivated more in Hawaii and California, U.S.A. than in Australia.
10. Nuts — highly valued, yield over several months (*M. integrifolia* bears some nuts all year round in warm climates).
    Trees are slow to bear in cool climates due to the slow rate of growth.
    Mixed stands seem to yield better, while single trees may not yield at all in some cases.
11. Generally unsuited to the cool climates. While dormant, Macadamias can handle temperatures as low as 20deg.F for short periods, without serious injury.[12] Trees in not particularly sheltered, but sunny position (frost-free) in Hobart Botanical Gardens, Tasmania, bear nuts. Large, healthy trees, in shady, sheltered sites at Melbourne Botanical Gardens, Victoria, bear good crops. Natural habitat is dense rainforest — scattered individuals among Bunya and Hoop pines. Rainfall 60"-100". Most suitable position — warm, sheltered (not necessarily very sunny), frost-free, well-watered, but well-drained.
12. Ordered from some nurseries.
13. See Jaynes[12] for further information.

1. *MEDITERRANEAN MEDLAR*
2. *Rosaceae* 3. *Crataegus azaroles*
8. Seed — takes 2 years for germination. Stratification, then warmth for softening of hard, outer seed case and germination.
9. W. Asia and S. Europe.
10. Fruit — fresh, jellies, etc.
    Hedgerow tree.
    Bee forage.
11. Suited to cool areas. Any soil — well drained. Open sunny site.
12. Some nurseries.
13. Many *Crataegus* species are worthy of cultivation — see Hawthorns.

1. *MEDLAR*
2. *Rosaceae* 3. *Mespilus germanica*
7. Small deciduous tree to 6m.
8. Seed.
   Budding in summer.
9. Persia. Cultivated for fruit in the past.
10. Fruit — fresh when over-ripe, jelly.
    Bark — dye.
    Hedgerow tree.
11. Well suited to cool areas. Any soil, sunny site is best.
12. Nurseries. Reasonably common garden ornamental.

1. *MESQUITES*
2. *Leguminosae* 3. *Prosopis* and *Strombcarpa.* Thirty species. Some important ones:— *P. juliflora, S. pubescens, P. chilensis, S. ciuerciscens, P. alba, P. glandulosa*
6. Algaroba (*P. juliflora*).
7. Spreading shrubs and small trees (in desert habitats).
8. Seed — germination excellent.
9. America from California to Patagonia. Mostly desert plants.
10. Pods — high protein, high sugar content, stock feed, poultry feed.
    Seeds — grown similarly to Gum Arabic.
    Bee forage.
    Good varieties yield as much as 50 tonnes/hectare, with stocking rates of 5-12 cattle/hectare (pods and rough pasture) on land with original capacity of 1 animal/50ha (rough pasture).
    Flowering (November) curtailed by rain.
11. Most species are very hardy and some occur naturally at 40 deg. S. in Argentina. However, humidity and lack of heat may result in low or absent yields. Totally drought-resistant. Any reasonably well-drained soil. Warm, dry site. Resists salt in soils.
12. Lord[23] mentions one species which should be available within Australia.
    Seed possibly from American seedsmen.

1. *MINTS*
2. *Labiatae* 3. *Mentha spicata, rotundifolia, piperita, citrata, piperita officinalis, pulegium* and others
5. Named varieties.
7. Low herb clumps. Some species die down in winter.
8. Root division — easy.
9. Europe. Used as culinary herb for well over 1,000 years.
10. Culinary herbs.
    Dyes.
    Bee forage.
    Pennyroyal (*M. pulegium*) — carminative, diaphoretic, emmenagogne, sedative. Used to promote menstruation. Other medicinal uses. Traditionally used in black puddings.
    Peppermint (*M. piperita officinalis*) — anodyne, antispasmodic, carminative, cholagogne, refrigerant, stomachic, tonic. Used for nervousness, insomnia, cramps, coughs, migraine, nausea, vomiting, heartburn.
    Commercial source of Menthol.
11. Well suited to cool areas. Grows best in rich, alkaline, moist soil, in shade but essential oil content may be higher in full sunshine. Most mints are rampant in moist garden conditions.
12. Herb nurseries. Gardens — some are very common.

M. pulegium, M. spicata and *M. piperita* are naturalized to some extent in Tasmania.

1. *MIRROR PLANT*
2. *Rubiaceae* 3. *Coprosma repens* and possibly other species
5. Many natural varieties and hybrids. Some ornamental cultivars.
6. Looking Glass Plant. Coprosma.
7. Large, evergreen, dioecious shrub 2-3m. Fast growing.
8. Cuttings — very easy. Seed.
9. N.Z. seaside plant. Very common ornamental.
10. Seeds — poultry forage (ref. *N.Z. Whole Earth Catalogue*) Hedgerow plant. Fire retardant.
11. Well suited to temperate areas. Any soil or site. Resistant to salt spray, drought and *fire.*[23]
12. Forestry Commission Nursery. Garden plants.
13. Along with other (native) species, the *Coprosma* is worthy of investigation and experimentation as a forage for poultry.

1. *MONKEY PUZZLE*
2. *Araucariaceae* 3. *Araucaria araucana*
5. No known cultivars.
6. Chilean Pine.
7. Large, symmetrical conifer; dioecious; very slow growing.
8. Seed — short viability. Cuttings — upright leading shoots.
9. Chile — important food source of the natives.
10. Nuts — rich in starch.
    — twice size of an almond.
    Eighteen good sized trees will yield enough nuts for a man's sustenance all year round.[37]
11. Well suited to cool areas. Deep, rich, moist soil is best. Sheltered site.
12. Possibly from nurseries. Recommended by Lord,[23] as a cool-climate ornamental, so should be available within Australia.
13. *A. braziliana* [*angustifolia*] also yields large nuts.

1. *MULBERRY*
2. *Moraceae* 3. *Morus nigra*
5. Numerous cultivars.
7. Deciduous, dome-shaped tree to 10m. Very long lived.
8. Cutting or layers. Very easily propagated and transplanted.
9. W. Asia. Established in Europe in ancient time. Not generally cultivated commercially.
10. Fruit — fresh, jam, wine.
    — animal forage (pigs and poultry especially).
    — fruit ripens over relatively long period in summer — up to 60 days.
    — one tree can feed one pig in the season, but large, old trees may yield much more.
    — yield as early as 2 or 3 years from cuttings.
    Morus spp. are companion plants for grapes[14] and form a trellis for grapes.
    Leaves repel worms in horses.[14]
11. Well suited to cool areas. Very hardy and tough. Any soil or site. Tolerant of shade.
12. Nurseries. Garden and farm trees — very common.
13. See Smith[18] for more information on Mulberries as animal forage.

1. *MULLEIN*
2. *Scrophulariaceae* 3. *Verbascum thapsens*
5. No named varieties.
6. Verbascum, Great Mullein, Aaron's Rod, Flannel Plant.
7. Tall, self-seeding, biennial herb, with white, woolly leaves and small, bright yellow flowers on dense spikes.
8. Seed.
9. Europe and W. Asia. Roadside and wasteland weed in Tasmania.
10. Flowers and leaves. Medicinal — anodyne, antispasmodic, demulcent, diuretic, expectorant, vulnerary. Excellent for coughs, hoarseness, bronchitis, bronchial catarrh. Other uses.
11. Well suited to cool areas. Does best in dry, sunny, sheltered sites. Rocky, bare sites satisfactory.
12. Seed from herb seedsmen or roadside plants.
13. Must not be confused with two other introduced *Verbascum* species of similar habitat which have green leaves, mostly hairless.
    See Curtis.[54]
    See Refs. 48, 53, for more information.

1. *NASTURTIUM*
2. *Tropaeolaceae* 3. *Tropaeolum majus*
5. Many ornamental cultivars.
6. Indian Cress.
7. Creeping or climbing perennial, usually grown as an annual. Self-seeding.
8. Seed.
9. S. America. Widely cultivated garden ornamental.
10. Leaves — seasoning (rich in vitamin C).
    Seeds — medicinally — antiseptic, expectorant, (antimyeotic and anti-bacterial when fermented). Used for infections.
    Leaves and flowers also have medicinal uses.
    Companion plant around fruit trees. Seeds are pickled as 'capers'.
11. Grows well in cool areas, cut back by frost. Most prolific in moist garden soils but will grow in most soils and sites.
12. Seedsmen, garden plants.
13. See Refs. 40, 48, 53 for more information.

1. *NATAL PLUM*
2. *Apocynaceae* 3. *Carissa grandiflora*
5. No named varieties known.
7. Thorny, evergreen shrub to 2m.
8. Seed or cuttings.
9. South Africa — valued as a hedge in S. Africa.
10. Fruit — jam, tarts, preserves. Very tough hedgerow plant.
11. Should suit warmer areas best. Most soils.
12. Mentioned by Lord[23] so should be available somewhere in Australia from nurseries.

1. *NEW ZEALAND FLAX*
2. *Lilaceae* 3. *Phormium tenax*
5. No named cultivars. Several leaf-colour varieties.

7. Clump-forming plant with strap-like leaves up to 3m.
8. Division.
9. New Zealand. A common garden ornamental. Once important export of New Zealand — one of the few commercial hard fibres from temperate regions.
10. Leaves — retted, a tough fibre, making a rope 60% as strong as the best manila rope.
    — unretted, tying plants to stakes.
    Buds and flowers — dye.
11. Well suited to cool areas. Very easily grown — not particular about soils or sites.
12. Nurseries. Gardens. Worth development of cultivars for improved fibre.

1. *NEW ZEALAND SPINACH*
2. *Aizoaceae* 3. *Tetragonia expansa*
7. Creeping groundcover.
8. Seed in November — soak overnight.
9. Native of Australia and New Zealand. Seaside plant.
10. Foliage as vegetable used like Spinach.
    — dye.
    — occasional animal forage.
    — soil stabilization.
11. Best suited to warmer areas — coastal rather than inland. Dry, sunny sites.
12. Some seedsmen, e.g. Thompson and Morgan.

1. *OAKS*
2. *Fagaceae* 3. *Quercus* about 600 species
5. A few ornamental cultivars.
7. Mostly large, spreading, deciduous, trees up to 40m. Long lived. Many fast growing and early bearing.
8. Seed. Excellent germination but acorns sometimes lose viability over a year or more.
9. Europe, Asia, Africa and the Americas — mostly in temperate regions.
10. Acorns — animal forage, high carbohydrate. Most valuable for pigs, which tend to put on soft, unsaturated fat rather than hard, saturated fat on an acorn diet.
    — flour or meal — species with acorns low in tannin.
    Timber — valuable hardwoods for a wide range of uses.
    Bark — astringent, tonic. Used internally to stop haemorrhaging, reduce fever, sore throats. Externally for varicose veins, sores, skin irritations. Tanning material.
    Leaf mulch of some species, including *Q. robur*, repels slugs and cutworms. Yield can vary greatly from year to year. Mixed stands tend to yield better than single species stands or single trees.
11. Most species are well suited to cold areas. Many deciduous species are more or less evergreen in the mild Tasmanian winters. Any reasonably well-drained soil. Some thrive on dry, rocky or infertile soil. Many species grow best in an open-grown situation. Some grow well in wet areas.
12. Acorns from local trees. Eight or more species in the Hobart Botanical Gardens, Tasmania.
13. Forty-five species growing in the Melbourne Botanical Gardens, Victoria, none over eighty years old and some 30m tall — all open grown.
    See Jaynes [12] for further information.

Q. virginiana. Live Oak; spreading evergreen to 25m. Easily transplanted and grows rapidly. Occurs naturally on sand, both well and poorly drained areas. On dry sands, the Live Oak is a dwarf tree or shrub. Acorns are sometimes sweet. Oil of acorns is said to be comparable with olive oil. Aids the growth of citrus. Reasonably common in Tasmania and North America.

Q. macrocarpa. Burr Oak: large tree to 40m or more on good soils in cold areas (N. Dakota, U.S.A) it is a low shrub. Free of pests. Large yields on alternate years. Very large acorn, sometimes sweet. N. America.

Q. lobata. Californian White Oak: large spreading tree to 30m. Acorns very long and sometimes sweet. Timber not very useful. Not a very easy oak to grow.

Q. alba. White Oak: under forest conditions a tall, small-crowned tree to 30m, on deep, well-drained, slightly acid soil. Acorns are good eating — were often boiled as a substitute for chestnuts, an oil used for a liniment being skimmed off. Timber is excellent. N. America.

Q. bicolor. Swamp White Oak: tree up to 30m along river banks and near swamps. Acorns are long, sweet and white. Easily transplanted and rapid grower. N. America.

Q. michanxii. Swamp Chestnut Oak: tree up to 25m on rich inundation areas. Acorns are very sweet, one of the best. Good annual yields. N. America.

Q. prinus [montana]. Chestnut Oak: tree to 20m. Vigorous on poor soils. Reasonably sweet acorns. Bark contains up to 11% tannin. N. America.

Q. muhlenbergii. Chinquapin Oak: large forest tree — does well on poor soils. Sweet acorns. N. America.

Q. ilex. Holm Oak: large spreading evergreen tree. Grown with *Q. suber* in Portugal for pig forage. Very high yields on alternate years. Average yields of 720 litres/annum have been recorded for one tree. Mixed *Q. ilex* and *Q. suber* forests gives up to 68kg/ha of pork per annum over a ten-year period. S. Europe.

Q. suber. Cork Oak: slow growing, evergreen tree to 25m. Very long lived. Cork can be harvested after 20 years, then every 10 years. Average yield in Portugal 240kg/ha *year*. Best cork from trees on dry, rocky poor soils. S. Europe, N. Africa.

Q. robur. English Oak: spreading tree for open-grown situations. Long used in Britain for pig forage. Very common in Tasmania. Europe.

Q. cerris. Turkey Oak: large, spreading tree up to 30m on good soils. Good on coastal sands. Large, long acorn. Secretion of stems used by Kurdistan tribes as sweetener. Relatively common in Tasmania. S. Europe. Asia Minor.

Other species:— *Q. mirbeckii; Q. oblusata; Q. lusitanica; Q. palustris; Q. pulstris; Q. pedanculata concordia; Q. rubra*, (all in Melbourne Botanical Gardens, Victoria). *Q. garryana; Q. coccifera; Q. persica*, etc.

1. *OCA*
2. *Oxalidaceae* 3. *Oxalis tuberosa*
6. Maori potatoes (Tasmania).
7. Perennial tuber — trifoliate (clover-like) leaves.
8. Tubers in winter.

9. S. America. Andes. Cultivated.
10. Tubers as vegetable harvested in winter. Sun dried for three days to reduce calcium oxalate content.
Leaves added to salad.
11. Hardy, grown in Bolivia to 4,000ft. Well suited to Tasmania. Rich garden soil.
12. No known commercial source. Gardeners.

1. *OLIVE*
2. *Oleaceae* 3. *Olea europea*
5. Many named varieties.
7. Small, low-growing, evergreen tree to 8m. Very long-lived — up to 700 years.
8. Cuttings struck in sand. Grafting — relatively easy.
9. Mediterranean region. Long in cultivation. Important commercial and subsistence crop in Spain, France, Italy and N. Africa.
10. Oil — fruit picked when fully ripe, but not soft. Fruit (and stones) crushed to a mash, then placed in cloth bags, these being stacked in a press. The oil collected is called virgin oil — the best quality. The mash can be mixed with a little boiling water and repressed for a second-grade oil. Oil is clarified and separated from the water in the fruit by rest and decantation.
Uses — cooking, medicinal, cosmetic, lamp fuel.
Fruit — picked green or ripe. Green olives must be soaked in a lye solution before pickling, to remove bitterness.
Pulp, remaining after oil pressing can be fed to stock.
Trees — shelter and occasional forage for stock.
Good oil varieties yield as much as 30% oil (50gal/ton).
Olives often bear in less than 4 years from cuttings.
11. Not well suited to Tasmania. Few grown here. Trees are frost hardy but warmth is needed for ripening of fruit. Olives are drought resistant and grow on poor, thin or rocky soils but yield best on more fertile soils.
12. Some nurseries.

1. *ORANGES*
2. *Rutaceae* 3. *Citrus sinensis*
5. Washington Navel and other Navels, Jaffa, Blood and valencia types.
7. Evergreen tree 5-10m.
8. Budding onto Citrus *sinensis, trifoliata* or other citrus. See Bailey[38] for details on growing stocks, budding techniques, etc.
9. Probably from India or South China. Long in cultivation.
Cultivated in Mediterranean area since fourteenth century.
10. Fruit Navel types (best eating oranges) bear winter and early spring.
— Valencia type (best juice orange) bears in summer.
— most other types other mid-season bearers.
— oranges can be left on the tree after ripening, without deterioration.
Bee forage.
Flowers — perfume.
11. Marginally suited to Tasmania. Growth stops below 10deg.C, thus avoiding cold damage. However, warmth is necessary for flavour and ripening. Shelter is essential. Light, fertile soils most suitable. Irrigation in summer, generally necessary. Mr. Chandler of Chandler's Nursery (Sandy Bay, Tasmania) says trees bear quite well in Hobart (Tasmania). A large tree in Launceston (Tasmania) garden, bears well against a white, north-facing wall of a house. Culture in front of a wall would seem most suitable. Valencia oranges are more suited to cold climates than other types.
12. Nurseries.

1. *OSIER WILLOW*
2. Salicaceae 3. ***Salix viminalis*** and others
7. Spreading, deciduous tree.
8. Easily grown from any branch, twig or piece of wood.
9. Europe.
10. Long shoots from pollarded stumps used for willow basketry — *S. viminalis* is the best but others can be used. Long 1 or 2 year-old shoots (wands), 2-4m long, cut in winter, bundled up to 1m wide and buried in trenches in damp ground, 1m deep. When the bundles show 1cm shoots in spring, the wands are stripped, using a V-iron fixed to a low post — bark and shoots come off easily. The wands are then stored dry. When needed for basketry, they are covered overnight with damp bags to restore flexibility. If wands are boiled, they last many years longer and are a tan colour.
Willows with their great root masses, bind creek beds against erosion.
Bee forage, especially weeping and pussy willows.
Fire retardants — steam rather than burn.
11. Well suited to Tasmania. The willow naturalized throughout Tasmania is *S. alba X. fragilis.* Curtis.[54]
Wet sites — along creek beds.
12. Ivan Ballard, basket maker of Launceston, Tasmania, may be able to supply detailed technique. Plants from nurseries or naturalized plants.
Mr. Ballard gave data for the techniques given here. His family planted the first basket-willows in Tasmania at Hobler's Bridge near Launceston, in 1830's.

1. *PAMPAS GRASS*
2. *Gramineae* 3. *Cortaderia selloana*
5. No named varieties.
7. Clump-forming grass to 3m. Rapid, vigorous grower.
8. Division of clumps.
9. S. Brazil and Argentina. Common garden ornamental.
10. Animal forage — cattle, horses, goats, etc.
Shelter — hedges. Can be used to "shed" sheep after shearing; shelter poultry.
11. Well suited to cool areas. Easily grown in almost any soil and site. Does well in water-logged position.
12. Forestry Commission Nursery, Nurserymen, Gardens.

1. *PEACH*
2. *Rosaceae* 3. *Prunus persica*
5. Many named cultivars including those of peach sport — the Nectarine.
7. Small, deciduous tree.
8. Seed of nectarines is often true to type. Otherwise shield-budding on peach or occasionally plum and almond stocks. One of the easiest trees to bud.
9. Asia. Cultivation in China since the tenth century B.C., at least. Common fruit tree.
10. Fruit — fresh, dried or bottled.
Bee forage.
Leaves in spring — dye.

11. Best suited to warmer areas but can be grown successfully everywhere if the right site is available. Sunny, sheltered position. Well-drained, deep, medium soils are best.
    Nectarines are slightly less hardy than the peach.
    Early bearers — often second year from budding.
12. Nurserymen.
13. Curly leaf disease is common. Preventative sprays of Bordeaux in winter. Trees in dry sites less susceptible than those in wet, damp positions.

1. *PEAR*
2. *Rosaceae* 3. *Pyrus communis*
5. Hundreds of named varieties.
7. Upright, decidious tree up to 20m. Long lived — up to 300 years.
8. Grafting, 2 year old seedlings, shield budded summer. Quince stocks give dwarf trees.
9. Europe, N. Asia and Himalayan region. Long in cultivation.
10. Fruit — fresh, bottled, dried.
    — animal forage (pigs especially).
    Bee forage.
    Wood — carving and turning.
    Fruit usually picked and ripened in a cool, dark place for good quality table fruit.
11. Well suited to cool areas. Cool, shady, moist sites, satisfactory. Tolerant of a range of soils.
    Pears tend to survive longer than other fruit trees in abandoned orchards.
12. Nurserymen.

1. *PECAN*
2. *Juglandaceae* 3. *Carya illinoensis*
5. Thirty-two important commercial cultivars in the U.S.A. — Jaynes.[12]
7. Large, spreading, decidious tree up to 50m.
8. Budding or grafting on to seedling rootstocks.
9. N. America. Cultivated since the mid-1800's. Not grown extensively outside southern U.S.A.
10. Nuts — mild, sweet flavour 72% oil.
    — good varieties yield 75-100lbs/tree by the 15th year.
    — can bear as early as 3rd or 4th year. Up to 20 years from seed.
    — yield is about 50% kernel in most varieties.
    — harvested by knocking with bamboo poles.
11. Not tested under mild Tasmanian conditions, winter chilling seems necessary. Growing season must be frost free (150-120 days depending on variety). Summer should be warm (75deg.-85deg.F is optimal). Some varieties ripen nuts in British Colombia (colder, but similar to Tasmania). Warm, sunny position. For long-lived trees, deep, loose, well-drained and well-aerated soil is required. Soil moisture should be constant and high in the growing season.
12. No known commercial source of trees in Australia. Some individual trees in W.A. and N.S.W. Research being conducted by Hawkesbury Agricultural College, in N.S.W.
13. See Jaynes[13] for detailed information on culture in the U.S.A. "Fritz" and "Witte" would seem the most suitable cultivars mentioned for cool areas.

1. *PERSIMMON*
2. *Ebenaceae* 3. *Diospyros kaki*
5. As many varieties in Japan, as apples, England. A few available here.
6. Date plums.
7. Deciduous tree to 15m yielding in winter.
8. Seed in winter. One year old seedlings usually large enough for grafting or budding. Shield budding most common method.
   D. virginiana often used as rootstock.
9. Japan and China. Widely cultivated there for many uses.
10. Fruit — high food value.
    — eaten when over-ripe — harvested when hard and ripened indoors.
    — some varieties dried (in China).
    — stock feed (seedlings) — fruit fall over long period.
    — astringent juice of unripe fruit with bracken-root flour makes an excellent waterproof glue.
11. Grows reasonably well in Tasmania. Fruit is late-ripening due to lack of summer warmth. Most well-drained soils and sites.
12. Seed — Goodwins. Budded trees — most nurseries.
13. Smith[18] believes the *Diospyros* species including the American ones have great potential as stock feed.
    See Simmons[17] for information on culture.

1. *PLANTAIN*
2. *Plantaginaceae* 3. *Plantago P. lanceolata, P. major*
5. No cultivar.
6. Lance-leaf plantain (*P. lanceolata*), Great plantain (*P. major*).
7. Perennial herbs, flowering November-March. Self-seeding.
8. Seed.
9. Europe, North and Central Asia. Naturalized in most temperate regions. *P. lanceolata* is a widespread weed of cultivation in Tasmania. *P. major* is less common.
10. Herb — astringent, demulcent, expectorant, haemostatic. Good for all respiratory complaints. Many other internal uses. Externally on wounds, insect bites, sores, etc.
11. Well suited to cool areas. Most positions and soils.
12. Common garden weed.
13. Medicinal value of both species in equal.
    See Refs. 40, 48, 53.

1. *PRICKLY PEAR*
2. *Cactaceae* 3. *Opuntia vulgaris*
5. *O. cantabridgida* (developed at Cambridge, U.K.).
7. Large, oval-stemmed cactus to 6m yielding winter/spring.
8. Cutting — stem plates air-dried for a few days, rooted in sand.
9. The Americas. Once a bad pest in tropical and subtropical Australia.
10. Fruit — fig-like ca. 7cm x 4cm.
    — gloves used to harvest, then scrubbed to remove spines.
    Spines — large, hard spikes — pins.
    Barrier plant — used like Hawthorn in Sicily, U.S.A. and S. America to contain animals. Can be used as cattle fodder if spines are removed by burning.
11. Not a prolific grower in Tasmania, definitely not a

pest. Grows to 1,400 ft. near Mt. Arthur (Tasmania), ("Highfields"). Warm, sheltered site best. Well-drained soil. Drought resistant.
12. Parent bush at "Highfield". Possibly nurserymen.

1. *QUEENSLAND ARROWFOOT*
2. *Cannaceae* 3. *Canna edulis*
7. Clump-forming perennial.
8. Division of tubers.
9. American tropics. Cultivated in Peru to 2,000 ft. Once cultivated at the Ramahyuck Mission on S. Coast, Victoria.
10. Tubers — cooked — sweetish taste, inferior to sweet potato due to fibre.
    — arrowfoot flour (*Tous les mois*).
    — animal forage, pigs especially.
11. One of the hardiest of the arrowroot plants but marginal in Tasmania. Grows in Melbourne Botanical Gardens, Victoria. Warm sunny position.
12. No commercial source known to authors.

1. *QUINCE*
2. *Rosaceae* 3. *Cydonia oblonga*
7. Small, slow-growing deciduous tree to 6m.
8. Layered shoots in autumn.
   Cuttings or suckers.
9. Persia. Long cultivated in Europe and Britain.
10. Preserves, tarts, etc.
    Fruit allowed to stay on tree until frost begins to strip the tree of leaves for full development of flavour. Will keep for 2 months once ripe.
11. Well suited to cool areas. Moist soil, most sites.
12. Nurserymen.

1. *RASPBERRY*
2. *Rosaceae* 3. ***Rubus R. idaeus*** and ***R. phonenicolasius*** (Wineberry)
5. Many cultivars resulting from crosses of these and other ***Rubus*** spp.
7. Thicket-forming canes.
8. Suckers from roots of the parent stool are removed and set out. ***R. phonenicolasius*** from tip suckers (lead shoots weighted to ground).
9. ***R. idaeus,*** native of Britain and much of the northern hemisphere.
   R. phonenicolasius, native of N. China and Japan.
10. Berry fruit.
    Bee forage.
    Bark of rhizome and root is antidiarrhoetic.
    Leaves — astringent, caridiac, refrigerant.
    Plants yield in 2nd year from propagation.
    Fruiting canes removed each year and fruit come on new canes.
    Leaves used for tea, in childbirth.
11. Well suited to Tasmania. Widely grown. Ripening fruit susceptible to damage from rain and hot winds. Sheltered (mainly from north), well-drained site.
12. Nurserymen, garden plants.
13. See Ref. 11 for information on culture, varieties, etc.

1. *RED CURRANT*
2. *Rosaceae* 3. *Ribes sativum*
5. Several varieties — Dutch Red, Fay's Frolic, Raby Castle, White Dutch.
7. Multi-stemmed, deciduous bush to 1m.
8. Hardwood cuttings.
9. W. Europe — streams and wet woodlands.
10. Berries — good keeping characteristics when compared with other berries. Ripens early, November-December.
    Bee forage.
11. Suited to cold areas. Subject to frost damage due to early flowering. Sheltered N.E. slope best site. Tolerant of some shade. Soils not very critical but dry sites not suitable.
12. Nurserymen.
13. See Ref. 11 for culture and varietal information.

1. *REEDMACE*
2. *Typhaceae* 3. *Typha T. latifolia* and *T. angustifolia*
5. No named cultivars.
6. Greater and Lesser Reedmace, Cat's Tail, Bulrush.
7. Tall, aquatic reed.
8. Division of crown (rhizomes and shoots).
9. Cosmopolitan. Not cultivated.
10. Seeds, roasted have nutty flavour.
    Whole plant has delicate, sweet taste.[48]
    Roots — peeled, cooked or grated raw.
    Young shoots — used like asparagus.
    Animal forage, mainly roots. Pigs especially.
    Duck and water fowl habitat.
11. Well suited to cool areas. Naturalized in dams. Any still or slow moving water or marsh. Seems to thrive on the pure clay banks of dams. Tends to colonize — small ponds and dams.
12. Plants in dams.

1. *RHUBARB*
2. *Polygonaceae* 3. *Rheum rhabarbarum*
5. Many cultivars.
7. Large-leaved, clump-forming perennial.
8. Division of rootstock.
9. Asia. Long in cultivation.
10. Leaf stalks — stewed fruit.
    — dye.
    Leaves — oxalic acid — insecticide.
11. Well suited to cool areas. Rich garden soil. Will survive adverse conditions — common in abandoned gardens.
12. Very common garden plant. Seed from seedsmen.
13. *R. palmatum,* rarely grown as an ornamental is a useful medicinal herb. See Refs. 40, 53.

1. *ROSEMARY*
2. *Labiatae* 3. *Rosmarinus officinalis*
5. No named cultivars.
7. Woody, evergreen shrub.
8. Cuttings.
9. Europe.
10. Culinary herb.
    Oil—perfume, insect repellant, hair and skin cosmetic.
    Oil and dried herb — expands tissues to which it is applied and thereby increases blood supply to those tissues. Good for heart and circulation.[48]
    Bee forage. Flowers October-November.
    Hedge.
11. Well suited to cool areas. Light soils best. Open, sunny site. Seaside plant.
12. Nurseries. Garden plants — very common.

1. *RUE*
1. *Rutaceae* 3. *Ruta graveolens*
5. No named varieties.
6. Herb of Grace.
7. Aromatic, perennial shrub.
8. Seed, division of roots or cuttings and layers.
9. S. Europe.
10. Herb (foliage and flowers). Medicinal — anthelmintic, carminative, emmenenagogue, stimulant, stomachic. Mainly for gout and rheumatism and nervous heart problems. Promotes the onset of menstruation. Should not be used by pregnant women.
Large doses are toxic.
Pest repellant — can be tried to plants to repel insects.
Culinary herb with game.
11. Well suited to cool areas. Dry, calcareous, poor soils are 'O.K.', Rue requiries a sunny position.
12. Herb seedsmen and nurseries.
13. See Refs. 40, 48, 53 for more information.

1. *SAGE*
2. *Labiatae* 3. *Salvia officinalis*
5. No named varieties.
6. Garden sage.
7. Shrubby perennial herb, grey-green leaves, purple-blue flowers, December-February.
8. Seed or cuttings.
9. Mediterranean region. Widely cultivated as culinary herb.
10. Leaves — culinary herb in general use.
— antihydratic, antispasmodic, astringent. Used for reduction of perspiration. Gargle for sore throats, laryngitis and tonsillitis. Helps eliminate mucus congestion in the respiratory passages and stomach. Crush fresh leaves for insect bites.
Bee forage.
11. Suited to cool areas. Cut back by severe frosts. Most soils, sunny position.
12. Very common garden herb.
13. See Refs. 40, 41, 48, 53 for more information.

1. *ST. JOHN'S WORT*
2. *Hypericaceae* 3. *Hypericum perfaralum*
5. No named varieties.
7. Shrubby perennial flowers, November, March.
8. Seed?
9. Europe, N. Africa and W. Asia. Occasional roadside plant (weed) in Tasmania.
10. (Herb) (flowers and leaves) — antispasmodic, astringent, expectorant, nervine, vulnerary. Used for nervous conditions. Oil extract for intestinal problems, colic and congestion of the lungs.
Externally, oil is used for wounds, burns, etc.
Many other medicinal uses.
May be poisonous to livestock.
11. Well suited to cool areas. Dry, gravelly soils are most suitable. Sunny or half-shaded position.
12. Herb nurseries.
13. See Refs. 40, 48, 53.

1. *SIBERIAN PEA TREE*
2. *Leguminosae* 3. *Caragana arborescens*
5. No named varieties.
7. Shrub.
8. Seed sown in autumn or spring. If in spring, soaked overnight in warm water.
9. Siberia. Closely related to the *Gleditsia.* Grown as an ornamental in the U.S.A.
10. Seed — some culinary uses.
— animal forage — poultry. Peasants in Siberia rear poultry on this species.
11. Presumably extremely hardy.
12. No known source. Seed probably from American seedsmen.

1. *SLOE*
2. *Rosaceae* 3. *Prunus spinosa*
6. Blackthorn.
7. Deciduous shrub or tree to 4m — very thorny. Suckering habit, forming dense thickets.
8. Seed or suckers. Budding for cultivated varieties.
9. Europe, W. Asia, N. Africa.
10. Fruit — used in cooking.
— animal forage.
Very tough barrier plant.
Wood used for hay fork teeth.
11. Very hardy and adaptable. Suited to cool areas. Drought resistant. Most soils and sites.
12. Naturalized on roadsides to some degree (Ref. 54). Some nurseries.

1. *SNOWBERRY*
1. *Ericaceae* 3. *Chiogenes hispidulum*
5. No named cultivars.
7. Creeping, evergreen shrub.
8. Seed sown in autumn.
Root offsets and cuttings in spring.
9. N. America and Japan. Not generally cultivated.
10. White barriers — very delicate flavour, one of the best flavoured berries.
Yields in autumn.
11. Should be well suited to cool areas. Moist, boggy, acid spot. Good near creeks over decaying logs. Shade loving.
12. No known source. Seed possibly from American seedsmen.
13. See Simmons[17] for information on culture.

1. *SORREL*
2. *Polygmaceae* 3. *Rumex scutatus*
6. Garden Sorrel. Sheep Sorrel (*R. acetosella*), also edible but not cultivated.
7. Leafy, clump-forming herb.
8. Root cuttings in late winter.
9. Europe.
10. Leaves — salads, soups.
— juice used as rennet in junket.
Linen bleach for stains. Internal antiseptic.
11. Well suited to cool areas. Moist, partly shaded site.
12. Some herb suppliers. Old gardens.
13. Not a rampant weed like sheep sorrel.

1. *SOUR CHERRY*
2. *Rosaceae* 3. *Prunus cerasus*
5. Many cultivars and crosses with *P. avium* (sweet cherry).
6. Kentish or Flemish cherry.
7. Deciduous tree to 7m, occasionally a shrub.
8. Seed stratified, must not be allowed to dry out. Cultivars budded onto *P. cerasus* or *P. ovium* stocks.
9. S.E. Europe. Parent of cultivated sour cherries. Widely distributed. Common around homesteads and occasionally on roadsides in Tasmania.

10. Fruit — jam, cooking.
— pig forage.
Bee forage.
Yields early summer.
Shelter belt tree.
11. Well suited to cool areas. Very adaptable to a wide variety of soils and sites, even on moraine in the Rasselas Valley, Central Tasmania.
12. Some nurseries. Seedlings possibly from roadside trees.

1. *STONE PINE*
2. *Pinaceae* 3. *Pinus pinea,* other species
5. No named cultivars.
7. Conifer with wide, flat crown. Up to 10-30m tall.
8. Seed, occasionally cuttings.
9. S. Europe. Cones collected in ancient times. Popular in Afghanistan.
10. Kernels — very good flavour — delicacy nut — small.
— rich in oil.
Cones — dye when young and green.
Cones are collected when mature, but unopened, mostly in winter. The cones open in summer sun or dryer and nuts are shaken free. In Afghanistan, used for chest complaints, gives warmth in winter cold.
11. Suited to cool areas. Not as hardy as most pines, but grows well (mature tree) at the Forestry Commisssion Nursery, Perth, Tasmania. Exposed, rocky, dry sites quite suitable. Some species resist coastal winds.
12. Forestry Commission Nursery.
13. Many *Pinus* spp give edible nuts. See Coulters Pine.
Europe: *P. pinea, P. cembra.*
China: *P. armandi.*
Siberia: *P. sibiria.*
India and Afghanistan: *P. gerardiana* (Hobart Botanical Gardens), Tasmania.
N. America: *P. cembroides* (including var: *edulus, monophylla* and *parryana*), *P. sabiniana, P. torreyana, P. coulteri.*

1. *STRAWBERRY*
2. *Rosaceae* 3. *Fragaria F. virginiana, chiloenis* and others
5. Numerous cultivars, mostly from crosses.
7. Runner-forming herb, fruiting for 4-5 years.
8. Runners from parent plants.
9. Americas.
10. Fruit — dessert berry.
Bee forage.
Requires intensive garden culture for good yields but may be useful and self-propagating herb-layer species.
11. Suited to cool areas. Heavy frosts kill blossoms. Rich well-drained garden soil.
12. Nurseries.
13. See Ref. 11 for detailed information on culture and varieties.

1. *STRAWBERRY GUAVA*
2. *Myrtaceae* 3. *Psidium littorale (cattleianum)*
7. Bushy, evergreen shrub.
8. Seed, layering or cuttings.
9. Brazil.
10. Dessert fruit.
11. Marginally suited to cold areas. Needs warmth for ripening and cannot tolerate hard frosts. Warm, sheltered, sunny position. Much hardier than the common guava (*P. gunjava*), which is truly tropical.
12. Some nurseries.

1. *SWEET CHERRY*
2. *Rosaceae* 3. *Prunus avium*
5. Many cultivars. Crosses with *P. cerasus* called "Dukes".
6. Mazzard, Gean.
7. Spreading, deciduous tree up to 20m. Long lived.
8. Seed, stratified, must not be allowed to dry out, sown in spring, or sown as soon as ripe, in autumn.
Budding or grafting onto *P. avium* or *P. cerasus* for cultivated varieties.
9. Europe. Natural habitat in open areas.
10. Fruit — desert. Yields early summer.
— animal forage. Pigs will crack and eat the nuts also.
Timber — valuable for cabinet making, musical instruments, etc. Most varieties are self-sterile and several, inter-sterile.
11. Well suited to cool areas. Late flowering means frosts are rarely a problem. Particular about soils and site. Perfectly-drained, deep, fertile soil (and loamy), for good tree development and fruiting. Sheltered location for good pollination.
12 Nurseries.
13. *See Tasmanian Journal of Agriculture,* May '76, "Cherry Culture in Tasmania", for details and varieties.
See Bailey [38] for detailed information on propagation.

1. *SWEET CHESTNUT*
2. *Fagaceae* 3. *Castanea sativa*
5. Over 200 cultivars in Italy. Few in Australia.
6. Spanish Chestnut.
7. Large, deciduous tree to 30m, with broad crown. Very long lived.
8. Seed must not be dried too hard or too little. Stratify. Cultivars are budded or grafted which is very difficult. Nut grafting is the simplest technique (see Ref. 12). We have good results from autumn planted nuts, under mulch *in situ.*
9. S. Europe. Introduced to Britain by Romans. Staple subsistence crop and important commercial crop in S. Europe.
10. Nuts eaten roasted.
— ground for sweet flour, rich in starch, low in oils.
— animal forage — high grade pig food.
— dried in hot sun or over slow fire for keeping.
— cured in chimneys.
— yields can be low in cold areas.
— nuts fall when ripe.
— grafted tree can yield in 5-7 years but seedlings may take 15, or more, years.
11. Suited to cool areas. Best in warmer parts. Most well-drained soils. Most sites.
12. Forestry Commission Nursery.
13. Sweet Chestnut is susceptible to the blight fungus which destroyed the American Chestnut.

1. *TRAPA NUT*
2. *Hydrocaryaceae* 3. *Trapa T. natans* and *T. incisa* (N. Japan)

5. Cultivars in China.
6. Water Faltrop, Water Chestnut.
7. Floating, aquatic and perennial.
8. Seed must not be dried out. Stored in water at 7-10 deg. C. Germination at 16-18 deg. C.
9. Persia, S.E. Europe, Australia. Widely cultivated in China, India. Major food of neolithic Europeans.
10. Nut (fruit) — dessert, rich in iron.
    — flour like arrowroot.
11. Probably suited to temperate areas. Warm, sunny ponds. Naturalized along rivers in Massachusetts, U.S.A. Some Australian rivers.
13. See Simmons[17] for information on culture.

1. *TREE TOMATO*
2. *Solanaceae* 3. *Cyphomandra betacea*
6. Tamarillo.
7. Short-lived, under-shrub to 4m.
8. Seed sown under glass in spring. Cuttings, from 1 or 2 year old wood, 1-2cm thick, up to 40cm long, cut square below a bud. Cuttings produce bushier, more windy-hardy plants.
9. Peru and Brazil. Grown in New Zealand for export (including Australia).
10. Fruit — fresh, stewed, chutney, etc.
    — very high in vitamin C.
    — dye.
    Yields in two years.
11. Marginally suited to cold areas. Frost and wind-tender, especially when young. Sheltered, frost-free position. Well-drained soil.
12. New Gippsland Seed Farm and other seedsmen.

1. *UGNI*
2. *Myrtaceae* 3. *Myrtus ugni*
5. No known cultivars.
6. Chilean Guava.
7. Compact, evergreen shrub up to 2m.
8. Cuttings in summer under glass.
9. Chile. Cultivated by Chileans and Spanish settlers.
10. Fruit — thick skinned berry, keeps well (relative to other berries).
    — jam, preserves.
    — highly aromatic.
11. Well suited to cool areas. Grows best in sheltered spot. Tolerant of dense shade. Not particular about soils.
12. Some nurseries.
13. See Simmons[17] for further information.

1. *WALNUT*
2. *Juglandaceae* 3. *Juglans regia*
5. Many cultivars — about 30 in Australia.
6. Persian Walnut, English Walnut.
7. Spreading, deciduous tree to 30m. Long lived. Various *Juglans* spp. used as stocks.
8. Seed germinate well in moist compost. This technique supplants stratification for many trees.
   Grafting or budding for cultivars, difficult.
9. S.E. Europe, through W. and Central Asia to China. Grown around homesteads and town houses in Tasmania since the early days of settlement.
10. Nuts — dessert nut.
    — oil, expressed — cooking and salad oil.
    Fruit — pickled.
    Timber — valuable for cabinet making, etc.
    Husks — tan and dye.
    Husks and leaves — essential oil Citronella (mosquito repellant).
    Good yields after 6-10 years. Well established orchids yield 8000 lbs./acre. Most seedlings yield well and produce a nut of reasonable quality. Budded trees drop nuts more readily than seedlings.
    Flies are repelled by the presence of a walnut tree[14] (possibly due to Citronella). Walnuts inhibit the growth of tomatoes and potatoes.[14]
11. Well suited to cold areas. Most positions and soils but grows and yields best on deep, well-drained, rich soil.
12. Seedlings — Forestry Commission Nursery. Some grafted varieties from nurseries — expensive.
13. See Jaynes,[12] Bush[10] and Howes[9] for further information.

1. *WAXBERRY*
2. *Myrtaceae* 3. *Myrica M. cerifera* (also *californica* and *carolinensis*)
5. No named cultivars.
6. Bayberry, Wax Myrtle, Tallow Shrub, Sweet Gale.
7. Shrub or tree up to 10m in favourable sites.
   Evergreen in natural habitat. Partly deciduous in cool climates.
8. Seed, stratified. Layering and division.
9. N. America. Woods and fields, from New Jersey to Florida and Texas.
10. Berries — wax-like fat used for candles. Berries boiled — wax skimmed off when cool.
    Bark, leaves and wax — astringent, tonic. Used for haemorrhages, sore throats, cuts, wounds, Wax effective against dysentery. See Lust.[53]
11. Probably suited to cool areas. Does not tolerate heavy frosts well.[23]
    Tolerant of salt spray and very wet soils.[23]
    Grows in almost any soil.[23]
12. Mentioned by Lord,[23] so should be in Australia.

1. *WHITE MULBERRY*
2. *Moraceae* 3. *Morus Alba*
5. Many varieties.
6. Silkworm Mulberry.
7. Deciduous tree to 15m.
8. Cuttings or layers — easy.
9. China. Staple food in parts of Asia.
   Leaves fed to silkworms.
10. Fruit — dessert.
    — dried, similar food value to dried figs, made into sweet flour.[18]
    — animal forage.
    Quality and yield of fruit vary considerably but some cultivars have fruit up to 5cm long.
11. Probably suited to cool areas. Any soil, moist sites, includes dry, rock ones.
12. Possibly from nurseries.
13. *M. rubra*, an American Mulberry, has similar uses.

1. *WILD RICE*
2. *Gramineae* 3. *Zizania aquatica*
5. No named cultivars.
6. Indian Rice.
7. Self-seeding, aquatic grass up to 4m.
8. Seed sown in mud on pond bottoms. Very short viability.

9. N. America and E. Asia. Cultivated in China. Important food of N. American Indians of the N.W. region
10. Grain — flour, bread, etc.
    — an acre (wild, untended) of Wild Rice is equal in nutrient value to an acre of wheat (cultivated).
    — drops as soon as ripe. Indians collect grain by pushing canoes through the rice and shaking the seed heads over the canoe
    — high-quality dairy cow feed.
    Solid base of stems — choice vegetable.
    Foliage — animal forage.
11. Very hardy. Should grow well in cool areas. Slow-moving water, dams, lagoons, lakes.
12. Wildlife Nurseries, P.O. Box 399, Oshkosh, Wisconsin. 54901. U.S.A. *Last Whole Earth Catalogue* gives source (American Nursery).
13. L.W.E. *Catalogue* also refers to book *Wild Rice,* by William Dove, published by Queen's Printers, Ottawa, Canada.

1. *WOOD MILLET*
2. *Gramineae* 3. *Milium effusum*
6. Perennial grass to 1m. Long, wide, spreading inflorescences.
8. Seed.
9. Grows in Britain and Europe. Not generally cultivated.
10. Seed — animal forage, especially poultry.
11. Probably well suited to cool areas. Shady, moist woods and forests.
12. No known source.
13. The fact that Wood Millet grows in forests makes every effort to find a source worthwhile.

1. *YARROW*
2. *Compositae* 3. *Achillea millefolium*
5. No cultivars named.
6. Milfoil.
7. Perennial, upright herb with white flower heads and creeping rootstock. Main flowering December-March.
8. Root division. (Easy).
9. Native of Central Europe. Relatively common weed in wet areas of Tasmania.
10. Flowering tops and foliage — antispasmodic, astringent, carminative, chologogne, diaphoretic, haemostatic, tonic. Many medicinal uses.
11. Well suited to Tasmania.
12. Herb nurseries. Roadsides, especially in N.W. Tasmania.
13. See Refs. 40, 48, 53.

Appendix C Formal Classification of Selected Species.

Genus	Species	Common Name	Genus	Species	Common Name
Ginkgo	biloba	Ginkgo	Malus	pumila	Apple
Pinus	coulteri	Coulters Pine	Pyrus	communis	Pear
Araucaria	bidwilli	Bunya Bunya Pine	Cydonia	oblonga	Quince
	araucana	Monkey Puzzle	Mespilus	germanica	Medlar
	angustifolia	Brazilian Pine	Eriobotrya	japonica	Loquat
Asimma	triloba	Custard Banana	Sorbus	terminalis	Chequers
Lauras	nobilis	Bay Laurel	Chaenomeless	speciosa	Japanese Quince
Morus	nigra	Black Mulberry	Crataegus	azoroles	Mediterranean Medlar
	alba	White Mulberry		coccinioides	Hawthorn
	rubra	Red Mulberry		ellwangeriana	Hawthorn
Ficus	carica	Fig		douglasi	Hawthorn
Humulus	lupulas	Hop	Rubus	idaeus	Raspberry
Quercus	virginiana	Live Oak		loganbaccus	Loganberry
	macrocarpa	Burr Oak		chamaemorne	Cloudberry
	lobata	Californian White Oak	Fragaria	virginiana	Strawberry
	alba	White Oak		chiloensis	Strawberry
	bicolor	Swamp White Oak		vesca	Alpine Strawberry
	michanxii	Swamp Chestnut Oak	Prunus	dulcis	Almond
	prinus	Chestnut Oak		armenaica	Apricot
	muhlenbergii	Chinquapin Oak		ceraifera	Cherry Plum
	prinus pumila	Dwarf Chestnut Oak		instilia	Damson Plum
	ilex	Holm Oak		laurocerasus	Laurelberry
	robur	English Oak		persica	Peach
	suber	Cork Oak		spinosa	Sloe
Fagus	granifolia	American Beech		cerasus	Sour Cherry
	sylvatica	European Beech		avium	Sweet Cherry
Castanea	sativa	Sweet Chestnut	Robinia	pseudoacacia	Black Locust
	mollisima	Chinese Chestnut	Acacia	melanoxylon	Blackwood
	crenata	Japanese Chestnut	Ceratonia	siliqua	Carob
Corylus	avellana	Hazel	Cytisus	proliferus	False Tree Lucerne
	maxima	Filbert	Gleditsia	triacanthos	Honey Locust
Myrica	cerifera	Waxberry	Pueraria	thunbergiana	Kudzu Vine
	californica	Waxberry	Lespedeza	servicea	Lespedeza
	carolinensis	Waxberry	Medicago	sativa	Lucerne
Juglans	regia	Walnut	Lupinus	polyphyllus	Perennial Lupin
	nigra	Black Walnut	Prosopis	juliflora	Mesquites
	sieboldiana	Japanese Walnut		chilensis	Mesquites
	cinerea	Butternut		alba	Mesquites
Carya	illonoiensis	Pecan		glandulosa	Mesquites
	ovata	Hickory	Strombcarpa	pubescens	Mesquites
	laciniosa	Hickory		cinerciscens	Mesquites
	tomentosa	Hickory	Caragana	arborescens	Siberian Pea Tree
Salix	viminalis	Osier Willow	Myrtus	ugni	Ugni
Phytolacca	americana	Pokeweed	Psidium	cattleianum	Strawberry Guava
Opuntia	cantabridgida	Prickly Pear	Myrica	cerifera	Waxberry
Chenopodium	album	Fat Hen		californica	Waxberry
	bonus-henricus	Good King Henry	Feijoa	sellowiana	Feijoa
	expansa	N.Z. Spinach	Trapa	natans	Trapa Nut
Tetragonia	rhubarbarum	Rhubarb	Oxalis	tuberosa	Oca
Rheum	scutatus	Garden Sorrel	Tropalaeum	tuberosum	Capuchin
Rumex	myrtillus	Bilberry	Ruta	graveolens	Rue
Vaccinium	corymbosum	Swamp Blueberry	Citrus	sinensis	Sweet Orange
	pennsylvanicum	Sweet Blueberry		limon	Lemon
	macrocarpon	Cranberry		maxima	Grapefruit
	mollisima	Banana Passionfruit	Fortunella	japonica	Cumquat
	kaki	Persimmon	Rhus	verniciflua	Lacquer Tree
Passiflora	virginiana	American Persimmon	Pistacia	vera	Pistachio
Diospyros	communis	Castor Oil Plant	Acer	saccharum	Sugar Maple
	sebiferum	Chinese Tallow Tree	Aesculus	hipposcastanum	Horse Chestnut
Ricinis	grossularia	Gooseberry	Zizphus	jujub	Jujube
Sapium	rubrum	Red Currant	Vitis	vinitera	Grape
Ribes	nigrum	Black Currant	Cornus	mass	Cornelian Cherry

Genus	Species	Common Name
Foeniculum	vulgare	Fennel
Petroselium	crispum	Parsley
Macadamia	tetraphylla	Macadamia
	integrifolia	Macadamia
Olea	europea	Olive
Sambucus	nigra	Elderberry
Valeriana	officinalis	Valerian
Symphytum	officinale	Comfrey
	tuberosum	Comfrey
Borago	officinalis	Borage
Physalis	peruviana	Cape Gooseberry
Salvia	officinalis	Sage
Mentha	spicata	Mints
	rotundifolia	Mints
	piperita	Mints
	pulegium, etc.	Mints
Thymus	vulgaris, etc.	Thyme
Melissa	officinalis	Hyssop
Lavandula	dentata	Lavender
Rosmarinus	officinalis	Rosemary
Monarda	didyma	Bergamot
Stachys	sieboldii	Chinese Artichoke
Origanum	margorana	Marjoram
Helianthus	tuberosus	Jerusalem Artichoke
Anthemis	nobilis	Chamomile
Cynara	scolymus	Globe Artichoke
Taraxacum	officinale	Dandelion
Chichorium	intybus	Chicory
Saggitaria	sagittifolia	Arrowhead
Urginen	maritima	Squill
Asparagus	officinalis	Asparagus
Phormium	tenax	N.Z. Flax
Phragmites	communis	Common Reed
Milium	effusum	Wood Millet
Zizania	aquatica	Wild Rice
Arundinaria	anceptse	Bamboo
	falcata	Bamboo
	falconen	Bamboo
	fastuosa	Bamboo
	hindsii	Bamboo
	macrosperma	Bamboo
Phyllostachys	anrea	Bamboo
	milis	Bamboo
	quilies	Bamboo
Chusquea	culeon	Bamboo
Cyperus	esculentus	Earth Almond
Canna	edulis	Queensland Arrowroot
Acorus	calamus	Sweet Rush

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About the Authors

BILL MOLLISON
Born in the small fishing village of Stanley, (Tasmania) Bill Mollison left school at the age of 15 to help run the family bakery. Between then and 1954 he held a variety of jobs including seaman, shark fisherman, mill-worker, trapper, snarer, tractor-driver and glass-blower. He spent nine years in the Wildlife Survey Section of C.S.I.R.O. followed by a year at the Tasmanian Museum in curatorial duties, and a further period of field work with the Inland Fisheries Commission. In 1968 he was appointed tutor at the University of Tasmania where he is currently senior lecturer in Environmental Psychology. He has published works on the history and genealogy of the Tasmanian Aborigines and on lower vertebrates of Tasmania.

DAVID HOLMGREN
David Holmgren was born in Fremantle, Western Australia where he spent his childhood. After matriculating from John Curtin Senior High School in 1972, he spent 12 months hitch-hiking around Australia including Tasmania. In 1974 David moved to Tasmania to study Environmental Design at the Tasmanian College of Advanced Education. His interest gravitated towards landscape design, ecology and agriculture and, during a close association with Bill Mollison, he developed the Permaculture concept as part of his studies.

It is proposed to form an association for action in Permaculture in order to:—

- gather and exchange seed and sources
- set up design schools
- work with local authorities
- tie in with the organic movement and Keyline
- form local groups and visit areas as they develop
- release news, evolve a newsletter
- plant a lot of perennials for man and the future.

If you want to help, forward $8 and S.A.E. to Bill Mollison, University of Tasmania, Hobart 7000. (Australian members only).

Your Name: .... Cash/Cheque/ Money Order: $..............

Full Address: ....

.... Post Code: ....

Special Interest
(local group organizers needed): ....

....

....

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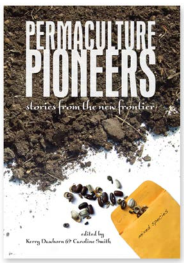
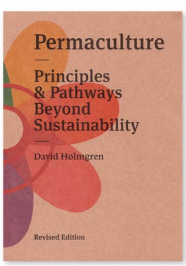
Further reading

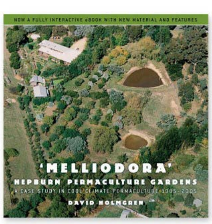


For more on the history of permaculture from multiple perspectives see *Permaculture Pioneers: stories from the new frontier* (Dawborn & Smith eds, 2011, Melliodora Publishing). A collection of personal essays from permaculture practitioners including David Holmgren's 'The Long View' referred to in the Preface (footnote 1).

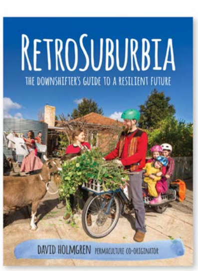
For more on what David has been doing since *Permaculture One* see holmgren.com.au, as well as his eight other books, which include:



Permaculture: Principles and Pathways Beyond Sustainability (2002/2017). Drawing together and integrating 25 years of thinking and teaching, David explores permaculture, sustainability and resilience through the lens of his permaculture design ethics and principles.



Melliodora: Ten years of sustainable living (1995/2005). Documenting David and Su's home base, this large-format book with e-book update provides plans, photos and commentary on one of Australia's best known permaculture sites.



RetroSuburbia: the downshifter's guide to a resilient future (2018). David's manual and manifesto for transforming suburbia promises a challenging but exciting mix of satisfying work, a more meaningful way of living, and hope for the next generation as we move towards an uncertain future.

MELLIODORA
PUBLISHING

About Melliodora Publishing

Melliodora Publishing was started by Su Dennett and her partner David Holmgren, co-originator of permaculture, to produce books and other media to support people in their permaculture journey, while bypassing the traditional gatekeepers of the publishing industry.

We aim to minimise adverse environmental impacts of the whole book creation, including printing, logistics and marketing chain, while providing a fair share return to authors, illustrators, editors and other creative contributors to the publishing process. We operate outside of monopolistic distribution and marketing systems of online conglomerates, and preference printing with owner-operated businesses in Australia and/or other markets rather than globalised corporations.

At all times we are guided by permaculture ethics and principles.

For more see melliodora.com

For more on permaculture see permacultureprinciples.com

For more on David Holmgren see holmgren.com.au;
for his take on possible climate change futures see futurescenarios.org;
and for his practical strategies for a resilient future see retrosuburbia.com