Section Three

Diversity

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Importance of Biodiversity

Biological diversity is responsible for the maintenance of the world as we know it. The gene pool is a real treasure. This living treasure of seeds comprises billions of years of evolution and at least 12,000 years of human selection for agriculture. From a biological viewpoint, genetic diversity is as essential to life as food, air and water. Today our society relies on only 150 out of a possible 80,000 food plants. Since 1990, of the variety of food plants that our grandparents ate, only 3% are still available today.

The loss of genetic diversity in the food supply chain directly impedes the safety of crops, because of their ability to adapt, to resist blights, pests and disease depends on variation. When one plant becomes extinct, so too will the 20 – 40 animal and insect species that rely on it.

Gardeners are emerging as principal biological heroes in the struggle of the era to maintain the biological diversity that sustains life on the planet.

Fetzer Garden, USA

Diversity and Stability

Generally, the more complex the web, the less likely it is that a disturbance will cause individual species to die out. So the system remains stable. If an organism's normal food source is not available there is so much variety (diversity) that it can eat something else. Also, if a particular consumer dies or moves away from the ecosystem, others will eat its feed.

So, in natural ecosystems, there is a relationship between diversity and stability.
The more variety in the system the better the system can survive a disturbance. Even on a farm, the right sort of diversity will help stabilise the ecosystem.

Diversity and Complexity

In nature, balance is associated with diversity and complexity. However, just by making the system more complex and diverse doesn't guarantee that it will be balanced. But diversity in many organic systems can mean less pest damage because pests have difficulty finding their food (because there is not a lot of one type of plant or animal) and because there are more animals (or plants) to destroy them.

Diversity of plants could also mean more allopathic effects where germination, growth and metabolism of one plant is inhibited by the release of chemicals from another plant.

What Do We Mean by Biodiversity

by Faith Thomas

With so much discussion about the importance of biodiversity it is essential to clarify what it actually means, and to ensure that we are aware of the many reasons for protecting and fostering it. The superficial nature of the mass media seems to breed a culture of partial understanding that is dangerous, leading to community decisions that fail to address important issues.

The term biodiversity simply means 'the variety of life', however, the simplicity of this definition in no way expresses the importance of biodiversity, that by compromising life itself.

There are three levels of life to consider when we talk about biodiversity:

- Diversity between ecological systems — as a dune to an estuary or a littoral rainforest as to dry sclerophyll forest
- Diversity between species – as a snake to a tortoise or a Eucalyptus punctata as to a Eucalyptus paniculate
- Diversity within species – as a Queensland blue to a Jap pumpkin or a Smith to a Jones.

The concept of biodiversity becomes more complex when we recognise the complexity of life itself. We all see the variety of life around us; there are millions of species on Earth and they give life a wonderful flavour and beauty. It is a sad thing when one of these species is declared extinct, but do we really think about how losing these species endangers the integrity of the web of life itself? Do we recognise the connections that exist between and within species and ecosystems?

Consider the humble mosquito, in no danger of extinction, but a good example none the less. If the mosquito was removed from the web of life how would this impact on the lizards, frogs and other species that feed on them? In a diverse system, other species (flies, gnats, fleas etc) are available and the frogs and lizards adapt; stability is easily maintained. But imagine a system already full of gaps, where diversity has already been compromised. Disturbance in the system is no longer so easily overcome.

Inherent in biodiversity is the ability for an ecological or natural system to maintain stability. Take a simple human example. In a natural disaster such as a flood or earthquake, a small group of people will be much more likely to survive if they all have different professions and occupations, than if they had the same skills and abilities. This principle holds true on all levels, from the diversity of ecosystems to the diversity of microorganisms in the human intestine. A stable system is resilient and can survive the onslaughts of both nature and human kind.

Consider diversity within species. When we look around us we can see this very clearly in our own species, within and between families, as well as across 'races'. We are all different, and diversity within a species does not stop at skin colour and facial features but also determines immunity, susceptibility to illness and many other survival traits.

We are part of the web of life.

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We don't consider diversity within species as much when considering, for example, food crops such as rice and wheat. Once upon a time there was a slightly different variety of rice in every bioregion of China. But with patented hybrid varieties pushed so heavily by large seed corporations, the vast majority of these species were discarded in favour of one or two that produced higher yields. These local variations are now extinct along with the survival traits bred into them over thousands of years.

Now, when problems arise such as drought, fungal disease or insect plagues, crops are damaged all over the country, leading to widespread famine and economic hardship. The new varieties are also often dependent upon many more inputs such as irrigation, pesticides and human labour; this is not their natural biological niche and they need to be coddled in order to survive. They have not developed to deal with the local conditions.

Biodiversity is also inherent in ecological systems and we must be aware of this when it comes to repairing the damage of land clearing and other ecological disturbance. For example, there are over seven hundred species of Eucalypt in Australia; around each one has developed a complex ecosystem that relies on the interactions with this dominant species in order to maintain its integrity. Birds that feed on its blossoms, insects that use its bark for habitat. It is therefore essential to replant the correct species when rebuilding or repairing a natural system.

It is also important to plant the right variety. A species can vary enormously from one bioregion to another, simply because it has developed genetically over hundreds (or thousands) of years to the climate, topography and soil conditions of that area. A species sourced from another area will very likely do poorly and may not even survive. Already, extensive land clearing in Australia has destroyed much of this genetic diversity, and with it the integrity, and stability, of entire ecosystems.

The principles of biodiversity are the same on the farm and in the garden as they are within a natural system. Biodiversity creates stability and resilience. In particular, fostering biodiversity can produce the following benefits for the organic practitioner:

- Planting species developed for your climate and soil type will not only help to preserve these species for further generations but also give you greater yields and healthier more independent crops. Continue to develop these species by saving the seed of the healthiest, most productive plants.
- Diversifying your plantings to include herbs and legumes helps create synergistic relationships that improve your soil fertility, attract beneficial predator species such as frogs and insects and deter pests.
- Planting a diverse range of indigenous native species will attract a wide range of bird, insect and reptile species essential for effective organic pest control.

Earth is a wondrous place and its wonder stems from the incredible and complex interactions and relationships between the millions upon millions of organisms and ecosystems, each evolved over billions of years to fill a unique niche, a little like a piece in a puzzle. The more we disturb and ill-treat this miraculous system, the more frayed and fractured it becomes. Holes are created that continue to unravel, slowly but surely destroying the intricate patters. Species and systems become isolated, a death sentence in a world where interdependence is law. Eventually things fall apart: forested land becomes desert, fertility gives way to barrenness and decay.

Look after your planet and its diversity. We too are a part of the web of life.

Hunter Organics, *Special Issue: Biodiversity,* 2003, p.4.

When we talk about biodiversity we are referring to birds, insects, plants, domestic stock, wildlife and biological life within the soil. Maintaining species diversity and the biological health of the system is essential to ensure a sustainable and productive system well into the future.

Biological Diversity

"Agriculture cannot be sustained without biological diversity (biodiversity). At some point, losses in biodiversity will always result in the failure of a civilization's agriculture. Without agriculture you cannot have businesses, artisans, governments or civilisations, because everyone is out hunting and gathering."

"When we talk about diversity in age structure, we refer to the need for members of all ages. This addresses those situations where all the "right species" might be present, but no young, which indicates these species might be dying out. The same example serves for what we mean by the "mass of life". Again, you could have all the right species present, but so few of their numbers, that you could hardly all the situation healthy."

Allan Savory, *Introduction to Holistic Management*, 'Importance of Biodiversity', Holistic Educators and Management, p5-2

Productivity and Biodiversity *Always* Go Together

In the old paradigm, organisms are predominately seen to compete for resources and for space. But we've got three space dimensions and the time dimension too. We've got space-time that we can fill up more thickly with life cycles of different sizes that occupy different space-times. This is exactly what organisms in a naturally biodiverse ecosystem do to maximise the reciprocal, symbiotic relationships that benefit all the species. So you can add fish, algae, poultry, worms, mushrooms, etc., turning the 'waste' from one cycle to resource for another.

The more lifecycles incorporated, the more energy and standing biomass are stored within the system, and the more productive the farm. It will also support more farmers or farm workers.

Productivity and biodiversity always go together in a sustainable system, as generations of farmers have known, and recent academic researchers have rediscovered. It is also the most energy efficient. Why? Because the different life cycles are essentially holding the energy for the whole system by way of reciprocity, keeping as much as possible and recycling it within the system.

Sustainable Systems as Organisms, Dr Mae-Wan Ho

Strength in Diversity

"When we first began planting trees we were really only thinking about establishing big, tall trees. The idea that there was value in other types of vegetation was still foreign to us. In time, however, we came to recognise the importance of shrubs and understorey plants as well. Indeed, it has become clear to us that the key principle in a healthy ecosystem is diversity. We believe that this is the most critical factor in attracting a wide range of native fauna, particularly native birds.

"We've been most keen to attract birds back to our land. Partly it's because we believe that they have a right to persist in the landscape, partly because we enjoy having them around and feel some satisfaction that our efforts to heal the land are having some effect. However, there's also a practical side to our efforts because many species of bird provide ecosystem services in the form of natural pest control on the farm. As well as the birds, there are also a number of beneficial insects which aid pest control. Native animals and insects are also important pollinators that help with growth and establishment of native plants, as well as improving our seed harvest.

"Diversity is the key. Variety in plant species, and variety in plant shapes and sizes. Variety in what's available through the year. One of the factors we have employed to assist birds and other animals to use the farm is to have a variety of plants flowering at all times of the year. Because many of the birds and insects rely on nectar as part of their diet, it's important to have a source of nectar available all year round. We now have at least one or two species of wattle flowering in every month of the year, as well as a range of other flowering trees and shrubs. Another important factor is to have some prickly shrubs in many areas, as these plants provide secure nesting sites for birds and a safe haven from predators.

"Unfortunately, we can't meet the needs of some species. Probably our greatest habitat deficiency is the lack of tress with hollows. Regretfully, we removed most of them long before we recognised their value, and can do little, in the short term to rectify that."

John Weatherstone, *Lyndfield Park, Looking Back, Moving Forward*, pgs10,11.



'Lyndfield Park'

Diversity is the Key

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John Weatherstone, *Lyndfield Park, Looking Back, Moving Forward*

Moving Towards a Sustainable Future

"We wanted to reduce the pressure we were placing on the land so that it would become more resilient to stress, while at the same time caring more for the assets of the farm upon which our enterprises were based: the soil, the nutrients it contained, the vegetation that held it in place and the native life that was part of its cycle.

"Our major changes included;

- reducing the stocking rates to allow the land to heal following the drought
- managing the level of grazing to increase soil organic matter
- initiating a tree planting program to protect both livestock and soils
- reducing the amount of cropping
- reducing the amount of cultivation during crop and pasture establishment
- retaining (i.e. not burning) crop stubbles and finding ways to incorporate them back into the soil
- planting a diversity of trees and shrubs to encourage the return of as many native birds as possible
- reducing the use of toxic chemicals wherever possible
- continuing to treat existing erosion areas and prevent further erosion
- increasing the establishment and use of perennial pastures for better water use, soil protection and livestock productivity
- seeking ways to replace livestock income with income from trees and shrubs.

"Not only did we believe that these steps would help make the farm a healthier and more pleasant environment in which to live and work, we also hoped it would improve the long term productivity of the property as well as increase its capital value."

John Weatherstone, *Lyndfield Park, Looking Back, Moving Forward*,

Diversified Farms

Diversified farms are usually more economically and ecologically resilient. While monoculture farming has advantages in terms of efficiency and ease of management, the loss of the crop in any one year could put a farm out of business and/or seriously disrupt the stability of a community dependent on that crop. By growing a variety of crops, farmers spread economic risk and are less susceptible to the radical price fluctuations associated with changes in supply and demand.

Properly managed, diversity can also buffer a farm in a biological sense. For example, in annual cropping systems, crop rotation can be used to suppress weeds, pathogens and insect pests. Also, cover crops can have stabilizing effects on the agroecosystem by holding soil and nutrients in place, conserving soil moisture with mowed or standing dead mulches, and by increasing the water infiltration rate and soil water holding capacity. Cover crops in orchards and vineyards can buffer the system against pest infestations by increasing beneficial arthropod populations and can therefore reduce the need for chemical inputs. Using a variety of cover crops is also important in order to protect against the failure of a particular species to grow and to attract and sustain a wide range of beneficial arthropods.

Optimum diversity may be obtained by integrating both crops and livestock in the same farming operation. This was the common practice for centuries until the mid-1900s when technology, government policy and economics compelled farms to become more specialized. Mixed crop and livestock operations have several advantages. First, growing row crops only on more level land and pasture or forages on steeper slopes will reduce soil erosion. Second, pasture and forage crops in rotation enhance soil quality and reduce erosion; livestock manure, in turn, contributes to soil fertility. Third, livestock can buffer the negative impacts of low rainfall periods by consuming crop residue that in "plant only" systems would have been considered crop failures. Finally, feeding and marketing are flexible in animal production systems. This can help cushion farmers against trade and price fluctuations and, in conjunction with cropping operations, make more efficient use of farm labor.

Sourced from *http://www.sarep.ucdavis.edu/concept.htm#Themes*

Soil Biodiversity

by Sandra Norman

When the term bio-diversity is mentioned, how many of us think about this in relation to the soil? Biodiversity is readily recognised and acknowledged when talking about plants and animals, for example, but little thought is given to the many organisms that live in the soil under our feet. Indeed, the benefit from these numerous and diverse forms of soil life is often overlooked. However, they contribute to the health of the soil and ultimately the plants that we nurture and grow the health of our domestic farm animals and of course the health of us, when we eat food grown and raised on healthy land.

As biodiversity is important for the health of our general environment, so too is biodiversity important and necessary for the soil. The multitude of macro and micro organisms present in a 'healthy' soil, many of which we usually don't think about because we can't see them, work tirelessly around the clock improving the condition of the soil.

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How is this biodiversity created in a soil? It is relatively simple - by providing food and habitat and suitable conditions. This means regular and generous applications of organic matter, not using chemicals, using appropriate tillage practices, maintaining moisture levels.

Organisms living within and associated with the soil act as natural recyclers, turning organic matter into humus, one of the colloidal fractions of the soil - the basis of soil fertility. Some of these organisms are predators - nature's own pest control system. Organic gardening and farming is about balance - ensuring biodiversity in the soil is part of this balance.

What are some of the organisms found in a living and fertile soil?

Macro organisms or the physical decomposers

1. Earthworms – the 'king' of recyclers – the castings of the humble earthworm are rich humus, full of plant nutrients held in a stable form for plants to use. This type of humus encourages fine root hairs to develop on plant roots, essential for the uptake of nutrients.

2. Millipedes –eggs laid in the soil – adults feed on plant material, breaking it down.

3. Centipedes – feed on living animals such as insects and spiders.

4. Ants – assist with the aeration and water infiltration through the tunnels left behind as they transport material to their nests.

5. Termites – some species not necessarily desirable near buildings, but they play an important role in decomposing dead wood – integral for the health of the 'bush'. The soil is opened up as they transport material to their nests.

6. Spiders – useful for pest control – feed on insects and small invertebrates.

7. Beetles – numerous varieties – some feed on fungal spores; others feed on insects, snails, etc; others feed on decaying vegetable matter.

8. Springtails – feed on fungi, decomposing plants.

9. Nematodes – not all nematodes eat plant roots – some feed on other organisms such as fungi, bacteria, algae, other nematodes, etc.

10. Mites – some feed on plant matter whilst others ingest nematodes, fly larvae, other mites, etc.

Micro organisms or the chemical decomposers

1. Bacteria – tiny, single celled organisms feeding on organic matter with the nutrients that are released available for plants; other types of bacteria feed on other soil life, particularly fungi; some bacteria can also fix atmospheric nitrogen.

2. Actinomycetes – usually more active in the later stages of decomposition as they are able to bread down the more difficult parts of organic matter. Some produce chemical substances (antibiotics) that kill nearby organisms including parasitic fungi. Other actinomycetes have a symbiotic relationship with some plant species (e.g. Casuarina sp.) forming nitrogen nodules on the roots.

3. Protozoa – small single-celled animas with bacteria being their main food source, although some do feed on algae, fungi other protozoa.

4. Fungi – most fungi live on dead organic matter and are present in high numbers during the final stages of decomposition. Soil structure is improved – they produce humus and as well as bind soil particles together. Some fungi are parasitic and feed from living plants.

5. Algae – tiny plants – some fix atmospheric nitrogen.

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It may appear that some of these organisms are consuming what could be viewed as 'beneficials', however it is the overall balance of the food chain that is relevant and a well managed organic garden should readily achieve this natural balance.

What is the benefit of these various organisms?

1. Improved soil structure
2. Improved aeration
3. Improved water infiltration
4. Improved water holding capacity
5. Improved porosity (pore spaces within the soil)
6. Decomposition of organic matter
7. Conversion of elements into a form able to be taken up by plants
8. Plant nutrients held in a stable and available form
9. Benefit to some plants through symbiotic relationships between micro-organisms and plant roots
10. Recycling of plant waste, dead insects etc., animal and insect excrement
11. Fixing of atmospheric nitrogen
12. Humus - one of the two colloidal fractions of the soil

Soil organisms are just like any other living organism – they have similar requirements viz. food and habitat. Every time we add organic matter in the way of compost, green manure crops, mulch, etc., we are providing both of these essentials... The regular and continuous addition of organic matter to the soil increases the diversity, population and activity of soil organisms. Our aim should be to ensure the conditions are suitable for these invaluable organisms, many of which are invisible to the naked eye.
The soil is the foundation – this is often overlooked and much time, energy and expense is spent trying to remedy problems that could have been avoided if attention had just been given to ensuring the foundations were in good condition. The ecosystem of the soil and the biodiversity within this ecosystem is just as significant as ensuring biodiversity elsewhere. Birds, animals, plants and humans are all dependent on this soil biodiversity.

Hunter Organics, Biodiversity: Special Issue, 2003 p. 27, 28

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Growing Media for Ornamental Plants and Turf, K A Handreck, N D Black, University of New South Wales Press, 1994
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The Importance of What You Can't Always See

Elaine Ingham Soil Food Web Seminars (April 2002)

Elaine Ingham is an American University scientist who has set up laboratories in USA and Australia to test soil for soil organism numbers and types to sell soil organism inoculants. She gave three seminars, one for orchardists, on fungal dominated soil, one for farmers and vegetable growers on bacterial dominated soil which I attended, and one for input manufacturers on making compost tea.

Elaine has done a lot of research into soil food webs in which many different organisms depend on eating each other in a whole chain from dead plant and animal material through fungi, bacteria, algae to the larger soil organisms such as earthworms and nematodes. The process varies according to the season and at any time there can be a big difference between the numbers of total soil organisms and organisms that are active. Total numbers of bacteria can vary from 600 million per gram of good organic soil, to 1 million in a conventionally farmed soil. Numbers of different species of bacteria can be 25,000 and 5,000 respectively. Numbers and diversity of fungi can vary similarly. If there is a good number and diversity of organisms in the soil, half the amount of plant litter should have been decomposed within six weeks of falling to the ground. Bacteria are more numerous around plant roots and they also glue themselves on to the leaves of plants.

The types of soil organism vary as a soil develops. On bare rock there are bacteria and no fungi, then as the rock breaks down into soil, more different types of organism appear. Weeds are the first plant colonisers – the soil tends to lack oxygen and be high in nitrate. When grasses develop, the fungus to bacteria ratio increases to that which is also suitable for growing most vegetables. A ratio of 1.1 is more suitable for grain and row crops. Shrubs, vines and bushes grow well on a soil with 2:5 fungus to bacteria ratio. The fungus bacteria ratio under deciduous trees can be 5:100 and under coniferous trees, the end of the cycle, 100:1000. Grasslands may naturally progress to trees unless disturbed by fire or grazing, (or held back by climate).

The farming system and soil amendments will favour a particular fungus to bacteria ratio. For example adding a lot of nitrogen fertilizer reduces the fungi in the soil and favours weeds such as thistles and Johnson grass, which like the high nitrate. Phytophthora fungus also likes high nitrate and low oxygen conditions. The aeration of soil and compost makes a big difference to the type of soil organisms that flourish – low oxygen conditions favour anaerobic organisms, which secrete alcohol, hydrogen sulphide and ammonia which are toxic to plants. Soluble fertilizers can also kill soil organisms, sucking water out of them, by an osmotic effect.

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So it is very important to ensure that anaerobic conditions do not develop in a compost, otherwise it may kill your plants. In a good, well-aerated soil, roots penetrate deep into the soil – eg grass roots can go down for 20 feet. Plant roots exude chemicals that attract and feed soil organisms. Exudates may account for 50-60% of the energy of the plant. They are different for each plant cultivar, and attract the organisms that will supply the nutrients the plant needs. If the soil conditions are not good, the exudates will attract and feed plant pathogenic organisms. A compacted soil tends to select for root pathogenic nematodes, as they are the smallest type of nematode. Good compost, which contains a good mix of organisms, gives plants systemic acquired resistance to pathogens…

Composts made from different types of plant material, with different carbon to nitrogen ratios, favour different types of organism – for example, bacteria have a C:N of about 5:1 so would predominate in a compost providing that ratio of nutrients, whereas fungi, with a ratio of 20:1, like less nitrogen and need more woody material such as sawdust. The type of nitrogen in the soil depends on which organisms predominate. In a fungi dominated soil, they excrete a lot of organic acids, which acidify the soil making it unsuitable for nitrifying bacteria as they like a soil pH of about 7. So then ammonium is the main type of nitrogen taken up by plants – perennial trees prefer this to nitrate, and are less disease prone. Whereas in a bacterial soil, the nitrifying bacteria change the ammonium to nitrate, which is what is best for grasses, enabling plenty of leaf growth.

The soil organism population also determines the volume of nitrogen supply to plant roots. Different types of organisms have different C:N ratios, for example protozoa (single-celled animals) are 30:1 whereas bacteria are 5:1, so there are plenty of protozoa feeding on bacteria, they release unwanted nitrogen which can then be taken up by plant roots. If the protozoa are not there, the bacteria will deprive the roots of nitrogen.

The balance of soil organisms affects calcium retention in the soil – a predominately fungal soil retains much more than a bacterial soil, and this is important for maintaining a favourable balance with magnesium.

Inoculated nematode trapping fungi can overcome potato feeding nematodes in six months. Alternatively, you can provide particular food to encourage particular organisms. Bacteria like simple amino acids, sugars and organic acids, whereas fungi need complex carbohydrates such as polysaccharides and cellulose, and vitamins.

N.Z, Harvests, Vol 55, No. 2, 2002, Pgs 22 & 23

The Value of Biodiversity

Commercial Production Benefits

Direct:

- Species are used and harvested to produce food, medicine, clothing and timber

Indirect:

- Pollination
- Biological control of pests, weeds and diseases
- Shelter
- Weed suppression
- Erosion management, nutrient retention
- Improving soil microbial and earthworm activity
- The maintenance of clean air and water

Other Economic Benefits

- Enhanced land values
- Supporting a 'clean green image' - potentially important for retaining overseas market access
- Tourism
- The potential for payments for enhancing or protecting biodiversity (especially in Europe).

Aesthetic Benefits

- People enjoy seeing species, landscapes and the ecosystems remain in existence,
- e.g. Australia would be culturally diminished if, for example, one or more of our wallaby species, or the lyrebird became extinct.

Cultural Benefits

- The Aboriginal concept of dreamtime.

Conservation Benefits

- Providing habitat for threatened or endangered species of flora and fauna

Biodiversity of Farmland, Good Management Practices, p8

Increasing Biodiversity

Species Diversity Includes:

- soil organisms; bacteria, micro-organisms, microflora, microfauna, mesofauna, macrofauna
- insect diversity includes the role of predator insects, bees, birds and butterflies and predators such as spiders, lady beetles, ground beetles, wasps and flies
- plant diversity includes crops, trees, shrubs, flowers, herbs and pasture plants
- animal diversity includes domestic animals and wildlife

Practices to Enhance Biodiversity on Your Site

Encourage earthworms as they provide many benefits.

- Minimise or eliminate cultivation to avoid many benefits.
- Minimise or eliminate cultivation to avoid damage to earthworm populations and the soil's physical and biological status.
- Choose machinery carefully to minimise its impact on the soil.
- Retain crop residues and mulches to improve the soil's nutrient levels, organic matter and structure.
- Rotate crops to create a balance of species living on the farm.
- Use pasture to provide a restorative phase for soil organic matter and structure.
- Retain habitats for insects and spiders with grass and diverse plant species along fence lines and in shelterbelts.
- Include native plants in mixed shelterbelts, paddock corners and woodlots.
- Adopt good practice to ensure successful plant establishment and management in shelterbelts and woodlots.

Use Diverse Plantings Such as:

- herbs
- flowering plants
- diversity of shrubs and trees
- providing habitats for bird species
- providing habitats for beneficial insects
- diverse understory plantings in orchards
- diverse species selected for wind breaks
- good variety of suitable pasture species
- incorporation of medicinal plants and herbal leys
- diversity of animals

Conditions Required for Increasing Species Diversity

- correct soil conditions
- nutrient availability
- water availability
- pollinator species
- adequate food source
- availability of habitats.

Monitoring Populations of Beneficial Insects

Yellow ice-cream containers set along the fence line of paddock A3 contain water, detergent and a preservative. They are highly attractive to beneficial insects such as hover flies, ladybirds, parasitic wasps and bees.

The traps have been at this site since 1994 and have been emptied regularly since that time to monitor populations of these insects. This enables the numbers of these beneficial insects to be compared before, during and after the conversion of Kowhai Farm from conventional to organic agriculture (as biodiversity on the farm is added and matures). We expect the populations to increase as the diversity of native and non-native plants on the farm increases. Biological control agents need pollen and nectar for protein and energy, as well as shelter provided by the field margin plants.

Before conversion, herbicides removed most of the latter. Numbers of parasitic wasps (Ichneumonidae), which lay eggs in or on caterpillars and other insects, have increased over time, indicating that this trapping method may give a good representation of changes in insect populations and communities over time.

Biodiversity of Farmland, Good Management Practices, p24

Trees

Multi-functional Role of Trees

Species which have a multi-functional role could include species which:

- are pioneer species; short lived trees which provide shelter to less hardy species during establishment stage
- provide bird habitats
- provide habitats for small insect eating birds
- flower over winter thus providing nectar for bees, birds and other beneficial insects
- have high quality timber
- are fire retardant
- provide shelter for stock, pasture and crops
- fodder plant
- suppress weeds
- minimise soil erosion and protect the soil
- have aesthetic, conservation, historical, cultural and recreational values
- provides habitat for beneficial species including wildlife
- salt tolerant
- indigenous to the area
- provides windbreak
- reduce the impact of salinity
- habitat enhancement
- controlling the incursion of weed seeds
- recycling nutrients
- producing fuel wood
- producing commercial timber products and seed.

Note: Consider tree selection carefully as there are also disadvantages which could come from the selected species.

Continued over page

Example: Multiple benefits of planting of honey locusts (Gleditsia triacanthos).

- serve as a fire retardant
- produce nutritious pods for stock fodder (up to 100kg per mature tree per season. These pods have a nutritive value equal to oats grain or quality pasture and are produced with no extra costs once trees are established)
- produce foliage which is also palatable to stock
- reduce the amount of water reaching the water table (thereby helps fight dryland salinity)
- provide good shade which allows the pasture to stay greener for longer
- recycle nutrients (which had leached below the root zone of pasture plants, these are recycled back onto the soil surface through the foliage and pods)
- slow the increase in soil acidity
- produce timber (a dense hardwood with a number of uses)
- produce excellent honey
- enhance our view (its an attractive tree that is green in summer, turning gold in autumn)

Negatives associated with planting honey locusts (Gleditsia triacanthos).

- honey locusts can become a weed
- no control over the sex of the seedlings hence
- no control over the number of pod bearing trees
- most common form has very large thorns which could pose a hazard to animals or vehicle tyres. (there are some thorn-less cultivars now available).

Criteria for Tree Selection

It is important to consider a wide range of criteria when selecting trees for the site. Consider using a diverse selection of species with a mix of trees, bushes and understory plants. Some considerations when selecting suitable species should include but are not limited to the following;

- suitability to biodynamic production
- adaptation to local microclimate
- free from pests and diseases
- good nutritional values
- will grow in harmony with other species
- root growth considered as to whether they grow downwards or sideways
- whether the trees compete with crops for water and nutrients
- whether they are deciduous or evergreen trees
- the ideal species should be indigenous to the area
- whether the trees tolerate wet feet or drought conditions
- space required for an established tree
- whether they require irrigation when being established
- water use after establishment
- spacing required between trees
- height trees will grow to
- whether the trees selected are able to be topped or sideways trimmed
- room required to manage the prunings if the trees are to be trimmed
- on-going maintenance required
- costs of on-going maintenance
- power lines that could be affected when the trees reach full height
- consultation with other local growers in the area regarding species selection.

Critical Factors in Establishing Trees

- Moisture
- Good preparation is the key
- Deep rip in the summer to shatter the soil
- Spray BD500 in the rip lines
- Remove grasses and weeds regularly
- Must have a good soil moisture profile
- Hilling soil to form planting banks; good for weed control and water management.

Diversity in Tree Planting

"It is all about diversity. Nature never plants in monocultures; I suspect that every species of tree, and even variety, has subtly different nutritional requirements. Also every living organism, including trees, 'consumes' and 'eliminates'. What is eliminated by one species/variety is nutrient for another.

"Within any single-species plantation, or 'monoculture', one will observe that there are trees that are 'high achievers' and 'low-achievers', the latter, up to 80 per cent, are culled after a few years, leaving the few trees to attain their full potential. This is obviously, very wasteful.

"Instead of planting say, 1,000 trees of a single variety over a given area, I am planting 1,000 seedlings of mixed species and varieties. They all have symbiotic relationships, enhancing the growth of each other – so they are all high achievers – as well as encouraging biodiversity to combat infestations etcetera.

"Most importantly, most of the varieties have crop value, and by judicious planning, can be selectively and readily harvested at their perspective maturities, without destroying the overall performance of the belts in which they are planted.

"I am convinced that well over 80 per cent of the trees planted will attain their full potential, and be harvested, vastly better than the customary 20 per cent. Most of the trees will coppice after harvest, and produce further crops, more quickly than the initial harvest, due to having established root systems, without additional establishment costs.

"The methods offer numerous other benefits; planted in straight rows, on the average contour, the 20 meter wide belts are not am impediment to other crop production practices. With good belt design, traditional crops can be grown right up to the belts, without loss of yield. In fact their yields will be enhanced, thanks to the protection from drying winds, provided by the belt of trees.

"During heavy rain, the belts of trees will harvest surface water flow from up contour, retaining it within the soil profile."

Acres Australia, Volume 12, Number 3, 2004, Pg 25.
To find out more about 'The Auria Research Project',
contact David Kennett, email auria@bigpond.com.

Tree Plantations

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Regulating the Woodland

By Rudolf Steiner

Farmers must understand something about fostering insect-life and bird-life, because everything in nature is interdependent – everything. I have to emphasize this again and again.

We need to keep these things vividly in mind because they are very important for our insight here. The right astralization of the air is brought about by the world of flying creatures, and this astrality is in interaction with the wooded areas, which direct it in the right way, just as in our body certain forces direct our blood in the right way. The effect of a forest is felt over a very large area, and in areas with no woods, this function must be preformed by something else, We must realize that in areas where fields and meadows alternate with woods, the vegetation is subject to quite different laws than in vast treeless regions.

You can tell that some regions of the earth were heavily forested before human beings had anything to do with this – for in certain matters nature is still wiser than people are – and it's safe to assume that if forests are naturally present in a given area, that their presence has certain advantages for the herbaceous and grassy vegetation of the surrounding farms. In such areas, we should be insightful enough not to cut down all the forests, but rather to take good care of them. However, since the earth is slowly changing due to all kinds of climatic and cosmic influences we should also have the courage – if we see the vegetation on our farms is being stunted – to expand the wooded areas in the vicinity, instead of merely doing all kinds of experiments on and with the fields. On the other hand, if we notice that the plants are growing rampant and lack strength to form seeds, we should take steps to clear certain areas in the woods. In areas naturally destined to be wooded, regulating the woodland is simply part of farming, and must be regarding in its full spiritual significance.

Steiner, R., (1993) *Agriculture,* PA. BFGA inc. USA. pp145-147

Shelterbelts

When planting and maintaining shelterbelts to buffer hot drying summer winds and/or the colder winter winds select different species according the wind direction and season e.g. deciduous trees to buffer the northerly winds but evergreen for the southerly winds.

Benefits from the Use of Shelterbelts

The benefits derived from planting trees and hedges to enhance the environment are very obvious, particularly to birdlife and bees. The increased humidity created by these areas of trees can increase plant production by 100%.

Benefits of Shelterbelts Include:

- enhances etheric energy of the site
- prevents drying off of soil moisture
- lessens evaporation rates
- helps in the control of soil erosion
- prevents leaching of humus
- higher growth rate between plantings
- improves level of production
- reduces stress in plants and animals
- diverts frosts around the site
- provides nesting sites for birds
- provides animal fodder in times of drought
- protection from the elements
- shade for animals
- provides source of flowers for pollinators
- prevents damage to the crop
- prevents breaking of branches heavy with crops in orchard management
- provides habitats for wildlife
- acts as a wildlife corridor
- provides firewood
- buffers chemical spray drift.

Establishing Shelterbelts

Shelterbelts should be:

- planted a right angles to the prevailing wind
- used solely to break the force of the wind and reduce its velocity
- so thick as to create wind turbulence on the far side
- not so thin that they do not fulfill their purpose (you should be able to see someone standing on the other side of the shelter belt)
- wide and multi-purpose, not merely a windbreak
- used for bee fodder, firewood, stock shelter and as a food source
- used to stop drying of soils and subsequent loss of humus.

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Role of Shelterbelts

The site must be protected against harsh winds. Shelterbelts can be planted to buffer cold winds during winter and spring and also to buffer hot drying summer winds. With the design and planting of any shelterbelt ensure that the winds are only buffered and not completely blocked so as to prevent air movement or cause turbulence on the downward side.

Consider the severity of winds when selecting suitable species. In very exposed site you will need to select trees which can be established on exposed sites. Once these plants become established they provide shelter for establishing plantings of less hardy species. You should consider planting at least three different species of varying heights; the lowest growing on the side of the prevailing winds.

Protective hedges between individual paddocks should be planted and should enclose the entire area. These plantings should be as varied as possible and could include pollination plants for bees and plants and species which provide habitats for predators. The more varied the planting, the better will be the biological effect.

December1982

February 2003

Shelterbelts, Photos courtesy John Weatherstone, Lyndfield Park

Maintaining Shelterbelt Plantings

Assess the health, growth and vitality of trees on a regular basis.

Undertake maintenance work as required which includes:

- checking density of plantings
- removing competing trees and/or branches as required to ensure adequate space, light, water and nutrients
- removing dead diseased or broken material.

Windbreaks and Farm Productivity

Why should a farmer fence existing vegetation, plant corridors and blocks of trees and shrubs – is there really an economic benefit in allocating land to trees and shrubs? There certainly is, reports BFA's Louise Skidmore, who explains that conservation and farm productivity are complementary.

Following are just some of the many advantages of planting trees and shelter belts that are relevant for all farming methods:

Look at Erosion, Salinity & Water Quality

Land degradation problems requiring the treatment of whole catchments (such as sheet and gully erosion), and some forms of dryland salinity, can be aided by strategic establishment of windbreaks. It is ironic that in Australia, where moisture availability often limits agricultural production through much of the year, so many land degradation problems are caused by an inability of crops and pastures to use enough of the incoming rainfall.

Infiltration of unused rainfall through the soil profile to the groundwater is the major cause of dryland salinity. Excess runoff erodes soil. On average an estimated 5-10% of rainfall is unused in Australian agriculture and percolates into the groundwater or runs off (Peck & Hurle 1973).

The water used by trees is significantly greater than by agricultural crops and pastures. It has been estimated that 30-40 mature trees per ha are sufficient to use all of this excess rainfall. Establishing trees and other deep-rooted perennial plants on farms helps produce a more closed water and nutrient cycle, retaining rainfall and nutrients that are at that site and using them productively. Trees reduce erosion, improve water quality by filtering and reduce rising salinity by keeping the water table low and away from the shallower roots of pasture and crops.

farms may help to control erosion and nutrient loss, lack of vegetation interrupts the nutrient cycle and exposes the soil to erosion.

In the mulga country, 10cm of topsoil is readily lost from wind erosion and runoff after storms. In SE Queensland, seven tonnes of topsoil is lost for every tonne of grain produced. Incidentally, in Victoria and South Australia where large scale clearing of land has occurred, the value of treed properties has increased by 20-30%.

Animals experiencing extreme hot or cold conditions require more energy to maintain basic metabolism and thus have less energy available to increase body weight, or to produce meat, milk or wool. More feed is required to simply counter the environmental stress. Under adverse conditions, livestock performance is inefficient relative to the quantity of feed eaten – animals graze less and sometimes not at all.

Experiments with penned sheep and cattle have shown that strong wind and rain double the energy requirement of animals. One Australian study from the New England Tablelands showed that cold stress can depress sheep live weight gain by 6kg and can depress wool growth by 25% (Lynch & Donnelly 1980). A study in Montana, USA showed that beef cattle protected by windbreaks were on average 16kg heavier than those unsheltered (USDA 1994).
In southern Victoria it has been calculated that the provision of shelter can increase milk production by 30%. 10% of this is attributed to the greater efficiency of conversion of feed, and 20% to the greater amount of feed available (Fitzpatrick 1994).

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The provision of adequate shelter can prevent dramatic stock losses under extremely adverse conditions. It can also provide small regular returns due to improved animal productivity. Other benefits of shelter to livestock include increased feed availability, reduced calf/lamb and off-shears losses due to stress, and increased efficiency of conversion of feed to meat, milk and wool.

Enhance Habitat for Insect Predators

A major benefit of fenced windbreaks and shelter belts is the provision of habitat for wildlife. Many species of wildlife – such as insectivorous birds – eat enormous quantities of problem insects, especially scarab beetles, cockchafers, crickets and grasshoppers.

Magpies will take thousands of scarab beetle larvae per hectare from pastures. A single ibis will consume 200g of insects a day – a flock might consume a half million grubs of insects a day. Insectivorous bats may consume half their bodyweight in insects every night (Platt 1995). This pest control costs nothing and is ongoing, year in year out. The encouragement of wildlife is generally complementary to agriculture. In fact the harmonization of nature conservation with productive farming is an essential feature in holistic organic systems.

Benefits to Crop Production

Vegetables, specialty crops, and orchards derive benefits from the provision of shelter (Baldwin 1988). Shelter helps reduce rubbing damage and the consequent downgrading of produce – this can reduce damage by as much as 30% for mangoes and citrus in Queensland.

The microclimate changes created by windbreaks accelerate crop development – giving growers a price advantage. Price of horticultural crops is strongly linked to quality. One New Zealand study (McAneny et al 1984) showed exportable kiwifruit yields declining from 40kg per vine near a windbreak to less than 10kg per vine in more exposed locations, with fruit damage increasing from less than 5% to greater than 40%.

Irrigation salinity, caused by excessive recharge of saline groundwater from applied irrigation water, can be reduced by windbreaks in combination with sound irrigation practices.

In broadacre cropping and pasture situations, although a windbreak may have an allelopathic effect and will compete with crop or pasture growth in a narrow zone immediately adjacent to it, a 70-80 meter strip of permanent vegetation will reduce soil moisture evaporation, erosion potential and result in higher yields (BFA News, Dec. 2000, p. 34). Moreover, a boundary windbreak will serve as a buffer zone to trap undesirable spray drift, an important consideration in an organic system.

By integrating conservation practices into a farm management plan, conservation and productivity will complement each other.

Whilst there may be some teething problems initially relating to establishment in the form of feral animals, weeds, costs and demands on resources, it is important to remember that the overall benefits of the active and balanced eco-system present in windbreaks and shelter belts, far outweigh the negatives.

Louise Skidmore, Director, Environmental Issues,
BFA News, Autumn 2001 ps. 28 & 29

Native shelterbelts

Compiled by Rachelle Carritt, Illustrations: Judith Denby Design, Formerly produced by NSW NPWS, as Land for Wildlife Note 7, Conservation Management Notes are published by the NSW National Parks and Wildlife Service for the Conservation Partners Program.

Some of the Advantages of Well Designed Native Shelterbelts

- protection of livestock from the extremes of temperatures and harsh winds—in wet and cold conditions
- shelterbelts can assist in reducing the loss of stock during calving and lambing offshears (Farming for the Future 1999)
- protection of crops and pastures—shelterbelts assist in crop and pasture production by reducing plant and soil moisture loss caused by extreme winds
- provision of habitat for local fauna and flora
- improvement to the aesthetic value of the property
- prevention of soil and wind erosion
- protection from fire— a shelterbelt can reduce wind speed, which affects the rate of fire spread.

Features of a Good Shelterbelt;

- shelterbelts that are open but without large gaps provide semi-permeable protection and are usually recommended for crops and pastures. Allowing some airflow through the shelterbelt ensures that deflected air is not prone to descending too rapidly causing unwanted turbulence on the leeside of the shelterbelt, providing a greater area of protection (Breckwoldt 1983)
- dense or impermeable shelterbelts can be used to protect small, confined areas such as farm buildings or yards (Breckwoldt 1983)
- L-shaped shelterbelts are ideal for areas requiring high protection
- shelterbelts do not need to be a strictly linear shape. Ones that follow the contour of the land or a creek or river line can still offer areas for stock shelter, regardless of changes in the direction of the wind
- the height of shelterbelts determines what area of land is to be protected (Breckwoldt 1983). The area of land protected by the shelterbelt is approximately 20 times the height of the tallest trees in the shelterbelt (Brouwer and Dutton 1992; Breckwoldt 1983; Stelling 1998). Large properties may require numerous of shelterbelts for protection
- a porous shelterbelt (porosity — 50%–60%)
- a non-porous shelterbelt (porosity —20%) (Abel et al. 1998).

Generally, longer shelterbelts are more desirable than shorter ones. Short shelterbelts tend to channel wind sideways around them — detracting from their effectiveness (Breckwoldt 1983). It is suggested that a shelterbelt's length be approximately 12 times the mature height of its trees, i.e. 240 metres long for a shelterbelt 20 metres high (Stelling 1998 and Breckwoldt 1983). Linking shelterbelts to other corridors of natural vegetation greatly reduces wind speed when compared to single isolated shelterbelts (Simpfendorfer 1989).

The shape and width of shelterbelts determine their effectiveness. An ideal shelterbelt may be one, for instance, whose entire length and height is relatively uniform in providing semi-permeable protection. If, however, there are large gaps along the length of the shelterbelt this can lead to 'jets' of wind that can reduce the effectiveness of the shelterbelt (Abel et. al. 1997).

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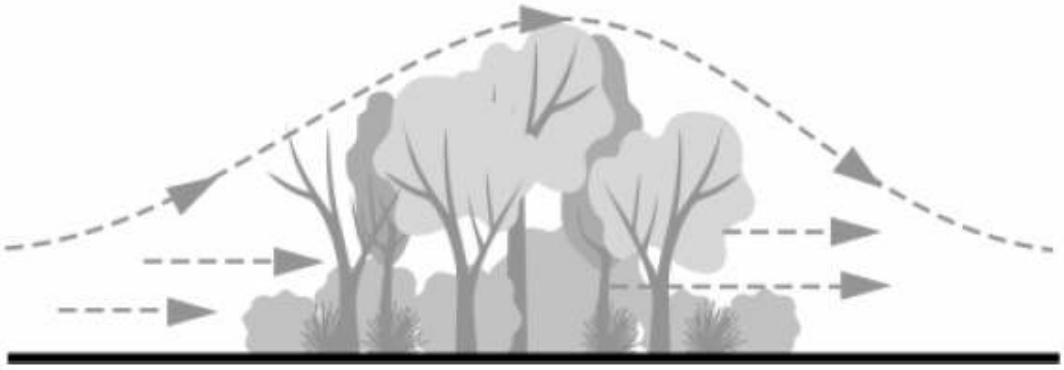
The greatest potential for wildlife habitat is in wide shelterbelts (around 5-7 rows of trees or more) connected to large areas of native bushland (Stelling 1998). In narrow shelterbelts (around 2-3 rows of trees) gaps are difficult to manage and widely spaced individual or isolated trees are prone to dieback and are unlikely to be replaced by natural regeneration (Dorricott and Roberts 1993). Native wildlife will benefit and be attracted to shelterbelts if they are planted with a wide range of local native trees, shrubs and grasses.

If a variety of species is not planted, the shelterbelt is prone to outbreaks of disease and pests — increasing the likelihood of dieback (Archer 1997). Consider species that provide good shade and are vigorous growers. These may be species that already grow on the property, or that are known survivors locally (Farming for the Future 1995). They will contribute to the effectiveness of the shelterbelt, as well as providing quality habitat and protection for native fauna

Permeable shelterbelts planted with a variety of local native species provide habitat for native wildlife without creating turbulence.



Identifying Shelterbelt Locations

Choosing suitable locations for shelterbelts is part of developing a Physical Property Plan (Whole Farm Plan) for the property, (Farming for the Future 1995).

Shelterbelts that form natural corridors with other areas of native vegetation provide the opportunity for wildlife movement. Take into consideration naturally occurring shelterbelts such as along tree lined watercourses, ridges, farm boundaries, roadsides, and native vegetation occurring along travelling stock routes. These areas can provide high quality habitat for wildlife.

Take advantage of existing habitat features. Consider establishing a shelterbelt that includes existing native plants such as old paddock trees and native grasses. These established areas will assist in any further regeneration process. Conversely, planting a shelterbelt in an area which is dominated by exotic grasses and has a history of fertiliser use will reduce the chance of natural regeneration in the shelterbelt. This may lead to weed control problems, and the competition of exotics with the planted natives (Sheahan, M. 1998).

Planning with neighbours can assist in determining the appropriate location for shelterbelts; maps and aerial photographs are also useful.

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Familiarity with the prevailing winds on your property will assist in determining the orientation of a shelterbelt. Generally, a shelterbelt that is at right angles to the prevailing winds will provide the best protection (Abel et al. 1997). When planting for shade, plan to avoid runoff from stock camps damaging waterways. Planting a buffer zone of native vegetation near watercourses can help in intercepting runoff as well as providing habitat for native fauna.

A shelterbelt on level ground will be most effective if orientated at right angles to the prevailing winds.

It is recommended that buildings be sited more than 1.5 and less than 5 times the shelterbelt height from a dense shelterbelt for protection from fire (Simpfendorfer 1989). Fire resistant species should be considered for these locations.

On undulating lands, wind flows parallel with the ground rather than from one direction (Simpfendorfer 1989). Shelterbelts on ridge tops give the greatest deflection of wind but are the most vulnerable to damage. A wide shelterbelt provides greater protection in exposed, windy areas.