

A Resource Guide on Ecological Gardening

Table of Contents:

The Ecological Garden	Water
Gardening with Nature	Plant Functions and Uses
Garden Biodiversity	Plant Companions and Antagonists
Building Natural Capital	Plant Guilds
Design Principles	Ecological Aesthetics
Soil & Fungi	

Ecological gardening applies permaculture¹ design to create sustainable home landscapes. Permaculture is a set of ethics, principles and techniques for designing sustainable human communities that have the diversity, stability and resilience of natural ecosystems. It builds on knowledge from sustainable agriculture, ecology, and agro-forestry.

In the late 1990s, Toby Hemenway, a permaculture instructor and practitioner in the Pacific Northwest, developed the concept of ecological gardens and plant guilds for temperate climates. Toby writes: “These gardens represent a new type of landscape that provides for people as well as the rest of nature. These are true backyard ecosystems ... places where conscious design is melded with a respect for nature and an understanding of nature’s principles”².

¹ The term permaculture was coined in the late 1970s by two Australian biologists, Bill Mollison and David Holmgren. It is a contraction of “permanent agriculture” or “permanent culture”.

² Hemenway, Toby. *Gaia’s Garden: A Guide to Home -Scale Permaculture*. Chelsea Green: White Junction, Vermont, 2001.

The Ecological Garden

Did you know you have an ecosystem in your own backyard and by working with nature you can help it function in a healthy and sustainable way providing food, beauty, and abundance for you and the wildlife you love?

The ecological garden is built on partnerships. One of the main partnerships in your garden is the partnership between plants and soil organisms. Plants cultivate the soil with their roots, they help moderate soil temperature and moisture, and they provide food and nutrients to soil organisms through their roots. Soil organisms provide shelter and a hospitable growing environment for seeds to germinate, they provide critical nutrients for plant growth, and they protect plants against stress and disease.

You can strengthen this partnership by:

- Establishing a diverse soil community. This means substituting compost for synthetic fertilizers. High quality compost contains a full complement of soil organisms and the proper balance of nutrients to maintain their livelihood.
- Establishing a diverse plant community. This means planting a variety of plants that provide an abundance of nutrients to organisms living at different soil depths.

Creating a healthy ecological garden means that over time you will need fewer inputs of labor, water, fertilizer and you will begin to witness the ecosystem take on a life of its own.

Gardening with Nature

Gardening with nature means working with, not against, natural processes to create a healthy and productive ecological garden. One of the main ecosystem processes is succession. Succession is the replacement of one plant and animal community with another over time. On land-based ecosystems, the process of succession usually proceeds from bare soil to annuals to perennials to shrubs and then trees.

Succession means the garden is a place of change and often of conflicting goals. Nature is trying to advance succession, creating a more complex and productive ecosystem, while many gardeners try to keep their garden at an early stage of succession.

The typical American garden is dominated by grasses and annuals and has bare, compacted or infertile soil – inhospitable conditions for plant growth and development. Nature responds by bringing in weeds. Weeds have adapted over long periods of time to survive in harsh environments and rehabilitate soils, creating conditions for other plants to grow.

Plants in the typical American garden are grouped according to species with large numbers of the same plant at the same location. Nature responds by bringing in pests. Pest populations tend to expand as long as there is plenty of food available and a shortage of predators.

Working with nature means:

- Designing gardens using a backbone of native trees, shrubs, and non-woody perennial plants. Native plants have adapted over time to the local environment and support native animal species. Annuals, ornamentals, and other plants can be included to provide food for humans, increase plant diversity and satisfy individual preferences.
- Covering bare soil with plants or mulch to protect it from wind, hot sun, and rain.
- Placing plants in communities instead of species groups to improve ecosystem function and minimize pests. In general, the more variety and abundance, the healthier the plant community.

Garden Biodiversity

To create a healthy ecological garden we need to invite many different species into the garden, creating a complex and balanced food web that ensures no one species becomes a major pest. This means creating a garden with many different layers and many different niches.

The land or garden has two topographies we can design for. The vertical topography has up to seven layers – tall-tree, low-tree, shrub, herb, ground cover, root, and vine layer. The horizontal topography has different microclimates. A microclimate is a local climate that impacts the plant and animal species present. As you walk the land you find depressed areas that are a little wetter and elevated areas that are a little drier. Each of these different microclimates represents a potential habitat for a new plant or animal species.

When gardening for biological diversity, there are particular species you need to attract to your ecological garden. Pollinators – bees, butterflies, bats – are important for the reproduction and fruiting of many plant species. Beneficial insects and birds are important for controlling pest populations. If you want to keep animal species in your garden you need to provide them with food, water and shelter throughout their entire lifecycle. The easiest way to accomplish this is to plant a variety of high-nectar plants that bloom throughout the season.

Building Natural Capital

Building natural capital is key to sustainability and one of the main responsibilities of landowners. But what is natural capital? And what does it mean to build it in the ecological garden?

Natural capital is the wealth inherent in our natural ecosystems. In the garden this wealth is embodied in plants, soils and other living organisms. Many forms of energy – light, wind, and water – enter our garden daily. We can increase our natural capital by using these energies to optimize our yields of food, wood, fiber, soil, and wildlife habitat.

An easy way to increase the natural capital on your land is to plant a diverse canopy of perennial plants that produce multiple yields over many years. Perennials are more efficient at capturing and storing the energy of sunlight than annuals since they are living on the landscape for longer periods of time.

Water is another energy that can be used to increase natural capital. Water can be captured and stored in many forms – barrels, cisterns, ponds, plants, and soils. Having a variety of strategies for capturing and storing means you have water freely available for times when you need to use it.

Consciously increasing the natural wealth on your land allows you to harvest sustainably while ensuring that wealth will be available for generations to come.

Design Principles

In designing ecological gardens, we look to permaculture for design principles and methods. Permaculture is a set of ethics, principles and techniques for designing sustainable human communities that have the diversity, stability and resilience of natural ecosystems.

At the heart of permaculture design is the belief that the greatest design constraint is the limits of our own creativity and imagination. Permaculture design is based on many principles but there are four that are particularly critical for the ecological garden.

Observe –

Know where you are... Know your place. Observe what is going on before making changes. This is often difficult because it takes time and patience –unappreciated virtues in our fast-paced world.

To observe and develop place-based knowledge means we must be outside in a place over many seasons. How does light move across the landscape at different times of the day and different times of the year? How does water flow? What are the microclimates? What are the primary pollinators and when do they arrive and leave? Keeping a journal of observations is a good way to begin building knowledge.

Connect –

Permaculture design is about building connections ... about cultivating relationships between elements. It changes the way we see the garden. When we locate a nitrogen-fixing plant behind a cherry tree we are establishing a connection between two plants. When we locate berry bushes next to the cherry tree we are establishing a connection between the berry bush and birds in order to divert their attention from the cherry tree.

One of the main tools for analyzing connections is needs-yields analysis. If you start with an element like an apple tree; you first consider its needs – it needs pollination, fertilization, weed management, and a wind barrier, among others. To satisfy these needs you would design a plant guild that contains insectory plants to attract pollinators, nitrogen-fixing plants to provide nutrients, weed-suppressing plants, and plants to moderate winds. You would then plant these elements in the guild or plant community in their proper position near the apple tree.

Next you consider yields and what elements might use the yields. The apple tree produces apples and leaves as two of its yields. Humans will eat the good apples. Bad apples will need to be collected to minimize pest problems. You can collect them for compost or animal feed or let the animals collect them for you. Another yield, leaves, may be left in place as mulch to protect plant roots during winter months. In this way you are designing a system and locating elements based on maximizing ecosystem function and using plants to solve problems.

Stack –

Stacking functions is a core design principle. Each element in a design performs more than one function. A fencepost may function to hold the fence in place and it may also function as a bluebird house. In any permaculture design, the innate functions of each element are considered and an attempt is made to stack additional functions. In this way you produce multiple benefits with minimum effort.

Minimize Risk –

Each function in a permaculture design is performed by more than one element. This is the basic principle of risk mitigation. In designing a plant guild you need to include more than one insectory plant if you want to attract beneficial insects. If you only have one plant and that plant dies or doesn't flourish your ecological garden will have lost its resiliency and its ability to support a critical insect population.

Soil & Fungi

Did you know that healthy soils are teeming with biological life? Did you know one teaspoon of soil has billions of organisms?

The soil is a complex food web of bacteria, fungi, protozoa, nematodes, earthworms, anthropods, and other insects that work to decompose organic matter, enhance soil structure, control pest populations, absorb water, break down pollutants, and supply critical nutrients to plants.

The majority of soils where humans live have been degraded by tillage, construction, compaction, loss of organic matter, and soil erosion. In many cases, few soil organisms exist to carry on their important work. As a gardener or landowner, one of your most important jobs is building soils and feeding soil organisms.

There are several ways you can replenish depleted soil communities:

- Get a soil test to understand your current soil's chemistry and biology.
- Add compost to the soil. High quality compost contains a full complement of soil organisms.
- Aerate the soil to insure water and air flow freely to soil organisms.
- Cover the soil with mulch or plants to protect it from wind and rain.
- Avoid tilling the soil. Use sheet mulch or cover crops to increase soil fertility.
- Select plants to match your soil types to help minimize stress and disease.
- In severely depleted soils, introduce plugs of healthy soil allowing the soil organisms from the plugs to colonize the depleted soils.

	Agricultural Soils	Prairie Soils	Forest Soils
	<i>Per teaspoon of soil</i>		
Bacteria	100 million to 1 billion.	100 million to 1 billion.	100 million to 1 billion.
Fungi	Several yards.	Tens to hundreds of yards.	Several hundred yards in deciduous woodlands. One to 40 miles in coniferous forests.
Protozoa	Several thousands of flagellates and amoebae. 100 to several hundred ciliates.	Several thousand flagellates and amoebae. 100 to several hundred ciliates.	Several hundred thousand amoebae, fewer flagellates.
Nematodes	10 to 20 bacterial feeders. A few fungal feeders. Few predatory nematodes.	Tens to several hundreds.	10 to 25,000.
	<i>Per square foot</i>		
Anthropods	Up to 100.	500 to 2,000.	10 to 25,000.

Earthworms	5 to 30. More in soils with high organic matter.	10 to 50. Acid or semi-arid have none.	10 to 50 in deciduous woodlands. Very few in coniferous forests.
-------------------	--	--	--

Number of soil organisms in healthy ecosystems. Soil and Water Conservation Society. *Soil Biology Primer*. 2000.

Water

Did you know that 30” of rainfall a year is 816,000 gallons/acre or 15,000 gallons falling on a 1000 square foot roof?

Most of this valuable resource flows off the land where it falls and into storm sewer systems or drainage ditches. Once it leaves your land it becomes a lost opportunity for producing a yield.

As a landowner or gardener, water needs to be captured and used to increase the biological activity or life on your land. This means having different ways to capture and store water until it can be used. The easiest and most efficient way to store water is in soil or in plants. To store water in soil, you need soils with high organic matter and good soil structure. To store water in plants, you need to create a dense canopy and diversity of plants. Water can also be stored in ponds, wetlands, cisterns, or rain barrels.

Water efficiency is increased with multiple uses. This means finding as many ways as possible to use and reuse water before allowing it to leave the farm or garden – in other words, keep the cycle going as long as possible.

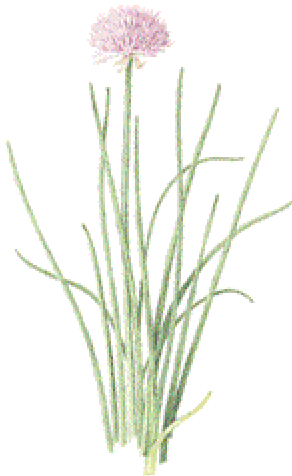
Plant Functions and Uses

Have you ever wondered how work gets done in a natural ecosystem when people aren't there to do it? How nature produces healthy ecosystems that endure over time?

Plants play a major role in healthy ecosystem function. Plants are more than just beautiful fixtures in an ecosystem, they are the workers that maintain and increase its productivity.

Individual plants may perform many ecological functions including nitrogen fixing, soil building and water purifying. Some plants are pest repellents, insectories, mulch makers, and soil cultivators. They may also provide animal forage, wildlife food and wildlife habitat. Plants also meet human needs for food, medicine, wood, fuel, fiber, essential oils, and beauty, among others.

In designing ecological gardens we look at the functions of each plant, their needs and yields, and consciously establish relationships between different plants to create self-sustaining plant communities or guilds.



Chives is a plant with many functions and uses.

- It is an easy plant to grow. The tender shoots are edible and high in calcium and vitamins A and C.
- It has a long history of medicinal use. It improves kidney function and has been used to treat kidney and bladder weaknesses.
- It is a good pest repellent. It has been found to deter Japanese beetles. A spray of chives is believed to cure apple scab and mildew on gooseberries.
- It is good at building soil and minimizing erosion since it is a long-lived perennial with fibrous roots.
- It is a good plant for attracting beneficial insects.
- It is a good companion plant with parsley, tomato, beets, carrot, apples, and roses.

We are currently building a plant community database for designing guilds. The database contains the following plant ecological functions and human uses:

Ecological Function	Description
---------------------	-------------

Ecological Function	Description
Air Cleaner	Cleans the air of pollutants. Sample plants include common milkweed, Gerbera Daisy and Chrysanthemum (known to remove benzene).
Animal Forage	Provides food for domestic animals. Sample plants include purple prairie clover (known to be high in protein), buffalo grass and little bluestem.
Erosion Control	Holds soils in place with fibrous root systems. Sample plants include sweetgrass (wet sites), balsam poplar (riverbanks) and prairie sage (dry sites).
Flood Management	Can withstand submersion in water and promote percolation to water table. Sample plants include annual ryegrass, feather reed grass and fountain grass.
Fortress	Provides a barrier to invasive plant and animal species. Sample plants include oats (good smother crop for weeds), buckwheat and lovage.
Insectory	Supports beneficial insects. Sample plants include milkweed, sweet alyssum, dill and angelica.
Mulch Maker	Decomposes quickly providing "on-site" mulching. Sample plants include comfrey, wild strawberry and spinach.
Nitrogen Fixer	Converts atmospheric nitrogen to plant usable nitrogen. Sample plants include wild lupine, sweetpea and black locust.
Nitrogen Scavenger	Has the ability to take up and/or store excess nitrogen. Sample plants include berseem clover, barley and oats.
Nurse	Fast-growing pioneer plants that support establishment of other plants. Sample plants with drought-tolerance include daylily, silverberry and phlox.
Nutrient Accumulator	Tap-rooted plants that draw nutrients from deep in the soil making them available near the surface. Sample plants include vetch, chives and sunflower.
Pest Repellent	Repels pests replacing the need for pesticides, herbicides, fungicides, and insecticides. Sample plants include peppermint (repels insects and mice), lemon balm (repels flies and ants) and garlic (repels aphids, deer and rabbits).
Restoration/Reclamation	Used for soil restoration and/or soil reclamation. Sample plants include pin cherry, junegrass and blazing star.
Soil Builder	Produces organic matter and improve soil structure. Sample plants include lilac, yarrow and other long-lived perennials with fibrous roots.
Soil Cultivator	Deep-rooted plants that penetrate, loosen, and aerate the soil. Sample plants include little bluestem, radish (breaks up clay soils) and faba bean.
Toxin Absorption	Takes up toxins from soil. Sample plants include black nightshade (removes PCBs from soil) and curlytop-gumweed (absorbs selenium).
Water Purification	Purifies water. Sample plants include common rush, ostrich fern and bunchberry.
Wildlife Food	Provides food for wild animals. Sample plants include witch hazel (ruffed grouse, pheasant), elderberry (many bird species) and sour cherry (swallowtail butterfly).
Wildlife Habitat	Provides habitat for wild animals. Sample plants include spike rush (waterfowl), high-bush blueberry (nothern mockingbird) and big bluestem (pheasants, ducks, and songbirds).
Windbreak	Creates microclimates by modifying wind and sun. Sample plants

Ecological Function	Description
	include Jerusalem artichoke, cornelian cherry and hybrid poplar.

Human Uses	Description
Aromatics/Fragrance	Are aromatic or have a fragrance. Sample plants include lavender, rosemary and anise.
Basketry and Weaving	Used in basketry and weaving. Sample plants include common reed, prairie willow and fragrant sumac.
Cleanser/Scourer	Used for cleansers or scourers. Sample plants include pennyroyal, cranberry and potato.
Compost	Used for making compost. Sample plants include chicory, yarrow and stinging nettle.
Container Garden	Used in container gardens. Sample plants include zinnia, thyme and kale.
Cut Flower	Used for cut flowers. Sample plants include black-eyed susan, cosmos and yarrow.
Dried Flower	Used for dry flowers. Sample plants include blue globe thistle, big quaking grass and sunflower.
Dye	Used for making dyes. Sample plants include goldenrod (mustard, brown, and yellow dye), carrot (orange dye from roots) and red raspberry (purple dye from fruit).
Essential Oil	Contain essential oils that can be extracted. Sample plants include sage (used in perfumes and shampoos), dill (used in soaps and medicines) and creeping thyme (used in perfumes and mouthwashes).
Fiber	Used for fiber. Sample plants include daylily (dried foliage used in footwear), swamp milkweed (bark is used for twine or cloth) and oats (hulls used in construction board).
Food	Used for food. Sample plants include anise (leaves can be eaten raw and seeds as mouth freshener), nasturtium (flowers have a peppery taste) and chokecherry (berries used in fruit juices).
Hanging Basket	Used in hanging baskets. Sample plants include hyacinth bean, thyme, and impatiens.
Insect Repellent	Used to repel insects. Sample plants include rosemary (sachets used in cupboards), parsley (juice used to repel mosquitoes) and lavender (repels mice).
Medicine	Used for medicine. Sample plants include blue cohosh (to facilitate childbirth), purple milkweed (as a cure for warts) and sweet woodruff (to treat liver and kidney problems).
Oil, Wax, Resin or Polish	Used for oils, waxes, resins and polishes. Sample plants include bitternut hickory (oil from seeds used in oil lamps), Japanese stone pine (pitch is obtained from rosin and used in waterproofing) and arugula (seed used for burning with little soot).
Soap	Used for making soap. Sample plants include summersweet, New Jersey tea, and wild lupine.
Wood	Used for wood products. Sample plants include sugar maple (for furniture and musical instruments), Amur corktree (for cork substitute) and northern red oak (for flooring and furniture).

Plant Companions and Antagonists

Plants, like members of any community, have other plants they work well with and plants they conflict with. A good plant companion may provide food or shelter for a pest or help a plant resist disease. Radish and spearmint are good companions for squash because they protect the squash from squash bugs. Garlic and chives are good companions for apple trees because they help prevent apple scab.

A bad plant companion or antagonist is often host for a similar pest or disease. Peppers and tomatoes are bad companions for apricot trees because they are all susceptible to verticillium wilt. Once one plant gets the fungus, it can easily spread if other “host” plants are close by. Potato is a bad companion for apple trees because it interferes with the ability of the apple tree to photosynthesize, produce proteins, and absorb nitrogen.

These relationships need to be taken into account when designing plant guilds.

Plant Guilds

Native plant communities are groupings of trees, shrubs, and non-woody plants that have evolved together as a community over time. Native plant communities often provide the starting point for designing plant guilds.

A plant guild combines natives, edibles, medicinal and culinary herbs, insectory and wildlife plants, plants that fix nitrogen, and others into synergistic, mutually beneficial groups that reduce labor, provide abundant yields for people and wildlife, and build natural capital. Over time, other members of the guild should meet each plant's needs and yields.

Plant guilds can be designed to solve different problems. The plant community database has five types of guilds:

- Sustainable landscape guild – designed to increase the sustainability of residential landscapes by providing food for humans as well as wildlife.
- Environmental guild – designed to solve environmental problems such as erosion control, flood management, compaction in heavy clay soils as well as provide wildlife food and habitat.
- Agricultural guild – designed to produce food in a sustainable way and insure a diversity of economic returns for farmers.
- Wildlife guild – designed to provide for the needs of specific wildlife species throughout their lifecycle.
- Ecological restoration guild – designed to restore native communities to the landscape.

Ecological Aesthetics

Ecological gardens look different than the typical American garden of lawns interspersed with trees, shrubs, and annuals. They also look different than natural gardens or vegetable gardens. They are evolving ecological gardens with many complex elements.

An ecological aesthetic has the following characteristics:

- It reflects the “special identity” of a place and works with the rhythm of the seasons, changing over time.
- It brings nature back into the garden; the garden becomes a place of life and movement for humans and animals.
- It is enhanced and enriched by the human cultures living in an area.
- It reflects the natural world in all its cycles – birth, growth, and decay become part of the garden landscape.
- It touches all the senses – bringing a variety of sights, sounds, smells, tastes, and textures into the garden.
- It supports abundance with its many layers and niches.