

Service Learning through Permaculture Projects



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Service Learning through Permaculture Projects

Improving the health of your club site and local ecosystem

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Garden Earth Naturalist Service Learning Projects and Permaculture

Introduction

GEN Service Learning integrates the eight Eco-Service Departments into easy-to-do projects that will improve the ecological health of a school site. The projects provide opportunities for GEN Club Members to identify problems, develop solutions, AND feel the satisfaction of seeing visible, tangible, (and often edible!) results. GEN Club Members can be involved in the design, planning, building, and ongoing maintenance of the projects.



The projects included here come from the field of “Permaculture.” The term permaculture is a combination of the words *permanent agriculture* and *permanent culture*. Permaculture views humans as an integral part of the natural ecosystem – not just as stewards, but as participants and beneficiaries. The Service Learning Projects include “rewards” for plants, animal wildlife, soil microbes, the air, the water, AND for humans.

Permaculture projects focus on *systems* that are sustainable. The physical parts of the project – the plants, the water, etc. – are all very important, but permaculture really zeroes in on the *connections* and *relationships between* things. For this reason, a large part of permaculture is about design – thinking as much through as you can *before* you implement the project. In the designing stage you take into account the “bigger picture” of the landscape: what’s already there, how natural systems are working, how parts of the system are connected, and how they may be supported by your project. You will likely look at the where the sun shines, where the water flows, and what the soil is like, for example. Then you look at what changes can be made, including the details of the new relationships -- what the living creatures in your new system need, which plants and/or animals work well together, and where things will go to connect them all together in a successful system.

Permaculture provides a framework of principles for thinking about those connections in project design and implementation. The principles guide us to create projects that are simple, energy-efficient, and connected. These principles can be applied to just about anything you might want to design.

Below are ten of the permaculture principles that frame the GEN Service Learning Projects. Each project activity includes a list of the principles clearly demonstrated through the project. You may want to share some of these basic principles with your club members as you work on the project.

Ten Permaculture Principles

Observe and replicate natural patterns

Nature is amazingly “engineered!” Natural patterns are all around us, and they predictably recur. There are many defined physical patterns that are easily observable: the branching patterns of trees, rivers and circulatory systems; the spirals of whirlpools, shells, and the cochlea of the ear; the honeycombs of beehives, wasps nests, turtle shells, and some types of tree bark. Life cycles, ecosystem relationships, and the flow of liquids are also all natural patterns; they are reliable in every natural setting. In permaculture we observe how nature has set up patterns and try to replicate them in designing a garden, a water system, or other project.

Diversity

This principle is very connected to the Biodiversity Department. Nature includes diversity as an important strategy for lasting a long time! Have you ever seen a natural place with things that are all the same? Or even the same color, or all the same shape, all the same height? In a garden, we include a wide variety of plants that are shaped differently, have different needs, and do different things. We also make sure that we have a diversity of connections between things.

Catch and store energy

Natural systems are constantly circulating energy – the energy of the sun, the wind, the flow of water. That energy can go through your system unused, or sometimes, as in the case of erosion, the energy can be damaging. By planting a tree, you are actually catching and storing sun energy; by digging a pond, you are catching and storing water energy. These “energies” can be stored until you need them.

Multiple functions

This is where creativity comes in! In permaculture, an element (a part of the design) has more than one function – ideally, in a permaculture system an element should have at least three functions. A fence around a garden, for example, doesn’t just designate your garden space, it can also serve as a trellis for climbing plants. It can be a place to hang tools, signs, or decorations. It can serve as a perch for birds or a place to hang a nest box. Use your creativity to come up with other functions!

Produce no waste

In nature, nothing is “wasted” – it’s used and then reused by something else. In permaculture designs, we always think about what’s “leftover” and how it can be used in the natural cycle. Fruits and vegetables don’t go into the garbage, they become compost. Leaves that fall in the autumn become mulch. Water from washing dishes can be filtered through stones and reused as garden water. We can also utilize old metal, carpets, wood, etc. in many creative ways in our permaculture projects.

Relative location

Where you put things is important, but where you put them in relation to other things is even more important! This principle guides us to think about what each part of our project needs as well as what it can give. A great example of plants being near enough to help each other out is the Native American “3 Sisters:” by planting corn, beans, and squash together, the corn serves as the “post” for the beans to climb up, the beans fix

(supply) nitrogen in the soil for the corn and squash, and the squash provides a nice ground cover all around to keep the moisture in for the corn and beans.

Use edges

The “edge” is where it’s at! An edge is the place where two environments come together – where, for example, a woodland meets a clearing. Because it has a little bit of both environments, the edge is a rich and valuable place. If you’re trying to attract birds, creating a small clearing in a woodland can help; you’re likely to find more birds at the edge of a woods because they can perch in the trees and drop down easily into the clearing to find food.

Redundancy

It’s important to have a “back-up” plan! With redundancy, we plan to have several different sources of something that’s important. Having several sources of water, for example, is important. Although we might count on the school water system for watering a garden, what if it gets shut off in the summer? Having access to school water AND a rainwater catchment tank means it’s more likely you’ll always have water for your garden

Obtain a yield

Projects are great to do simply for the reward of learning, or for the pure fun of it. It’s even more rewarding to get something tangible, such as vegetables, fruits, or medicines, from a garden as a result of your work. These are all called “yields.” In planning a project it’s important to think about how many different yields you can produce, how much you’ll get, and when you expect to get it.

Turn problems into solutions

Here’s creativity once again! You’ll undoubtedly encounter problems in any project you might do, but by turning a problem on its head and looking at it from many different perspectives, you can often turn that very problem into a solution. It’s the “make lemonade from lemons” attitude! For example, if you have a low spot on your school site where rainwater pools, it may seem to be a muddy mess. But, if water naturally drains to this point, it might be just the perfect spot for a small pond. Dig the pond, use it for attracting wildlife, storing water, and growing aquatic plants, and you’ve turned your problem into a beautiful solution!

Tips for Managing GEN Service Learning Projects

GEN service learning projects are all the things most kids LOVE – active, fun, hands-on, and outdoors – and so you can expect a high level of engagement from them. It’s also true that because the activities are active, fun, hands-on and outdoors, it takes a bit of structured management to keep the children focused and engaged in accomplishing the project tasks at hand. Here are a few tips for guiding children in these outdoor project settings.

- Gather the project materials and have them “ready to go” at the project site before the children arrive.
- Send information about the project home with the children before the project starts. Indicate that children should dress appropriately for the weather and for physical, possibly “dirty” work.
- Set clear boundaries of where children may be during the project time.
- Share with children the proper use of tools.

- Keep children directly engaged in the project by giving them very specific tasks. (The GEN projects include detailed task-by-task descriptions.) Often two or three tasks can be going on simultaneously so that all children are engaged at all times.
- A team approach often works well. Form teams of three or four children who work well together. Have them sign up for specific tasks or you can assign them. The teams rotate through different tasks so that the children have a chance to try out most or all of the steps to the project. For example, in building a mulch bed, the Sunflower Team gathers dry leaves on the site, while the Apple Tree Team spreads several mulch layers on the beds, and the Oak Team is responsible for watering the layers down. After doing this for a 10-minute period, the teams switch jobs, and then 10 minutes later they switch again.
- Allow time for clean-up. Emphasize the importance of keeping tools clean and putting them away. Have a specific place for tools to be gathered.
- Allow time for wrap-up and reflections on a day's accomplishments. Briefly discuss what the next steps are for the next project session.
- When the project is completed, celebrate! Some suggestions for celebrations are:
 - Have a picnic or snacks near the feature you have built. Take pictures.
 - Install a sign or plaque recognizing your club's efforts.
 - Have a dedication ceremony or "grand opening" and invite parents, school staff, local officials, or even the press to share in the celebration.

Yummy Compost

Description

Composting is a cornerstone of organic gardening – and it’s really, really easy! Basically, you take all the organic “leftovers” you can find (yard waste, kitchen waste, and other organic materials), put them together in a container, and let the Soil Department critters take over to turn it all back into rich soil. This project involves building simple containers in which to create and store the “yummy” compost. You can choose from the three different types of compost bins described: one made of heavy wire, another made of a garbage can, or a third made of wooden pallets, depending on the materials you have at hand and your budget.

“Yummy” Compost Connections

GEN Eco-service Departments

Soil Department
Food Production Department
Biodiversity Department

Permaculture Principles

Observe and replicate natural patterns
Produce No Waste
Relative Location
Obtain a Yield
Turn Problems into Solutions

Background

In order to thrive and do their decomposing work, the Soil Department critters need a good environment and “yummy” nutrients. The following are important for supporting Soil Department workers in a compost pile:

Eco-Standards Checks: Soil and Recycling Department

- *Carbon and Nitrogen* - Bacteria and fungi break down carbon materials for use as an energy source. Dry leaves, straw, hay, sawdust, newspaper, and cardboard – things that are typically yellow or brown – are high in carbon. The decomposers also need nitrogen for synthesizing proteins. Grass clippings and other green plant material, kitchen scraps, and manures are good sources of nitrogen. Often these are green or gooey. For optimal decomposition, compost piles generally have a lot of carbon and a little bit of nitrogen, in a ratio of volume of about 30:1. (The carbon materials naturally take up much more space than the denser nitrogen-rich materials.) Too little nitrogen slows decomposition down, but too much can generate ammonia gases and unpleasant odors.
- *Air* – Decomposers, like all living organisms, need oxygen. Compost bins should have holes so that air can get in so that aerobic decomposition – decomposition in the presence of oxygen – can occur.
- *Water* – Decomposers also need moisture. For best results, it is recommended that compost piles have the consistency of a well-wrung sponge -- not too wet and not too dry.

There are two main methods of composting. The “hot” compost method is quick: a full pile is put together and then the whole thing is turned every few days to allow air to flow through and keep the decomposers very active. The “cool” compost method is slower but simpler: you can add to your pile over time and you don’t need to turn it. The procedures outlined below follow the cool compost method. By building two bins you eventually will have one compost pile that you are actively building (that is, adding food scraps as they become available), and another one that has been filled and is decomposing. By the time the second one is filled, the first will have “yummy” compost available for use.

A note on odor: If a compost pile is maintained correctly, it should have an earthy smell, but not an unpleasant one. As long as air can flow into the pile and it is covered with carbon materials (leaves, etc.), odor should not be a problem. A bad smell tells you that something isn't quite right and needs correction.

How to Build a Compost Bin

Preparation

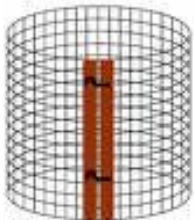
Determine which of the three bin types will work best for you. Consider availability of materials (reusing free, existing materials is always a plus!), your budget, and your comfort with tools. Plan to build two bins of the same type.



Wire Bin

Materials

- 12.5 feet ½ inch hardware cloth, 36 inches high (available at hardware stores)
- 3 metal or plastic wire clips or ties
- wooden pallet (optional)



Step 1: Roll out hardware cloth. With wire or tin snips, cut the wire ends of the hardware cloth off close to a cross wire. With a metal file, file down the ends so that there are no sharp edges.

Step 2: Roll the hardware cloth into a circle, overlapping the two ends.

Step 3: Fasten the two ends with clips or ties. This will create a circular fence approximately 4 feet across.

Step 4: Set the circular fence on a level ground surface or on a wooden pallet. The pallet will allow air flow into the compost pile from below.

Step 5: Fill bin with organic materials and allow to compost. When fully composted, open the wire clips to remove material.

Wooden Pallet Bin

Materials

- 4 wooden pallets of the same size
- 1 additional pallet (optional)
- 8 large hook and eye gate latches (bolt latches or bailing wire are also options)



Step 1: Attach hooks and eyes or bolt latches to connect pallets at right angles. This will make a four-sided bin. The pallets can also be tied or wired together.

Step 2: Place the bin on a level surface or on top of another pallet. Note: The base pallet will decompose faster than the side pallets, but it provides more air flow to the compost pile.

Can Compost Bin

Materials

- garbage can with lid
- drill
- cement blocks, bricks or a wooden pallet (optional)



Step 1: Drill three rows of half-inch holes, 4 to 6 inches apart around the sides of the garbage can. Then drill several holes in lid and bottom of the can.

Step 2: Place the can on a level surface. Or place on cement blocks, bricks, or a wooden pallet to increase air circulation from below.

Siting Your Compost Bin

The above compost bins are not very easily moved, so before you begin filling them, work with your club members to find the best place for it. Consider the following questions:

- Where will you get the carbon materials and how far do you want to haul them?
- Where will you get the nitrogen materials and how far do you want to haul them?
- Where will the finished compost be used and how far do you want to haul it?
- Where are there flat areas?
- Are there any places the school administration would NOT want to have a compost pile? (A compost pile by the front door, for example, may not be highly desired!)

Making “Yummy” Compost

Step 1: Gather together materials containing carbon --dry leaves, straw, hay, sawdust, newspaper, and cardboard. (Note: The Fall is a great time to start a compost pile!) If you can, shred the leaves, newspaper or cardboard; the smaller they are, the faster they will decompose faster.

Step 2: Gather together materials containing nitrogen – grass clippings, freshly pulled weeds, and/or plant-based kitchen scraps. You might arrange with the school kitchen to set aside a bucket of lunch scraps. (Note: Scraps containing meat, dairy, or heavy oils are generally not recommended because they take longer to break down and are more likely to attract rodents.)

Step 3: Place a thick layer of carbon materials at the bottom of the bin; woody debris works well for this. Then add a thin layer of nitrogen material. The ideal ratio is 30 parts carbon to one part nitrogen; however this does not need to be precise. Repeat the layering, ending with a thick layer of carbon materials to control pests and odors. The pile should not smell bad if it is topped

Yummy Compost Timeline

A compost system can be set up at any time of the year, but because of the abundance of yard debris, fall is a great time to start.

Fall

- * Build compost bin
- * Start the compost pile

Winter

- * Add kitchen scraps and leaves

Spring

- * Check to see that pile is damp, but not too wet
- * Finish filling the first bin and start filling the second

Fall

- * Remove finished compost from first bin if (it has decomposed and turned into soil)
- * Use as fertilizer in the garden

thickly with brown leaves or other carbon materials.

Step 4: Find a steady source of kitchen scraps (ideally, the school cafeteria). Place a bucket with a lid in the kitchen to collect the scraps. Empty it onto the compost pile periodically; always add carbon materials on top of the scraps.

Step 5: Check the pile periodically to make sure that it is damp, but not too damp. It's fine for the pile to stand in the rain, but be sure that excess water can drain out.

Step 6: Let the Soil Department do its job. At some point you will want to stop adding new materials and let the pile sit; begin filling the second bin. Compost should be finished in 6 to 9 months, depending on weather and the types of materials in the pile.

Step 7: Open the bin and remove the compost. The bottom of the pile is likely to be the most decomposed. Use the compost to build the fertility of your soil.

Estimated Budget

Wire Bin

Total cost: approximately \$25

Wooden Pallet Bin

Total cost: approximately \$30 (However, wooden pallets can often be found for free at stores that receive trucking shipments.)

Can Compost Bin

Total cost: approximately \$25

Other items for purchase may include a bucket with a lid for collecting compost (though these can often be found for free), and a shovel.

Tips for Managing the Project

- Involve the children in the “design” of the compost pile. Guide them to consider the kind of bin to build and where to locate it.
- As you build the bin, have club members do particular tasks. Consider whether they have the skills to use drills or hammers. There will likely not be enough tasks for all members to be occupied in the building project, so engage the other club members in gathering leaves and other yard debris.

Questions for Reflection

What are the Permaculture Principles illustrated in creating “yummy” compost?

- How does creating compost **replicate natural patterns**?
- How does composting help us to **produce no waste**?
- Why did you put the compost bin where you did? (**relative location**)
- What is your **yield**?
- How can a compost pile **turn a problem into a solution**?

Learning in the Garden

- 1) As the pile decomposes, periodically scoop up a bit from the center. Observe whether the individual ingredients are still intact and whether worms or other critters are present.
- 2) As the pile decomposes, place a thermometer in the center. Compare the temperature to the air temperature. Find out why heat is generated in an active compost pile.
- 3) When the compost is finished, conduct soil tests on it. How does it test for organic materials? What is the pH?
- 4) Plant two beans, one in plain schoolyard soil and one in soil mixed with the finished compost. Place both plants in a sunny window. Water each plant with the same amount of water. Observe, record, and compare the growth of the beans.

**Chart 1: Eco-Service and Permaculture Connections
Yummy Compost**

GEN Departments	Permaculture Principles
<p>Biodiversity Department A compost pile enhances the biodiversity of the organisms we call “decomposers.” The resulting compost adds to the organic matter in the soil, which contributes to the diversity of plant life in a garden.</p>	<p>Observe and Replicate Natural Patterns How does nature make soil?</p>
<p>Food Production Department Compost produces food on two levels. The action involved in composting feeds important members of the Soil Department – bacteria, fungi, and earthworms. The compost added to a garden improves the soil and helps the plants produce edibles for humans and/or wildlife.</p>	<p>Obtain a Yield Composting yields rich, fertile soil.</p>
<p>Soil Department Compost creates soil rich in organic matter. A compost pile concentrates Soil Department “action” above ground. Bacteria and fungi that are primary decomposers are nourished and compost piles often attract earthworms.</p>	<p>Produce No Waste Composting involves many materials that are often considered “waste.” By bringing them together to decompose, these materials are put productively to use.</p>
	<p>Relative Location In a garden system, it’s important to think through where everything goes, even something as small as a compost bin. The closer it is to the garden, the less energy you need to expend moving it.</p>
	<p>Turn Problems into Solutions Kitchen scraps, leaves, and grass clippings often go into the waste stream and end up in landfills (problem). Composting turns them into useable rich soil (solution).</p>

Worm Composting

Description

Worm composting (“vermiculture” or “vermicomposting”) uses worms to break down kitchen food scraps and other organic material into compost. The worms eat and digest the food scraps, and then excrete their waste. This waste, called “castings,” is full of nutrients, making wonderful fertilizer for garden soil.

Worm composting is easy to do. The worms are kept in a simple plastic or wooden bin. Strips of newspaper or cardboard serve as their living space or “bedding.” As long as their basic needs of air, moisture, food, and shelter are met, the worms will grow, eat, poop, and reproduce – and you get great compost!

Background

Because of the many roles they play in the natural soil ecosystem, earthworms are a gardener’s delight.

Worms eat fungi, bacteria, nematodes, protozoa and other organic material. They shred organic matter, making it small enough for other organisms to eat. They help bacteria and other microbes move through the soil by carrying them in their slime. Worms make tunnels in the soil, making it easier for plant roots to push through. The tunnels also help the soil hold more moisture and oxygen. Last but not least, worm poop is full of organic nutrients that enrich the soil.

Inside their tiny bodies, chemical “magic” happens in worms. Although they are toothless, worms are masters at breaking things down. They grind their food in their gizzards using sand and rock particles. They don’t have digestive enzymes either; they rely on bacteria in their alimentary canal to do the breakdown work. The bacteria extract the nutrients the worms need to grow and reproduce and the rest moves through their bodies as castings. As the material moves through the worm’s alimentary canal, a thin layer of oil is spread over the castings. The end product is odorless, pH neutral, and nutrient-rich.

Worm poop provides huge benefits for the garden soil. Research shows that castings are 50% higher in organic matter than soil that hasn’t gone through an earthworm, with 7 times more phosphate, 3 times more magnesium, 5 times more useable nitrogen, and 1.5 times more calcium than other topsoil. Castings also contain manganese, copper, zinc, cobalt, borax, and iron. The chemical structure of the castings make these nutrients easily absorbed by plant roots, and humic acid in the castings stimulates plant growth. The oil on the castings helps to release the nutrients slowly and steadily, so, unlike many fertilizers, worm castings do not burn plant roots. In addition, the texture of the castings helps the soil retain moisture.

Worm Compost Connections

GEN Eco-service Departments

Soil Department
Food Production Department
Biodiversity Department

Permaculture Principles

Observe and Replicate Natural
Patterns
Produce No Waste
Obtain a Yield
Turn Problems into Solutions

Eco-Standards Check:

Soil and Recycling Department

Conduct checks in area where you have added worm castings.

Earthworms work their “magic” naturally in most soils, feeding on the organic debris from fallen leaves, dead plants, and dead animal bodies. This also happens naturally in compost bins (see Yummy Compost) and mulch beds (see Instant Garden). A worm composting system compliments these processes; it simply concentrates the worms, their food, and their poop production in a container to create an abundance of nutrient-rich castings that can be applied to the garden as needed.

It is important to note that only certain kinds of worms do well in containers. While many garden worms like to burrow deep into the earth, red wigglers, *Eisenia foetida*, live, eat, and reproduce within the first few inches of the soil surface. Red wigglers are small yet hardy, and they have huge appetites for kitchen scraps. For these reasons, *Eisenia foetida* are the “stars” of worm composting systems.

Materials

- Wooden or plastic box, approximately 24” x 12” x 12,” with lid
- Drill or knife (for cutting holes in box)
- Newspaper, cardboard, paper egg cartons, shredded leaves or straw
- Handful of sand or soil
- Kitchen scraps, largely fruit and vegetable (no meat)
- A bucket with a handle and a lid for collecting kitchen compost
- *Eisenia foetida* (red wiggler) worms

A Red Wiggler’s Basic Needs

* Air – Worms, like other living things need oxygen. Not having lungs, they “breathe” through their skin. Be sure your worm bin is well-aerated.

*Water – A worm’s body must be moist; if it dries out it will die. At the same time, worms can’t swim, and they will drown if too much water gets into the bin.

*Food – Worms can eat their body weight’s worth of food every day. In a worm bin, soft fruits and vegetables are preferred; avoid pits, seeds, and hard skins.

*Darkness – Worms strongly prefer moist, dark places; too much time in the light can result in paralysis. Be sure your worm bin has a cover or lid.

*Warm but not hot temperatures – Red wigglers can withstand a range of temperatures between 40 and 80 degrees F, but 70 to 75 degrees is optimum. In cooler temperatures they become inactive.

How to Set up and Maintain a Worm Composting System

Preparation

Step 1: Consider your sources of food scraps to feed the worms. If possible, arrange to collect scraps from the school cafeteria. The scraps can include fruits, vegetables, coffee grounds, crushed egg shells, bread, and grains – the softer and gooier the food the better! Avoid meat, oils, sugary things, and dairy products as they are more likely to attract insects and rodents. Also avoid large amounts of citrus as it will make the worms’ environment too acidic for their liking.

Step 2: Collect food scraps for a week. Weigh them. For every pound, you should provide a square foot of surface area for your worms. In other words, for a container that is two feet square in area, you’ll need to have two pounds of suitable food scraps each week.

Step 3: Determine a site for your worm bin. If you live in a fairly mild climate, the bin may be indoors or out; red wigglers can live in temperature ranges between 40 and 80 degrees F. In a moderate climate you can keep your bin outdoors if it is well-insulated. Many worm composters keep their worms outdoors most of the year, but move the

bin indoors in the coldest months. If outdoors, be sure the bin is protected from direct sun and rain.

Step 4: Find a source for red wiggler worms, *Eisenia foetida*. Fish bait stores may carry them, but be sure that you purchase composting worms and not nightcrawlers or other kinds of fish bait worms! Red wigglers are widely available through internet suppliers and can be shipped to your location. Purchase approximately 1,000 worms (one pound) for every half pound of food you'll be feeding the worms per day. Order the worms so that they will arrive after you have the worm bin set up.

Worm Composting Timeline

A worm compost system can be set up at any time of the year. Harvest the castings approximately every three to four months.

In moderately cold to colder climates, you can keep the worm bin outdoors during the spring, summer, and fall but bring it indoors while the temperatures are below 40 degrees F.

Creating the Bin

Step 5: Worm bins are simply boxes with holes on the bottom for moisture drainage, and covers or lids on top to maintain a moist and dark environment. The box should be fairly shallow, approximately 12 inches deep. A 24"x12"x 12" box can work well for a small classroom-sized composting system.

Bins can be made out of wood or plastic. Wood is generally more absorbent and a better insulator for the worms, but plastic may be easier if you are planning to move the bin to different locations. Try to use materials you already have on hand if at all possible. If you buy wood to build a box, avoid boards that are treated with chemicals. Simple plastic containers can easily be purchased at a local store.

Step 6: Drill or cut 8 to 10 ¼-inch holes in the bottom of the box. This will allow for moisture drainage and air flow.

Step 7: Place the bin on top of bricks or wood blocks. If indoors, it is important to put a tray underneath the bin to catch liquid drainage. This liquid can be used as a plant fertilizer.

Step 8: Put a cover on the container. For indoor bins an opaque cloth or dark plastic garbage bag can serve as a cover. Outdoor bins should have sturdy lids to keep the rain as well as rodents out; however, the lid should allow air to flow into the container.

Bedding

Step 9: The bedding is where the worms live. To make the bedding, tear newspapers into strips, and cut up pieces of cardboard or egg cartons. You can also add shredded leaves or straw. Moisten this mixture, then squeeze out the water until the bedding feels like a wrung-out sponge. (Note: It is very important to keep this level of moisture in your worm bin – not too wet, not too dry.)

Estimated Budget

Red wiggler worms can be purchased from suppliers for around \$30 per thousand worms (approximately one pound).

With a little digging, it's likely you'll be able to gather up the other materials for free. If you need to buy new materials for the bin, wood boards, screws, and hinges for a wooden box may cost around \$15, while a plastic box with lid may be purchased for around \$10.

Step 10: Put the moist bedding in the bin, filling it approximately three-quarters full. Add a little sand or soil as grit for the worms' gizzards. Make sure that the bedding includes lots of small spaces for air to flow through and the worms to crawl into.

Step 11: As soon as your worms arrive in the mail, put them into the fresh bedding. Observe as they crawl downward, moving away from the light. Cover the bin, but make sure that air can flow in.

Feeding the Worms

Step 12: Open a space in the bedding and add in the food scraps. Cover the scraps over with bedding materials. With enough bedding material over the composting food, you should not have odors or problems with pests.

Step 13: Put the scraps in a different location each time you feed the worms.

Harvesting the Worm Castings

Step 14: As time goes on, you will see the bedding disappear and more and more brown, earthy worm castings appear. When almost no bedding is left – usually around three months – it is time to harvest the castings. (Note: It is important for the worms' health to remove them from their waste.) There are two ways to do this.

a. The Gradual Way -- Don't feed the worms for a week, allowing them to finish up whatever is left in the bin. Move the castings to one side of the bin. Put fresh bedding in the empty side and bury food scraps with lots of fruit into the bedding. The worms will gradually migrate into the new bedding. Remove castings from the bin as needed, pulling out any leftover bedding, food, or straggler worms. Return the worms to the new bedding.

b. The Hands-On Way - Spread a plastic sheet or tarp on the ground. Dump the contents of the worm bin onto it. It will likely include castings, decomposing food, bedding, and worms. Remove the large pieces of food and bedding. Make several piles. The tops of these piles will be exposed to light, so the worms will naturally crawl to the downward seeking darkness. Remove the top of the pile, separating castings from bedding and food. Let the pile stand a few minutes, then take another layer off. Repeat until you reach the bottom where the worms have settled. Set up fresh bedding and return the worms to their bin.

Note: There will undoubtedly be worms of all sizes in amongst the castings, including tiny white eggs. It can be lots of fun to pick through the castings to retrieve these and put them back in the bin, but it's okay, too, if you miss them and they end up in the garden.

Step 15: Use the castings as a soil amendment in the garden or orchard. Castings are also excellent in a potting mix for starting seedlings.

Worm System Maintenance

Worm bins shouldn't stink! If yours does, it is telling you that something is out of balance. A strong odor is likely due to too much food in the bin; the worms haven't been able to get to it and the food is decomposing without enough oxygen. If this happens, stir up the bin contents to

aerate it and stop adding food for a while. (Remember that worms will eat less in colder conditions, so adjust your feeding accordingly.) Check to make sure there is adequate drainage.

Worm behaviors can also signal that something has gone awry with your system. If you find worms crawling up the sides of the bin or on the lid and it looks like they're trying to escape, they are! The bedding may be too dry for them, so you'll need to add water to entice them to come back. Or the environment may be too acidic; for that you can add a little garden lime, and make sure that you do not include citrus in the food scraps.

Don't be alarmed if a world of little critters comes to share the bin with the worms – it's the natural succession of an ecosystem, and these critters generally co-exist. However, make sure the bin does not become overrun with ants; too many ants can diminish the worms' food supply. The presence of an ant nest generally means that the environment is too dry; remove the dry ant-infested bedding and add new moistened newspaper or cardboard shreds. The presence of fruit flies means you need to bury the food scraps deeper in the bin.

If you maintain your worm bin in balance -- moist, dark, and plentiful (but not too much!) food, your worms will live out their lifecycle doing what they do: eating, pooping, and reproducing.

Tips for Managing the Project

- Emphasize that worms are living beings that need on-going care, and be sure your club members are committed to this effort before purchasing the worms. Worms will live for several years and they will continually reproduce, so your worm system can theoretically last indefinitely. Have a plan for maintaining them over the summer and after the club members have graduated.
- Involve club members in making arrangements for the worm project: finding their food scrap source, identifying a place for the bin, researching suppliers, and gathering free materials.
- Rotate worm feeding responsibilities. Have club members assess the worms' progress and report back to the others.
- Make the first harvest of castings a fun, hands-on event.

Learning in the Garden

- 1) Have students get to know their worms better by researching fun facts on worm anatomy, worm mobility, feeding and pooping habits, and reproduction.
- 2) Investigate what it takes to create a pound of worm castings. Keep a record of:
 - * how much food you feed your worms per week (in ounces or pounds)
 - * how much food you feed your worms prior to your first harvest
 - * how much the castings weigh when you do a full harvest of your bin
- 3) Develop experiments to test the benefits of worm castings in the garden. When planting seedlings of the same type, add castings to one and not the other and compare their growth. Conduct a test of organic matter with hydrogen peroxide on two soil samples, one with castings and the other without. Come up with other tests to see how the worm castings affect your soil.

Questions for Reflection

What are the Permaculture Principles illustrated in worm composting?

- How does worm composting **replicate natural patterns**?
- How does composting help us to **produce no waste**?
- What is your **yield**?
- How can worms **turn a problem into a solution**?

Resources

Books

- Mary Appelhof's book, *Worms Eat My Garbage*, is the most acclaimed source for information on worm composting. The book can be ordered through Appelhof's website, <http://www.wormwoman.com>.

Websites

- North Carolina State Cooperative Extension, <http://transylvania.ces.ncsu.edu/content/VermicultureWormProductionInformationandLinks&source=alexander> – contains information on raising earthworms, a directory of resources and suppliers, a vermiculture curriculum, and information on worm composting in school cafeterias
- Washington State University, <http://whatcom.wsu.edu/ag/compost/mrcworms.htm> - contains simple how-to information, and a guide for teachers
- California Integrated Waste Management Board, <http://www.ciwmb.ca.gov/organics/worms/> - includes fact sheets, classroom worm composting, and an interactive game for kids
- The Adventures of Herman, <http://urbanext.illinois.edu/worms/teachersbin/index.html>, a website on vermiculture for kids.

**Chart 1: Eco-Service and Permaculture Connections
Worm Composting**

GEN Departments	Permaculture Principles
<p>Biodiversity Department While intended for worms, a worm compost bin inevitably creates an ecosystem with diverse life forms. The harvested castings added to garden soil create enriched conditions for a wide array of soil and plant life. A thriving garden or orchard will then attract a diversity of insects, birds, and other wildlife.</p>	<p>Observe and Replicate Natural Patterns Worm compost bins mimic natural living conditions for earthworms. The worms, in turn, carry out their natural functions, contributing to the fertility of the soil.</p>
<p>Food Production Department Worm composting is part of the food production cycle. Worms eat leftover fruits and vegetables and convert them into fertile compost. The compost added to a garden improves the soil and helps the plants produce edibles for humans and/or wildlife. A healthy soil also provides food for billions of critters who live in the soil.</p>	<p>Obtain a Yield Worm composting yields a rich, fertile soil amendment. This in turn helps to yield healthy plants.</p>
<p>Soil Department Earthworms are major workers in the soil department. Worm composting systems provide rich and concentrated environments or worms to do their decomposing work.</p>	<p>Produce No Waste Worms take kitchen waste into their bodies and convert it into a rich, fertile compost.</p>
	<p>Turn Problems Into Solutions Kitchen scraps that go into a landfill don't often turn into compost; they turn into stinky rot because they don't get enough oxygen. If we take the potentially stinky scraps (problem) and feed them to worms, we get less odor in the landfill and great compost for our gardens (solution).</p>

“Instant” Garden

Description

“Instant” Gardens can be built and planted in just an hour. These garden beds use the “no till” and “sheet mulch” approaches: they are built above ground using cardboard, compost, leaf litter, grass clippings, and whatever other organic matter you might have on your site. Once built, you can plant right into them by making dirt-filled pockets. “Instant” Garden beds are great for planting potato eyes or plant seedlings. With the help of the Soil Department crew, these garden beds just get better and better over time.

Background

Instant sheet mulch gardens are an excellent way to nourish and build soils. The construction of typical garden beds by digging (tilling) methods can be a rough experience for Oli Earthworm and his Soil Department crew; churning up the soil tears apart the delicate networks established there. Pulling out weedy plants to clear the way for a new bed can also cause disturbances in the Soil Department. Instant sheet mulch gardens avoid these issues by building *up*, above the ground, allowing what’s underground to stay intact.

Instant sheet mulch gardens not only allow the existing soil to remain, they actually *create* more soil over time. Since the components of the bed are all organic, they break down (with the help of Oli and his crew), and form new soil on top of the already existing layer.

Instant gardens are also energy-savers. Building new garden beds can often be very energy-intensive; whether you use gasoline powered tillers or shovels and human muscle power, it can take a lot of energy and hard work to turn over and loosen hard-packed soil. The sheet mulch method requires some gathering of materials, but not much else; in fact, with a group, throwing on the layers to make the bed can be just plain fun!

How to Build an Instant Garden

Preparation

Step 1: Find a garden site. Instant gardens can be any size, any shape, and in any location that has the right amount of sun for what you want to grow. For most flower and vegetable gardens you will need at least 6 hours of sun per day; a site that gets direct sun from a southern direction is best for this. You will need water to build the bed and maintain a garden, so consider where water spigots are located and whether you have access to a hose.

Step 2: Gather materials: cardboard, compost/manure/worm castings, dry leaves, green materials, straw, etc. This is the most time-consuming part of the project. For 50 square feet of bed area, you will need approximately the volume of a full-sized pick-up truck (2 cubic yards). If you aren’t able to gather large quantities, start with a small bed.

Instant Garden Connections

GEN Eco-service Departments

Soil Department
Food Production Department
Pollination Department
Biodiversity Department

Permaculture Principles

Observe and replicate natural patterns
Produce No Waste
Multiple Functions
Obtain a Yield
Turn Problems into Solutions

Eco-Standards Checks:

Soil and Recycling Department
Biodiversity Department

Building the Bed

Building the bed is like making lasagna— several layers and then the “topping.”

Step 3: Cut back (**but don't pull!**) vegetation on the garden site. Leave it on the ground. Water the soil and let it soak in.

Step 4: Spread a light layer of “gooey” stuff – kitchen scraps, manure, or grass clippings – on the ground. (Think of this as the “sauce” on the bottom of the lasagna pan.) This is worm food, serving to attract the worms up from the soil and into the new garden bed you're building.

Step 5: Remove all tape from the cardboard boxes. Lay the cardboard on the ground in the shape of the garden bed. (This is the bottom layer of lasagna.) Be sure to overlap the cardboard so that there are no gaps where the old vegetation might grow through. Spray with enough water to soak the cardboard.

Step 6: Spread a layer of compost or manure over the cardboard. (This is another layer of sauce.) Add grass clippings and other green material. Spray lightly with water.



Step 7: Throwing leaves and yard debris (the “meat layer”) on top of grass clippings and wet cardboard.

Step 9: Top the bed with a two-inch layer of seed-free organic material – straw, wood shavings, finely ground wood chips, or dry leaves. (This is the lasagna “topping.”) This top layer will give the bed its final look, so consider how visually appealing you need it to be. When the bed is finished, it should stand a foot and a half to two feet high. Spray the entire bed with water.

Materials

- Cardboard boxes broken down to lay flat. Grocery store boxes are excellent, and large appliance boxes are even better. You will need enough to cover the ground under your garden area.
- Kitchen scraps
- Compost and/or chicken cow or horse manure. Worm-castings can be added to this, if available. Use as much as you can gather!
- Grass clippings and/or green leaves.
- Bulk mulch: dry leaves, yard waste, straw, spoiled hay, and/or wood shavings -- any combination of these is fine. You'll need about 2 cubic yards (a pick-up truck full) to cover a 50 square foot bed.
- Straw, wood shavings, leaves, or finely ground wood chips
- A wheelbarrow (optional – may be needed if materials must be hauled across the school site.)
- Water and a hose
- A kitchen knife
- Soil (may be potting soil or finished compost)
- Plant seedlings or potatoes eyes for planting

Step 7: Throw on a thick layer (12 to 18 inches) of dry leaves and yard waste. (This is the “meat” layer.) Straw, spoiled hay, or wood shavings can also work for this layer. If you're using straw, be sure to shake it out so that it doesn't stick together in tightly bound clumps. Water the top of this layer enough so that it soaks through and the mulch material is damp, but not dripping wet.

Step 8: Add another layer (an inch to two inches) of compost, worm castings, or green material (the cheese...).

Instant Garden Timeline

Sheet mulch beds can be built at any time of the year. Early spring is a good time to build one if you are planting potatoes or spring vegetables or flowers.

Fall can also be a good time to build a bed because leaves and yard debris are often abundant. You may want to wait until spring to plant; by that time, there may already be some rich decomposition in the bed, adding to the fertility.

Note: Sheet mulch beds are very forgiving – you don't need to be too exact!

Planting

Step 10: Reach into the mulch and make a deep, narrow pocket. With a knife, pierce the cardboard and make a small opening. (This might best be done by an adult -- the jabbing motion downward can cause your hand to slide onto the blade.) This allows the Soil Department crew easier access into your mulch bed; it also allow the future plant roots access to the soil below.

Step 11: If you are planting seedlings, fill the pocket with soil, open a hole for the seedling roots, and place the seedling in. Gently pack the soil around the plant. Water, and place the "topping" mulch layer around the plant.

If you are planting potatoes, cut potatoes into pieces so that each piece has one eye. Make a deep hole in the mulch bed and add a handful of soil. Place a potato piece in the hole, cover with a little dirt, then put the mulch back so that hole is just barely noticeable. Water the top layer. As the potato plant grows, add more bulk mulch layers (straw, dry leaves) to the top to keep the plant climbing and producing more potatoes down below.

Care of the Bed

Mulch beds get better with age! Over time, you will see the bottom layers of mulch turn into rich soil. Just keep adding organic materials and be sure the bed stays moist, and it will simply keep decomposing and getting richer all the time.

Tips for Managing the Project

- Be sure to have all of the materials on the site when you are ready to build the bed, but leave some last minute yard debris to be gathered by the children. Leave the cardboard boxes intact or partially broken down – the kids can do the rest, flattening the boxes and removing the tape. Know where an accessible hose and spigot are.
- Have children work in teams of three or four. One team can cut back the existing vegetation while another breaks down the cardboard boxes. Another team or two can gather dry leaves, grass clippings, or whatever yard debris is around. If you have a compost pile on site, have another team collect a wheelbarrow full of compost. If needed, another team can get the water system set up.
- If the garden bed is large, the whole group can pitch in together to throw on the various layers of mulch. If the bed is small, assign the teams a specific layer to which they can contribute. Make the "throwing on" of each layer a celebration – a soil-building celebration!

Estimated Budget

Though the materials list is long, a sheet mulch bed does not cost much; the idea is to use what you have easily available on your site. If you need to buy compost or manure it is available at garden supply stores for less than a penny per pound. Straw can be purchased for around \$4.50 per bale.

Organic seed potatoes can be purchased for approximately \$3.00 per pound.

Learning in the Garden

1) Watch how the bottom layers of mulch change over time. Keep a log of what you see as the cardboard and yard debris decompose and turn into soil.

2) As the mulch turns into soil, conduct tests for organic matter and pH. Use a Berlese funnel to look for worms, grubs, arachnids, insects, and snails. How does this soil compare to other soil samples on your site?

3) Research the "Soil Food Web," the amazing relationship between plants, bacteria, and fungi in the soil.

Questions for Reflection

What Permaculture Principles are illustrated in an “Instant” Garden?

- How does a sheet mulch garden **replicate natural patterns**? (Hint: how does a forest build soil?)
- How does a sheet mulch garden help us to **produce no waste**?
- How does your “Instant” Garden have **multiple functions**?
- What is your **yield**?
- How might an “instant” garden **turn a problem into a solution**?

Chart 1: Eco-Service and Permaculture Connections “Instant” Garden

GEN Departments	Permaculture Principles
<p>Biodiversity Department A sheet mulch bed enhances the biodiversity of organisms in the soil as well as the diversity of plant life growing in the soil.</p>	<p>Multiple Functions A sheet mulch bed: 1) creates new organically rich soil; 2) recycles organic materials from the site; 3) provides a place to plant plants that attract pollinators and/or provide food for humans and wildlife.</p>
<p>Food Production Department The organic material in the sheet mulch bed provides food for many soil organisms. The bed may be planted in potatoes or other foods for humans or wildlife.</p>	<p>Observe and Replicate Natural Patterns How does nature make soil in the forest?</p>
<p>Pollination Department The garden bed may be planted in flowering plants attractive to pollinators.</p>	<p>Obtain a Yield A sheet mulch garden “yields” rich soil, flowers, and/or vegetables.</p>
<p>Soil Department The sheet mulch bed creates soil rich in organic matter. By leaving the ground intact, the bed building does not disturb the existing biological networks in the soil.</p>	<p>Produce No Waste Use simple materials from the site and materials that might be thrown away to build a garden bed.</p>
	<p>Turn Problems into Solutions Lots of fall leaves on your site (problem) can be just what is needed to build a rich mulch bed (solution).</p>

Keyhole Garden

Description

Keyhole gardens are garden beds designed to be space-efficient and energy-efficient. A simple keyhole bed is horseshoe-shaped with a path leading into the middle. In the very center is a small round area in which to stand or squat. From here, a gardener can reach around the horseshoe shape and tend to all of the inner ring of the bed.

The U-shape of the bed adds an aesthetic appeal to a garden area. In contrast to the human-created linear and angular look of rows or typical raised beds, keyhole beds use the curve – a shape common to the natural world. Several keyholes can be put together to make an interesting arrangement of bed space and “cul-de-sac” pathways.

Keyhole beds are often built using the lasagna-layering sheet mulch method (see “Instant Garden”), but the bed can be created simply by mounding good soil. Once built, keyhole beds can be used to grow whatever you’d like.

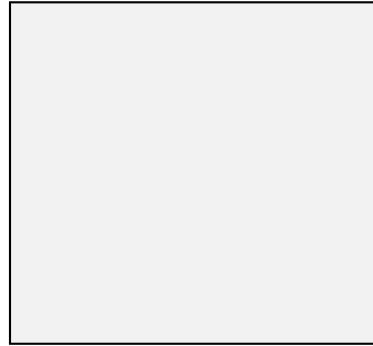
Background

Keyhole gardens are space-efficient. In planning a garden, you have to think not only about the plant beds, but paths to get to and around those beds. If you are serious about keeping feet off of your garden soil (to avoid compaction), then you will need to build a bed so that you can reach all parts of it from the pathways. In many gardens, this means a good percentage of the garden area becomes pathway instead of planting space. If, however, you take a rectangular bed and wrap it around into a keyhole shape, you’ll end up needing only one-fourth of the space dedicated to pathways.



Keyhole gardens are energy-efficient. If you face the keyhole garden with the horseshoe opening toward the south (the sun), you can create a warm microclimate within the keyhole part of the bed. Taller plants planted on the outer rim on the north side of the bed will create a cold barrier, keeping the warm air from the sun trapped in the center of the bed. The tall plants can also shelter the shorter, more tender plants from the wind.

A keyhole bed can also catch flowing water. If you are on a slope, the pathway to the bed center should lead downhill. That way, rainwater flowing down hill will enter through the



Eco-Standards Checks:
Soil and Recycling Department
Biodiversity Department

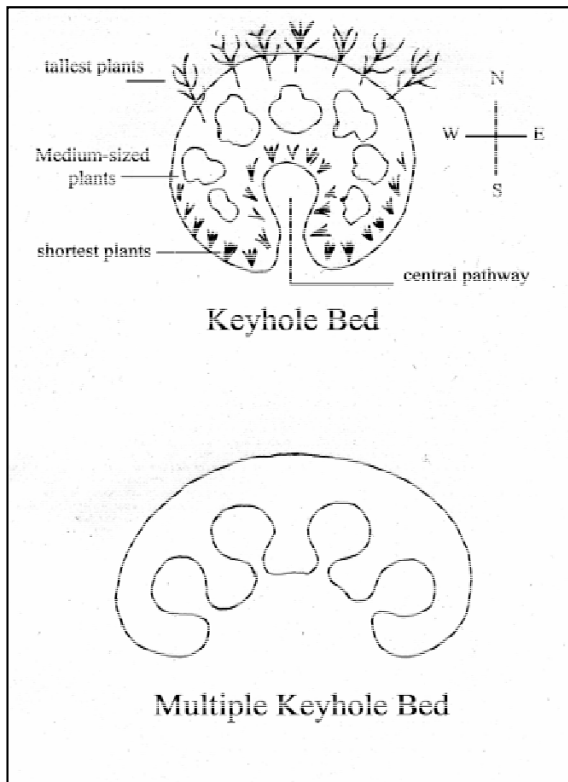
pathway and spread to the root zone of the entire bed. Plants that prefer more moisture should be planted around the inner circle of the bed.

How to Build a Keyhole Bed

Building the Bed

Step 1: Find a site for the keyhole bed. Consider the availability of sunlight and water for the garden. If you are planting on flat land, face the bottom of the keyhole (the opening of the horseshoe) toward the south so that sun will shine most directly on the inside of the bed.

Note: If you are planting on a slope that faces south and you want to catch water in the inner circle, you'll need to do the opposite: turn the opening of the horseshoe uphill to the north. You'll also need to reverse your planting plan; see *Note* below *Step 4*.



Step 2: Outline a circle approximately 8 feet in diameter. Fill the circle materials to create a sheet mulch bed. (See "Instant Garden.") On the south side, move the soil to create a small, short pathway (about 18 inches wide) to the bed center. Remove a little more soil in the bed's center to create an inner central circle, about two feet in diameter.

Step 3: Dig a small trench, just a few inches deep, around the central circle where it meets the planting bed. This will help catch rainwater and allow it to soak in beneath the bed.

Planting the Bed

Step 4: Plant the bed with flowers, herbs, or vegetables – anything that can be planted in a "regular" garden bed can be planted here! Place the tallest plants toward the north edge of the bed so that they don't block the sun shining in from the south. Place the shorter plants and those that are most likely to need attention (extra water, weeding, or harvesting) on the inner circle, closest to the keyhole pathway.

Note: If you are planting on a slope and have turned your keyhole around to catch water, plant the taller plants on the inner edge and toward the north, and the shorter plants on the outer edge toward the south.

and have turned your keyhole around to catch water, plant the taller plants on the inner edge and toward the north, and the shorter plants on the outer edge toward the south.

Step 5: Water, mulch the bed, and watch the plants grow!

Tips for Managing the Project

- Involve the club members in selecting the garden site and developing a planting plan.
- Be sure to have all of the materials on the site when you are ready to build the bed.
- Have the club members work in teams to shape the bed, create the pathway, and dig the water trench.
- They can also work in teams to plant the bed, water it, and mulch it.

Estimated Budget

A keyhole bed itself costs very little. If you do not have your own compost or you do not have sufficient yard debris for mulch, you may need to purchase them. Otherwise, the biggest "cost" is in your own time and energy.

Questions for Reflection

What are the Permaculture Principles illustrated in a Keyhole Bed?

- How does a keyhole bed **replicate natural patterns**?
- How does the concept of "**edge**" help us to design a space-efficient bed?
- What are the **multiple functions** of a keyhole bed?
- How does a keyhole bed help to **catch and store energy**?
- What is your **yield**?

**Chart 1: Eco-Service and Permaculture Connections
Keyhole Garden**

GEN Departments	Permaculture Principles
<p>Climate Control Department A keyhole bed can create a microclimate, catching heat from the southern sun in its center.</p>	<p>Catch and Store Energy By orienting it toward the sun, a keyhole bed can “catch” and store sunlight, creating a warm microclimate in its center. On a slope, a keyhole bed can catch the energy of rainwater in its center.</p>
<p>Food Production Department With good rich soil, a keyhole bed creates a food-producing ecosystem for Soil Department critters. The bed can also nourish plants that produce food for wildlife and/or humans.</p>	<p>Multiple Functions A keyhole bed: 1)creates an efficient space for growing plants; 2) builds soil; 3) can create a microclimate ; 4) catches rainwater; 5) can produce food for wildlife and/or humans.</p>
<p>Pollination Department The garden bed may be planted in flowering plants attractive to pollinators.</p>	<p>Observe and Replicate Natural Patterns A keyhole bed is based on curves, a pattern seen often in nature, rather than lines and angles typical of many gardens</p>
<p>Soil Department A keyhole bed includes a healthy soil system, rich in organic materials and nutrients. A bed built using the sheet mulch method can create new soil.</p>	<p>Obtain a Yield A keyhole garden “yields” rich soil, flowers, herbs, and/or medicine or edibles for humans.</p>
	<p>Use Edges The rounded shape and a keyhole bed actually reduces the amount of garden-pathway space needed. But the creative use of “edge” for the inner pathway makes all parts of the bed easily accessible to the gardener.</p>

Tire Garden

Description

Tire gardens are planting containers made of used tires. The tires are cut, cleaned, and filled with dirt, creating a small raised bed for planting. The dark, heavy rubber of the tires captures sunlight and provides extra warmth to the plants in the cooler months. This additional heat can help plants get an earlier start in the spring and/or ward off the frost of autumn.

Tire gardens can consist of a single tire planter, a row of tires, or a ring of them. (Tires can also be stacked on a hillside and packed with rammed earth to create a plantable tire retaining wall. See “Resources” below for construction details.)

Background

Old tires seem to be everywhere! It is estimated that residents of the United States throw away nearly 250 million tires every year – stacked end to end, this “garbage” would wrap around the Earth one and a half times. On the ground, discarded tires are a big environmental problem: with their bulkiness, tires fill up landfills. They often end up in streams or other natural areas, and when they lie about in the outdoors, they fill with water and become breeding grounds for mosquitoes. Tire gardeners, on the other hand, view old tires as wonderful resources, with many positive attributes. These gardeners take tires out of the waste stream and put them to good use.

As small raised beds, tire planters provide many advantages for plants, the soil, and for humans. By building the soil ecosystem upward (instead of digging down), the critters from the Soil Department are not disturbed, and their delicate soil-food web is kept intact. (See “Instant Garden.”) Tire planters are also human energy-savers when the soil is hard-packed and not very fertile; going upward with a rich soil ecosystem is simply easier on the muscles than breaking it up and remediating it. You can even make tire planters, stacked two deep on top of concrete!



Spring flowers give a new use to old tires.

Tire beds also create micro-climates that support plant growth. Soil warms faster when it is elevated; raised beds have been known to increase spring soil temperatures by 8 to 13° F over the soil temperatures at ground level. The heavy black tire rubber absorbs sunlight, creating even more warmth in the soil within the tire. In addition, since water always moves downward, raised beds allow for good water drainage; this is particularly helpful in low, wet areas or in heavy clay soils.



Eco-Standards Checks:

Soil and Recycling Department

Pollination Department

Biodiversity Department

Materials

- Used tires
 - Utility knife
 - Heavy garden gloves
 - Good soil, with plenty of organic matter
 - Shovels
 - Seeds or seedlings.
- Mulch (yard debris, including dry leaves, or seed-free)

With these micro-climate advantages, tire gardens can extend the growing season significantly. In cold climates, snow melts and spring rains often keep the soil wet and cold, pushing back the first planting date significantly. In the tires, the warmer, well-drained soil is more able to receive and nurture tiny seeds or seedlings. Likewise, in the fall, plants in tire beds are less susceptible to early frosts. Ultimately this means not only that you have more time for plant production, but that you may also be able to grow a wider range of plants within the extended growing season.

How to Build a Tire Garden

Step 1: Find a source for used tires. Check with a local car mechanic, service station, or tire dealer; it actually costs them to dispose of old tires, so these folks are usually delighted to have you take them away. Club members themselves may have extra car or truck tires around their homes just waiting to be put to good use.

Step 2: Define the size, shape, and purpose of your tire garden; will you have just a single tire planter, a line of tires, a stack, or a circle configuration? Consider how many tires you have, the space you have to work with, and the human energy you have to put into it. Be sure that the design allows the children to reach the planting areas from a pathway.

Step 3: Find a site for the tire garden. Consider the availability of sunlight and water. Choose an open, south-facing site whenever possible.

Step 4: Clean the tires thoroughly, inside and out.

Step 5: Lay the tires on the ground in the garden space in your desired configuration.

Step 6: Very carefully, use the utility knife to cut the sidewall of the tire completely off of the upper side. (The blade must be very sharp to cut the thick rubber; gloves are recommended for finger protection!) Once cut, the top of the tire should provide an open circle for planting, with the treaded sides serving as the round vertical wall.

Step 7: Fill the tire with good soil, rich in organic material.

Step 8: Plant seeds or seedlings. Water, cover with mulch.

Step 9: Watch the plants grow! Since tire gardens have a warmer and drier microclimate than the soil around them, be sure to monitor the soil moisture, especially in hot or dry summer months.

Tire Garden Timeline

Winter

- *Gather tires
- *Design the garden

Late Winter/Early Spring

- * Cut the tires

Spring

- * Fill the tires with rich soil
- * Plant
- * Water and mulch

Summer

- * Keep plants well-watered and mulched
- *Weed as necessary

Estimated Budget

Most tire gardens cost next to nothing. Don't pay for tires! With just a little effort you should be able to get them for free. (You might even get paid to take them away!) It may, however, cost a little to transport the tires back to your school site.

If you have your own compost (See "Yummy Compost"), the rich organic soil should not cost anything either. If you don't have your own, you may need to purchase some from a nursery.

Likewise, try to use what you have around you for mulch. Buy prepared mulch or straw only if necessary.

The only real cost to creating a tire garden is likely to be the seeds or seedlings. If the seeds are organic, they may cost between \$2 and \$4 per packet, depending on the type of seed. Small seedlings will cost between 50 cents and \$2.00 per plant.

Tips for Managing the Project

- Involve the club members in selecting the garden site, developing a planting plan, and gathering materials as much as possible.
- Be sure to have all of the materials on the site when you are ready to build the tire garden.
- It is recommended that an adult do the actual cutting of the tire walls.

Questions for Reflection

What are the Permaculture Principles illustrated in a Tire Garden?

- How does a tire garden exemplify the principles of **produce no waste** and **turn problems into solutions**?
- What are the **multiple functions** of a tire garden?
- How does a tire garden help to **catch and store energy**? (Think “microclimate.”)
- What is your **yield**? How can a tire microclimate affect your yield?

Learning in the Garden

- 1) Use the geometric formula for determining the area of a circle (πr^2) to calculate the amount of planting area you have in your tire garden.
- 2) Keep a record of soil temperatures inside the tire and just next to it at ground level. Compare to find out just how much of a microclimate the tire creates.
- 3) Plant the same type of plant in the tire and next to it. Compare the plants' growth.

Resources

Websites

- A New Use for Old Tires, <http://www.backwoodshome.com/articles2/sanders98.html>, Includes information on tire walls, tire compost bins, and a method of growing potatoes using old tires.
- Blooming Planters, <http://www.wuvie.net/tireplanter.htm> – Gives detailed information on how to make colorful flower-shaped planters from tires. (This method is more complicated than the method described here.)
- Open Mulched Tire Garden - http://www.northerngreenhouse.com/ideas/how_to/tiregarden.htm - Describes a variety of advantages to tire gardening.
- Recycling Tires - <http://www.humboldt.edu/~ccat/wastereduction/recycling/desideria.FA2000/> - Provides a diagram and photos of tire retaining wall construction.

**Chart 1: Eco-Service and Permaculture Connections
Tire Garden**

GEN Departments	Permaculture Principles
<p>Climate Control Department The thick black rubber of tires absorbs heat from the sun, creating a warm microclimate. The raised bed effect also creates a microclimate; it is much warmer and drier inside the tire than outside.</p>	<p>Catch and Store Energy The black rubber of an old tire catches and stores sunlight. This energy is transferred to the soil and plants as warmth.</p>
<p>Food Production Department Plants in a tire garden can produce food for humans and/or for wildlife. You can grow vegetables and/or flowers in tire beds. In addition, the rich soil in the planters provides more food for Soil Department workers.</p>	<p>Multiple Functions – A tire garden: 1)creates a space for growing plants; 2) builds soil; 3) creates favorable microclimates for growing plants; 4) keeps tires out of the waste stream; 5) uses marginal land.</p>
<p>Pollination Department Tire gardens are excellent places to plant flowering plants attractive to pollinators.</p>	<p>Obtain a Yield - A tire garden can yield flowers, herbs, vegetables, or medicine for humans.</p>
<p>Soil Department A tire garden builds a rich soil ecosystem upward without disturbing the delicate soil-food web that already exists under the ground.</p>	<p>Produce No Waste – Tire gardens reclaim tires that would have otherwise gone into the waste stream.</p>
	<p>Turn Problems into Solutions - Used tires are a problem! Each year millions of tires are thrown into landfills, and many end up in streams or other natural places. Tire gardens employ used tires as a great resource for creating raised bed microclimates.</p>

Catching the Rain

Description

A rainwater catchment system collects and stores rain water that falls naturally on the roof of your school building. A pipe attaches to the building's gutter downspout, diverting water into a storage barrel instead of onto the ground. The barrel top is covered with a screen to prevent debris or mosquitoes from getting into the stored water. The bottom of the barrel has a spigot for accessing the water. The water that you "harvest" can be used to irrigate your garden, clean your tools, or fill a pond on your school site. (Note: Because there can be contaminants on the school roof, this simple system is NOT intended for drinking water storage. However, there are more complex systems that filter the contaminants to provide drinking water.)



Background

While people in many parts of the world experience serious water shortages, millions of gallons of this precious resource literally flow by, unused, in the form of rain. In the U.S., rain falling on rooftops or paved ground surfaces is often channeled away from buildings and delivered into storm drain or sewage systems, far from our homes and gardens. And then, when dry times come, we find ourselves with government water use restrictions and withering plants.

Just how much water slips by us? Let's say you have a small school building measuring 100 feet long and 60 feet wide; the square footage of the roof surface is 6,000 square feet. Now let's



A simple rainwater catchment system built by kids (with the help of a few adults!)

say you live in a place that averages 40 inches of rainfall per year. It is known that one square foot of rain one inch deep produces 0.623 gallons, so if we multiply $6,000 \times 40 \times 0.623$, the roof of this school building will yield approximately **149,520** gallons of rainwater per year! We know that the water is not "lost;" the unending water cycle returns it to Earth somewhere, but why not catch it and use it while we can?

Humans have been harvesting rainwater around the world for hundreds of years using simple technologies, from wide-mouthed containers open to the sky to bamboo gutters channeling water into garden ponds. In recent years rainwater harvesting has become more popular in parts of the U.S., particularly in the southwest and in areas newly affected by drought. Many local governments now provide incentives for

property-owners to install catchment systems (see Resources below), and rainwater catchment products abound in the marketplace.

Eco-Standards Checks:
Water Purification Department
Soil and Recycling Department

How to Build a Simple Rainwater Catchment System

Rainwater catchment systems are widely sold in kits. The steps described below outline a less expensive, do-it-yourself method. While the system is relatively simple, it does require some skill with tools. The instructions below assume you are using a plastic barrel.

Step 1: Obtain approval for the catchment system from the school administration. Work with the administration and custodial staff to determine an appropriate site. You will need to be able to place the rain barrel directly under a shortened gutter downspout.

Step 2: Gather all of your materials and tools.

New rain barrels can be ordered on-line. You can also find less expensive -- or free -- containers through outlets that use food-grade storage containers. Tanks or drums formerly used to hold cola syrup are commonly used as rainwater barrels. Bakeries and brewing supply stores may also have food-grade drums they are no longer using. Do NOT use barrels formerly containing industrial chemicals or other non-food grade liquid. (See Resources below for information on a conservation group that creates rainwater barrels out of used food containers.)

The support base is optional, but it is recommended. By elevating the rain barrel, you will get better water pressure. The base should be at least 2 feet high and can be made from concrete blocks, a sturdy wooden platform, a heavy-duty metal barrel, or other sturdy materials.

Step 3: Select an existing gutter downspout from which to catch the rainwater.

Cutting the downspout to fit

Step 4: To determine the length of downspout needed, set the height of the support base and barrel temporarily next to the existing downspout. Mark a line on the downspout 3 inches above the top of the barrel. Move the barrel and support base aside, and use a hack saw to cut the downspout to the marked length.

Installing the spigot on the barrel

Step 5: Place the barrel on its side. Drill a hole $\frac{3}{4}$ inches in diameter on the side of the barrel, 4 inches from the bottom of the barrel. If a $\frac{3}{4}$ inch drill bit is not available, mark the outside diameter of the $\frac{3}{4}$ inch

Materials

- 30- to 55-gallon plastic tank – clean and leak-free
- 10 feet of 1-1/2 inch diameter plastic pipe (more length if overflow line needs to be extra long)
- Teflon tape for pipe threads or other thread sealer
- Hose spigot with $\frac{3}{4}$ inch female threaded end
- Galvanized metal nipple, $\frac{3}{4}$ diameter, 1 inch long
- 2 neoprene rubber washers, 2 inch diameter, with $\frac{3}{4}$ inch hole (if the hole is slightly less than $\frac{3}{4}$ inch, they will still work by stretching onto the $\frac{3}{4}$ inch pipe)
- 1 nut with $\frac{3}{4}$ inch pipe threads (bolt threads will NOT work –use locknuts for electric conduit if the plumbing department doesn't have such nuts)
- A metal washer with a hole just large enough to fit over the $\frac{3}{4}$ inch nipple
- Window screen, approximately 3 feet wide by 3 feet long
- Bungee cord approximately 8 feet long when stretched (or 2 that stretch 4 feet each)
- 2 rubber elbows of 1-1/2 inch diameter, with built-in hose clamps on each end
- One 1- 1/2 inch plastic pipe adaptor, one end with male pipe thread, one end barbed.
- One 1-1/2 inch hose clamp
- 2 nuts with 1-1/2 inch pipe threads (bolt threads will NOT work)
- Optional - Materials for the support base – a sturdy metal barrel, concrete blocks, a strong wooden platform, or other sturdy materials

Tools

- Electric drill (with extension cord if needed)
- $\frac{3}{4}$ inch butterfly drill bit
- 1-1/2 inch hole saw
- Tin snips
- Slotted screw driver
- Large plier
- Crescent wrench
- Large round file or rasp
- Felt-tipped marker
- Carpenter's level

hole, then use a smaller bit. After drilling, widen the hole to 3/4 inch using a round rasp or round file.



Parts for installing spigot, from left to right: a nut with pipe threads, metal washer, neoprene washer, 1-inch nipple, 2nd neoprene washer placed on nipple, spigot (with nipple already attached).

Step 6: Screw together the spigot and the 1 inch long nipple. Slip the neoprene rubber washer over the nipple and push it up against the spigot.

Step 7: Insert nipple into the 3/4 inch hole in the barrel, with the spigot projecting outside the barrel. Reach into the barrel (or crawl in), and slip a rubber gasket washer over the nipple inside the barrel.

Then slip the metal washer onto the nipple up against the rubber washer. Use teflon tape or other pipe sealant

on the nipple threads. Screw a nut onto the nipple inside the barrel, and hand tighten it until it snugs against the metal washer. Tighten the nut with a wrench or large plier while a second person holds the spigot with the spout pointing toward the bottom of the barrel. It is tight enough when the spigot will not wiggle or easily turn from side to side.



One child tightens the nut from inside the barrel while another holds the spigot on the outside.

Installing the overflow connection

Your rain barrel will likely fill and overflow during a heavy rain. A pipe attached near the top of the barrel provides an outlet for overflow, carrying the water away from the catchment system.

Step 8: Determine where you'd like to direct overflow water so that it does not pool near the school building. Try to direct the overflow water to a planted area that can absorb the water and not create erosion. Be sure that the overflow pipe will not obstruct any walkways or other access.



The overflow pipe is attached to the barrel using the plastic barbed adaptor (on the right) and the rubber elbow (on the left).

Step 9: Mark a point 3 inches from the top of the barrel where the drain overflow hole should go. Drill a hole 1-1/2 inches in diameter on the side of the barrel at the point marked. If a 1-1/2 inch drill bit or hole saw is not available, mark the outside diameter of the 1-1/2 inch hole, then use a smaller bit. After drilling, widen the hole to 1-1/2 inch using a round rasp or round file.

Step 10: Screw a 1-1/2 inch nut on to the threaded end of the 1-1/2 inch barbed pipe adaptor as far as it will screw by hand.

Step 11: Insert threaded end of the 1-1/2 inch adaptor into the 1-1/2 inch hole in the barrel. Reach into the barrel and screw a 1-1/2 inch nut on to the threaded adaptor inside the barrel, and hand tighten it until it snugs against the inside of the barrel. Hold the inside nut in place with a wrench or large plier while tightening the outside nut

firmly against the outside of the barrel. Attach the 1-1/2 inch overflow pipe to the adaptor after raising the barrel on to its base (See Step 17).

Installing the screen mesh on the top of the barrel

Step 13: Cut the screen mesh in a circular shape with a diameter 12 inches more than the diameter of the barrel.

Step 14: Place the screen mesh over the open end of the barrel so that it lays flat. Check to see if there is enough screen material to extend past the edge of the barrel by at least 6 inches on all sides. Then fold the screen down along the sides of the barrel, making sure the screen over the top of the barrel remains flat and taut. This step will require more than one set of hands. Stretch a bungee cord around the barrel near the top to hold the screen in place.

Final Steps

Step 15 (Optional): Place the support base in position under the downspout. Check the top of the base to be sure it is level. If needed, add gravel or soil under the support base to bring it to a level position and to make sure that it does not wobble. Place the barrel on support base

Step 16: Attach the barrel to the building with metal strapping, if possible.

Step 17: Attach a 1-1/2 inch elbow to the barbed end of the overflow pipe adaptor and tighten the hose clamp. Determine the length of 1-1/2 inch pipe by measuring the distance from the bottom of the 1-1/2 inch elbow to the ground beside the barrel. Cut the pipe with a hack saw and insert it into the 1-1/2 inch elbow, letting the pipe hang vertically down the side of the barrel. Tighten the hose clamp to hold the pipe in place. Install the second 1-1/2 inch elbow to the bottom of the 1-1/2 inch pipe, and turn the elbow to point its opening toward the location where you will direct the overflow water. Tighten the hose clamp to hold the elbow in place. Measure the distance from the elbow to the location where the water will flow. Cut the second piece of pipe to match this distance. Insert the pipe into the end of the 1-1/2 inch elbow, and tighten the hose clamp to hold it in place.

Step 18: Direct the downspout over the top of the barrel. It should be approximately 3 inches from the screen mesh, but not touching the screen.

Step 19: Test your system either by spraying water from a hose onto the roof or by observing what happens during the next rain. Watch for leaks and adjust as necessary.

Step 20: Celebrate! Your school is now part of a worldwide effort to turn rainwater "problems" into solutions!

Rainwater Catchment System Timeline

A rainwater catchment system can be installed at any time of the year. However, if you live in an area that has rainy and dry seasons, try to install the system just prior to the rainy season so that the club members can see results.

Once you have gathered your materials, the actual work on the barrel may take up to three hours.

The steps can be broken into three work sessions:

- 1) installation of the spigot;
- 2) installation of the overflow connection;
- 3) installation of the screen and final steps.

Estimated Budget

Rainwater system kits are available for \$150 to \$200, depending on how big and fancy you'd like to get.

Supplies for a do-it-yourself rainwater catchment system with a plastic barrel cost in the range of \$65 to \$70.

Costs include:

Plastic food-grade container with lid - \$15 to \$20
Plumbing supplies - \$ 40
Metal screen - \$ 5
Bungee cord - \$ 5

Maintaining Your Rainwater Catchment System

Check your system periodically to make sure that the screen is clear of debris and that the spigot and overflow pipe are well-attached, with no leaks. Observe the overflow area after a heavy rain to be sure that the outflow is being distributed and absorbed and not causing pooling or erosion.

Tips for Managing the Project

- If you are not comfortable using drills, rasps, and wrenches, find another adult who is. This may be a great way to engage the school custodian or a handy parent in your club's activities.
- Be sure to have all of the materials on the site when you are ready to build the catchment system.
- Involve the children as much as possible; opportunities to learn to use tools are important for children. However, there can be a delicate balance between allowing them to practice and getting the project done. Decide beforehand which tasks you feel comfortable allowing the children to do, and be sure to supervise any use of a drill or cutting tool.

Questions for Reflection

What are the Permaculture Principles illustrated in your rainwater catchment system?

- How does rainwater catchment **replicate natural patterns**?
- The catchment system catches and stores water. How does the system **catch and store energy**?
- How does a catchment system help your school to **produce no waste**?
- Why would you want to have **redundancy** of water sources?
- How does a rainwater catchment system **turn a [potential] problem into a solution**?

Resources

Websites

- *Rainwater Harvesting for Drylands and Beyond*, Volumes I and II, by Brad Lancaster – A compilation of strategies, tips, illustrations, examples, and success stories for rainwater harvesting systems. Website: www.harvestingrainwater.com
- The Rainwater Harvesting Community, www.harvesth2o.com - Includes articles, FAQ, and instructions for establishing collection systems.
- University of Florida Sarasota County Extension Office – How to Build a Rainbarrel, www.sarasota.extension.ufl.edu/Hort/Pubs/Rainbarrel.shtml, – Provides step-by-step instructions, photos, and ideas for low-cost storage containers.
- Rain Barrels: More than a drop in the bucket for conservation, http://www.stlouispark.org/pdf/Metrowide_rain_barrel.pdf - A comprehensive, easy-to-read guide to home rainwater catchment; includes information on the “whys” of rain water catchment, how to’s of building a system, as well as tips on rain barrel maintenance
- Water-Harvesting Financial Incentives and Resources, www.harvestingrainwater.com/rainwater-harvesting-inforesources/water-harvesting-tax-credits - provides information available financial incentives for rainwater catchment systems, including rebates, tax credits, and grants.
- F.O.R- Made Rain Barrels, <http://www.riverfriends.org/SideMenu/FORSale/RainBarrels> - Friends of the Rappahannock in Virginia make and sell rain barrels out of re-used food containers.

**Chart 1: Eco-Service and Permaculture Connections
Catching the Rain**

GEN Departments	Permaculture Principles
<p>Pest and Disease Control Department Mosquitoes are known to breed in standing water. Rainwater catchment systems include screens to prevent mosquitoes from reaching the stored water.</p>	<p>Observe and Replicate Natural Patterns There are many rainwater catchment systems all around us in nature. Lakes, ponds, bogs, and swamps all catch rainwater and store it on the earth's surface. Underground, aquifers and the water table collect and store water that has filtered through the soil. Nature stores the water, then slowly lets go of it.</p>
<p>Soil Department Rainwater that falls off a roof can hold a great amount of energy – energy that can erode soil. Rainwater catchment systems channel that water into storage tanks and allow for slower disbursement into the soil. The stored water can add moisture to the soil during dry times.</p>	<p>Obtain a Yield Rainwater catchment is often called "harvesting" – water is the yield!</p>
<p>Water Purification Department Rainwater catchment systems bring into focus many aspects of this department: how water flows, water quality, how water is used, and how it can be conserved. By slowing water and preventing erosion, we keep silt-laden water out of our natural waterways.</p>	<p>Produce No Waste Millions of gallons of water flow right by us each year. Rainwater harvesting systems help us to store and use at least some of this precious resource.</p>
	<p>Redundancy Your school undoubtedly already has a water system. But what if something were to interrupt it – a pipe were to burst, electrical pumps didn't work, or, worst case scenario, your local water source were to dry up? Having a "back-up" water source makes good sense!</p>
	<p>Turn Problems into Solutions Heavy rainfall can cause destructive flooding and/or soil erosion. But that same water that falls heavily on a given day will be a welcome gift during a dry spell.</p>

A Spiral of Herbs

Description

An herb spiral is a small garden bed made of soil and rocks in the shape of a three-dimensional spiral. Standing about three feet high and five feet across, the planting space winds from the bottom up, around and around to the top. The winding plant beds form a variety of microclimates; sun-loving herbs are planted on the south side, while shade-tolerant herbs are planted on the north side. The different levels of height also create differences in soil moisture; with water naturally draining down, the moisture-tolerant herbs are planted toward the bottom, and the herbs that thrive in drier soil are planted at the top.



Background

The spiral is one of nature's beautiful basic patterns; you find spirals in seashells, sunflower seedheads, and the double helix of DNA. We create them in spiral staircases and screw threads. If you look closely, you can see spirals are very space-efficient; the spiral contains its space coiled up instead of stretching long. In fact, an herb spiral that is three feet high and five feet wide actually contains 30 linear feet of space!

Eco-Standards Checks:

Pollination Department

Pest and Disease Control Department

In addition, the three-dimensional spiral bed provides a clear demonstration of matching microclimates to plant needs. The sunny south-facing side of the spiral near the top is a great place for herbs that like hot and dry conditions, such as oregano, rosemary, and thyme. Parsley and chives, on the other hand, are better located on the bottom and on the north side of an herb spiral, since they can handle the cooler, damper conditions. The spiral bed provides many opportunities to experiment with different sunlight and moisture needs of a variety of plants.



A spiral planted in a variety of herbs.

Growing a bed full of herbs is also an exploration into the deep connections between plants and insects. Many herbs are flying insect attractors, drawing pollinators into the garden with their scents and nectars. Other herbs, such as parsley and dill provide food for certain types of caterpillars. Still other herbs play the role of "aromatic pest confuser;" their strong scents attract and confuse insect pests, stopping them from finding and eating other garden crops. Mint, oregano, rosemary, thyme, and yarrow are among these.

Finally, the spiral herb bed is a wonderful way to explore the world of herbs: the subtle flavors and aromas plants can offer, the different parts of plants that may be useful, and the sheer beauty

of the plants as they grow and flower. The chart below suggests some herbs to try in a spiral, their sunlight and moisture needs, and their functions and uses.

How to Build an Herb Spiral

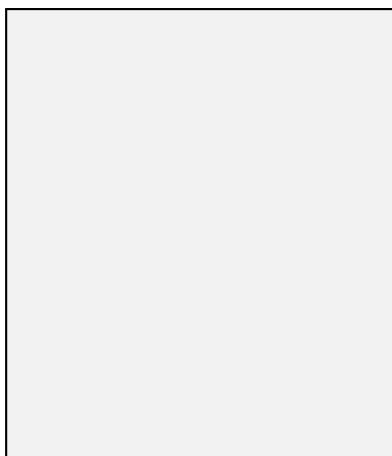
Preparation

Step 1: Find a site for the spiral. Observe the path of the sun and determine which way north, south, east, and west lie. The south side of the spiral area should be clear of trees or buildings so that maximum sunlight can reach the plants. Consider, too, where your water source is.

Step 2: With the club members, choose the herbs you would like to plant. Sketch out a planting plan using the chart below to match the plants' sunlight and water needs with the position on the spiral. Purchase the herbs either as seeds or as seedlings; seedlings are recommended for an easier start and greater likelihood that your club members will see results.

(Note: The chart below is simply a guide; feel free to experiment with other herbs that interest you.)

Step 3: Gather together the rocks and soil you will need to build the bed. Gather the tools, too.



Building the Spiral

Step 4: Mark out a 7- to 8- foot diameter circle. Then mark a 5-foot diameter circle inside that one. The smaller circle indicates where the spiral itself will go; the larger circle indicates a walking path around it.



Placing rocks on a dirt mound to form a spiral.

Step 5: In the center of the 5-foot circle, place a mound of rocks or rocky soil. This will start the mound that will become your spiral. Over this, place a mound of soil so that it stands three feet high and fills the 5-foot circle. (Note: Most of these plants are known to be hardy and not very "fussy" about the soil quality or pH.)

Step 6: Place medium-sized rocks on the mound to form a spiral pattern. Start at the bottom and wind upwards and inwards, making about three circles, into the center of the mound. The planting beds formed should be about one foot wide.

Herb Spiral Timeline

Early Spring

- * Choose a site and design the garden
- * Build the spiral

Spring

- * Purchase plants
- * Plant
- * Water and mulch

Summer

- * Keep plants well-watered and mulched

Fall

- * Harvest and dry herbs
- * Cut plants back as needed

Spring

- * Replant annuals

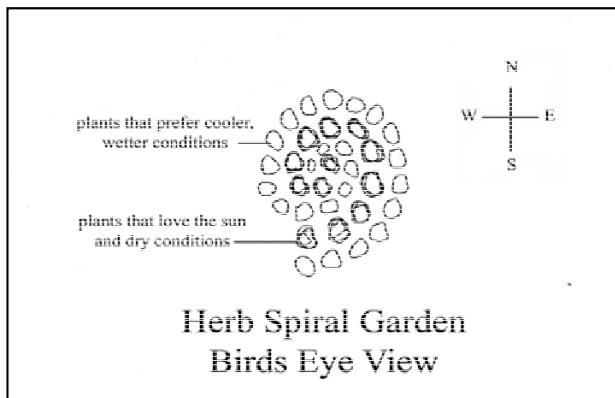
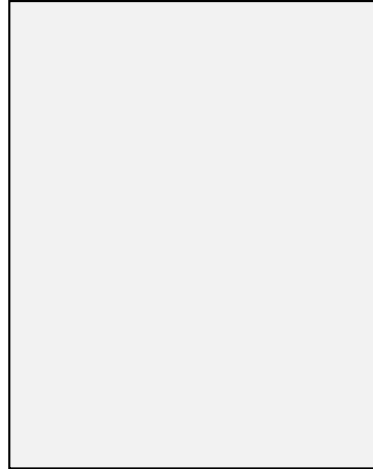
Step 7: Place additional small rocks in a ring around the spiral to outline the larger marked circle. This will define the pathway around the spiral.

Planting and Maintenance

Step 8: Plant the herbs. Water them and mulch the bed to conserve moisture.

Step 9: Water as necessary. Once the plants are established, normal rainfall and mulch should limit the amount of garden watering you will need to do. In drought conditions, however, you may need to water them from time to time.

Step 10: Observe the herbs as they grow. They will tell you by their looks and strength if they are in the right place in the spiral! Some of them may do so well they will try to spread and take over, so cut them back as needed. (Note: Most of



the herbs listed in the above chart are perennials or biennials, so if they are healthy, they will not need to be replanted each year. Cilantro and calendula are annuals and will need to be replanted.)

Step 11: Harvest the herbs and use them! There are many books and on-line resources with specific information on how to harvest, dry, and use a variety of herbs.

Tips for Managing the Project

- Create a context for an herb garden by having the children smell and/or taste a variety of herbs. Have them identify the ones they prefer. Discuss the role of herbs in cooking and medicines.
- Have the club members conduct the research to determine the specific needs of a variety of herbs. Have them work together to develop a planting plan based on their research.
- Be sure to have all of the materials and tools on site when you are ready to build the spiral.
- Since you'll be working in a small space, have children rotate through different jobs. For Step 5, one group can shovel dirt, while another group shapes it into a mound. (Be sure that hands and heads are out of the pathways of shovels!) For Step 6, some children can pick out appropriate-sized rocks, while others place them on the spiral; another group can work on outlining the circular path.
- Celebrate when you are finished!

Questions for Reflection

How does an Herb Spiral represent some of the Permaculture Principles?

- How does an herb spiral **replicate natural patterns**? Why is a spiral an efficient use of space?
- How does a **diversity** of microclimates support plant and animal diversity?
- What are some of the **multiple functions** of an herb spiral? (Hint: Consider the Pollination, Food, and Pest Control Departments!)
- What is your **yield**?

Learning in the Garden

1) Keep a log of the growth of the various herbs. (Students might pick one favorite on which to focus.) Record information on leaf and flower development, smells, and any other changes over time. Also indicate any signs of yellowing, insect damage, or other types of distress.

2) Observe and identify insects that visit the spiral. Observe which flowers attract each kind of insect. Try to observe an "aromatic pest confuser" at work.

3) Harvest some of the herbs and dry them. Learn more about their useful properties. Use them in cooking or medicine-making.

4) Learn more about culinary herbs of other cultures.

Chart 1: Plants for an Herb Spiral

Plant Name	Sun Needs	Moisture Needs	Functions
Rosemary	Full sun	Drier, well-drained soils	Leaves used in cooking; aromatic pest confuser; attracts pollinators
Oregano	Full sun	Drier, well-drained soils	Leaves used in cooking; aromatic pest confuser
Thyme	Full sun	Drier soil	Leaves used for cooking, medicines, preserving foods; aromatic pest confuser
Dill	Full sun	Drier, well-drained soil	Leaves and seeds used in cooking; flowers used in pickling; attracts pollinators; host plant for black swallowtail caterpillar
Parsley	Part shade	Wet or poorly drained soils	Leaves used in cooking, high in Vitamins A & C; host plant for black swallowtail caterpillar
Chives	Full sun to part shade	Well-drained soil	Leaves and flowers used in cooking; aromatic pest confuser, attracts pollinators
Sage	Full sun	Dry, well-drained soil	Leaves used in cooking, teas; aromatic pest confuser
Coriander (Cilantro)	Part shade to full sun	Moderately wet soil	Leaves (called cilantro) and seeds (called coriander) used in cooking and medicines; aromatic pest confuser
Feverfew	Full sun to part shade	Moderately dry soil	Leaves used as medicine
Calendula	Full sun to part shade	Moderately dry soil	Flowers used in cooking, medicine and as a dye; aromatic pest confuser; attracts pollinators
Echinacea (Purple coneflower)	Full sun to light shade	Moderately dry soil	Roots used in medicinal tea; attracts pollinators, birds
Roman Chamomile	Full sun to light shade	Moderately dry soil	Flowers used in tea; attracts pollinators
Yarrow	Full sun	Does well in dry soil	Flowers, leaves, and stem used as medicine; aromatic pest confuser

**Chart 2: Eco-Service and Permaculture Connections
Herb Spiral**

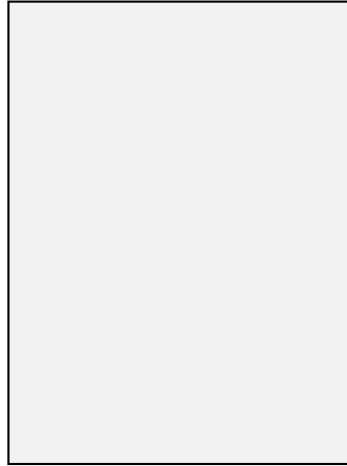
GEN Departments	Permaculture Principles
<p>Climate Control Department Gardeners can create microclimates to foster optimal plant growth. The herb spiral demonstrates the variability of microclimates within a very small space.</p>	<p>Diversity With its diversity of microclimates, an herb spiral fosters the growth of a wide diversity of plants. This, in turn, attracts a diversity of insects and birds to the garden.</p>
<p>Food Production Department Some herbs contain vitamins and minerals for humans and grazing wildlife; others add flavor to human food. Many herbs are used as medicines.</p>	<p>Multiple Functions A herb spiral: 1) creates a space-efficient planting bed; 2) provides microclimates; 3) provides plants that attract pollinators and plants that confuse pests; 4) yields culinary and medicinal herbs; 5) can be visually and aromatically beautiful.</p>
<p>Pest and Disease Control Department Many herbs are called “aromatic pest confusers.” Their strong scents attract and confuse pests, stopping them from finding and eating other garden crops.</p>	<p>Observe and Replicate Natural Patterns The spiral is a space-efficient natural pattern.</p>
<p>Pollination Department Many herbs develop flowering heads that are attractive to pollinators.</p>	<p>Obtain a Yield An herb spiral yields culinary and medicinal herbs.</p>

A Beneficial Garden

Description

A beneficial garden could well be called a “relationship” garden – it’s designed to promote useful relationships between plants and animals. “Beneficials” are insects, spiders, birds, and other wildlife that can be helpful in your garden. A beneficial garden features plants that attract these animals. Many of the plants attract pollinators with their sweet nectar, bright colors, and appealing smells. Some draw in birds and insects that eat garden pests. Some serve as nurseries for eggs and larvae of beneficial insects and spiders. With their foliage, many of the plants provide shelter for beneficials, and some serve as winter homes for them.

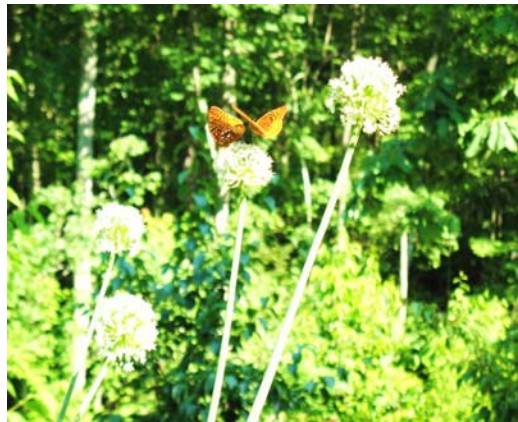
People can also be included as beneficiaries of these cultivated relationships. Beneficial gardens are beautiful places, full of colors, patterns, shapes, and scents that are appealing to humans as well as to insects and birds. There are practical benefits for humans as well. The species featured in the plant list below are all useful to humans in some way, as edible foods, teas, culinary herbs or as medicine.



Background

Beneficial gardens are a wonderful demonstration of the “needs and yields” relationship in nature. Plants need pollination (see Pollination Department) for reproduction, and ground insects and other arthropods for soil health (see Soil Department). Plants also need phosphorus, which birds can supply through their excrement. Birds, insects, spiders, and bats can also provide needed pest control for plants by feeding on insects, larvae, fungus, and bacteria in the garden. At the same time, plants can give back, providing many needs for these animals. In a beneficial garden, we plant a wide variety of plants to attract and accommodate a wide variety of animals. Diversity of relationships is a key to a successful beneficial garden.

Eco-Standards Check:
Biodiversity Department
Food Production Department



Meeting Animal Needs

In planning a beneficial garden, we include features that meet a range of needs for beneficial animals. The following are some of

the services that plants can provide. (See the Beneficial Garden Plant List below for information on plants that specialize in these areas.)

Nectar – Many plants provide pollinators with sweet, energizing nectar from their flowers. Nectar is sugar water with amino acids, minerals, and vitamins, and each flower has a nectar that is suited to meet the nutritional needs of the pollinator. Include in your garden a range of flower colors, shapes, and sizes to attract different pollinators. (See the Beneficial Animal Table for details.) Grow flowers in clumps so that flying insects can easily locate them. Also try to select plants that flower at different times (early spring, late spring/early summer, mid-summer, late summer/early fall) in order to keep a continuous supply of nectar for pollinators.

Pollen – We usually think of pollinators searching for nectar and inadvertently passing pollen from one plant to another. But some invertebrates, such as wasps, bees, and beetles, eat pollen as a protein-rich food source. Pollen is particularly sought after when these animals are rearing young or producing eggs. Flowers with this relationship will produce large amounts of pollen, enough for its own reproduction as well as food for insects. Some flowers produce two types of pollen: normal pollen that is involved in flower reproduction, and sterile pollen that is more appealing for food. (Many of the high pollen producers are trees and grasses.)

Bird Food – A beneficial garden abounds with food delights for many different kinds of birds. Hummingbirds are famous “customers” of beneficial gardens, using their long beaks to suck nectar from flowers. Some birds eat insects and insect larvae that are considered garden pests. Robins eat Japanese beetle larvae, for example, and cardinals eat the adult beetles. Many other birds feed on the fruits, nuts, and seeds of a garden. While you might think that this will take away from your yield of berries, figs or sunflowers, you can also look at it the way nature does –plant enough to go around!

Bird Shelter – Birds need safe perches and nesting sites. Many like to find cover in a wooded area and be able to drop down into an open area for feeding. Planting a beneficial garden near the woods is ideal, as long as trees are north or west of the garden or do not cast too much shade on it. Shrub plants that form thickets in a garden can also shelter some types of birds, such as bluebirds, robins, and wrens. Evergreen plants are particularly useful as shelter for birds during the winter months.

Invertebrate Nurseries – Beneficial invertebrates need places to lay their eggs; this is called “oviposition.” Some lay their eggs in the soil and some under a plant groundcover, while others prefer plant stems, branches or leaves. Some lay their eggs on specific “host” plants on which the larvae will feed when they hatch; the monarch butterfly, for example, lays its eggs on the milkweed plant, which is devoured by the emerging caterpillars, while the black swallowtail caterpillars hatch on parsley, fennel and dill plants, munching on them during their lives as larvae.

Invertebrate Shelter - All plants, from flowers to grasses to trees, can provide habitat for beneficial animals, but, just as with humans and their shelters, there are definite preferences among insects and other arthropods. Many beetles seek shelter in dead leaves on the soil surface, while parasitic wasps and spiders find certain living plant leaves suitable places for

resting. Many invertebrate species need overwintering places for hibernation. Dried flower heads and stems of perennial plants provide important overwintering habitat.

Water—Animals need water, even if in tiny amounts. Insects and birds need an open water source with sticks, leaves, or plants for perching on to access the water. Some insects, such as butterflies, need very shallow areas for drinking, while bees need a wide wet surface so that they can sense humidity in the air. To serve the various needs, include a wide shallow water container in your garden. Muddy areas are also helpful: butterflies can sip water from mud puddles, bees and wasps can use mud in home-building, and some pollinators extract minerals from a muddy mixture of soil and water.

The more an animal's needs are met in your garden, the more likely it is to stick around and do something for you – whether it's pollinating plants, eating pests, or leaving excrement for fertilizer!

How to Build a Beneficial Garden Preparation

Step 1: Find a garden site. Look for an open sunny space that gets at least 6 hours of sun per day. The size of the garden will be dictated by the amount of sunny space available (and the amount of energy you have to build it!) – there is no minimum or maximum size. Ideally, the garden should be open to the sun in a southern or southeastern direction. You will need to keep the garden watered, so consider your water source when siting the garden.

Step 2: Find out as much as you can about the soil at your garden site: the pH, the level of organic matter, the nutrients in the soil, and whether there are any possible contaminants. The easiest way to do this is to send a sample to your local extension service. The results should tell you what is missing and what you need to add to the soil to make it healthy for an active garden.

Step 3: Work with club members to select the plants for your garden. Look over the Beneficial Garden Plant List and the Beneficial Animals Table. You can start by selecting the types of animals you want to attract to your garden and then discover which plants to grow, or you can select the plants that you want to grow and discover which beneficial animal you will attract.

Be sure that your garden can meet the plants' needs with regard to climate, soil type and moisture needs. Also consider which yields (food, tea, medicine, etc.) you would like to have from your garden.

Materials

- Plant seedlings and/or seeds
- Soil amendments as needed (per the results of your soil test)
- Cardboard and other materials for sheeting mulching (see *Instant Garden*) OR used tires (see *Tire Garden*), or non-treated wood for a raised bed
- Compost, worm castings, or finished manure
- Mulch (leaves, wood chips or straw)
- Shovels, hand trowels
- Water (hose or watering can)
- Wide, shallow water container
- Wood or metal post or other structure for a bird perch (optional)
- Wooden board and paints or laminated poster for educational sign

Select a variety of plants that bloom at different times. The plant list below contains only perennial plants (those that will flower and produce seed for two or more years), as this will ensure a long-lasting garden. Adding single-season annuals can diversify the garden each year, if you choose.

Step 4: Design the garden. Determine the garden's shape; consider a rounded keyhole bed with a small central path (see *Keyhole Garden*). Be sure that you are able to reach all parts of the garden from a pathway.

As you decide where each plant will go in the garden, think about:

- plant height and sun position– with the south sun at your back
- the small plants should be planted in front and the taller plants behind
- plant growing habits- be sure to allow for growth and spreading
- blooming distribution – spread the plants that bloom at the same time around the garden
- plant functions – include plants considered to be “nitrogen fixers,” “dynamic accumulators” and “aromatic pest confusers.” Nitrogen fixers help plants to gather useful nitrogen, dynamic accumulators pull up nutrients from deep in the soils, and aromatic pest confusers attract and confuse garden pests with their strong scent. Place them strategically around the garden.

Beneficial Garden Timeline

Winter

- * Choose the garden site
- * Design the garden

Early Spring

- * Build mulch beds

Spring

- * Purchase plants
- * Plant the garden
- * Add water container and bird perch

Summer

- * Keep plants well-watered and mulched

Fall

- * Leave debris in garden for overwintering habitat

Plan where the water container will go amongst the plants. A low spot is a good place for it; rain water can naturally drain into it.

Consider adding a bird perch. This can be a simple post, a birdbath, a trellis or a fence – any place where a bird can sit in your garden.

Step 5: Obtain the plants at a local nursery or through the internet. (See Resources section.) Try to find them as started seedlings, although some may only be available as seeds.

Step 6: Build the garden bed. The easiest way is to make a sheet mulch bed (see *Instant Garden*). You can also make a raised bed garden out of tires (see *Tire Garden*) or build a raised bed with non-treated wood. Be sure the soil you use in the garden has plenty of organic material. Include worm castings and/or compost if you can (see *Yummy Compost* and *Worm Composting*).

Step 7: Plant according to your design plan. If planting a seedling, dig a hole twice as wide as the seedling's root ball and deep enough so that the plant is set at the same depth it was in the nursery container. Be sure that the beginning of the plant stalk is even with the top of the hole. Gently break up the root ball. Fill the hole. For seeds, follow directions on the seed packet.

Step 8: Spread compost, composted manure, or other organic soil amendments around the plant. Water the plants in and mulch heavily with leaves, straw, or small wood chips.

Step 9: Find a wide, shallow container for water in the garden. Dig a hole the size of the container and set it in so that the top of the container is level with the ground. Fill it with water so that it overflows slightly and makes the ground around it damp and muddy.

Step 10: Put the bird perch in the garden.

Step 11: Make and hang a sign or poster explaining the purpose of your beneficial garden – the beneficial animals won't need it, but the humans might!

Step 12: Celebrate your beneficial garden with a grand opening or other fun celebration.

Care of the Garden

Watering

As they become established, the plants will need watering. Water daily for the first three days after planting, every other day for the next week, and then every three days for another week. Place the hose low to the ground, directing the water gently to the plant. The water will take a while to get through thick mulch, so water longer than you think you need to. Water in the early morning or evening; avoid watering in direct sunlight.

Maintenance

Keep the bed well-mulched to keep the soil moist and to prevent the return of weeds. Check the water container periodically to make sure it is full. In warmer months you may need to change the water frequently to avoid mosquitoes breeding in the container. (Mosquitoes are NOT one of the beneficial insects you are trying to attract!) As the weather cools and the plants die back, leave most of the plant debris in the garden; this provides overwintering habitat for many of the beneficials.

Do NOT use pesticides around the garden area – even organic ones. No pesticide is species-specific, so it may inadvertently kill the very critters you are trying to attract. Let nature do the pest control.

Estimated Budget

Your beneficial garden budget will depend on the size of the garden and the types of plants you want to cultivate. Seedlings typically range from \$5 to \$9 per plant. Mail-order seeds range from \$2.00 to \$4.00 per packet, and they are also sold by the pound. Small fruiting shrubs generally cost \$15 each for 1-gallon containers. Shipping costs are additional.

Other expenses may include soil amendments and garden tools. Most of the garden bed building should cost little but time and energy. Water containers, bird perches, and signs can easily be made out of materials you have lying around.

Harvesting

Don't forget that the plants have a benefit for humans! Check the plant descriptions to know when and how to harvest them.

Tips for Managing the Project

- Involve the club members in the design of the garden. Help them to explore and be amazed by the intricate plant-animal relationships. Create two poster-sized lists, one of plants, the other of animals, then guide the children to match the needs of one with the yields of another. Challenge them to come up with 25 or 30 different potential relationships in your garden.
- Start with a small-sized garden, easily manageable, with a small but diverse group of plants. You can always add more plants or features to the garden.
- Have a plan for maintaining the garden, particularly over the first summer as the plants get established.

Questions for Reflection

How does a beneficial garden represent some of the Permaculture Principles?

- How does a beneficial garden **replicate natural patterns**?
- What are some of the **multiple functions** of a beneficial garden?
- Why is it important to have **diversity** in a beneficial garden healthy?
- What are the **yields** of a beneficial garden?

Learning in the Garden

1) Keep a log of the pollinators you see. Identify them and record to which plants they were attracted.

2) Look for predator insects and invertebrates; you may need to use a magnifying glass because some are very small. Record what kind they are and where you find them. You may find some on plants and others in the debris on the ground. Try to find some in "action" – feeding on aphids or caterpillars or other garden pests.

3) Visit the beneficial garden in winter. Look for invertebrates in some of their favorite overwintering places – in dry flower heads, hollow stalks, leaf debris, or on evergreen plants.

Resources

Websites--Pollinators

- www.pollinator.org, website of the North American Pollinator Protection Campaign and the Pollinator Partnership – includes information on national efforts to protect pollinators, detailed resources on specific pollinators, and a list of pollinated foods.
- www.fs.fed.us/wildflowers/pollinators/index.shtml, US Forest Service, includes information on pollinators as well as tips on gardening to attract pollinators
- www.kidsgardening.com, National Gardening Association, provides information on planning a pollinator garden
- www.dels.nas.edu/pollinators/index.shtml, Earth and Life Studies at the National Academies, Resources on Pollinators, provides a broad range of information on pollinators, including tips for developing a pollinator garden

Websites--Other Beneficial Functions

- www.no-dig-vegetablegarden.com/index.html, No Dig Vegetable Garden provides kid-friendly information on beneficial insects and birds, and organic pest control
- www.umext.maine.edu/onlinepubs/htmlpubs/7150.htm, University of Maine Cooperative Extension, has descriptions and diagrams of common beneficial invertebrates

- www.ext.colostate.edu/pubs/insect/05550.html, Colorado State University Extension, contains descriptions and photographs of some common beneficial insects and other arthropods

Websites—Plants

- plants.usda.gov/, US Department of Agriculture, contains a listing of hundreds of plants found in the US; includes a plant profile and photograph

Sources for Obtaining Plants

- Many of the plants listed in the plant list below are fairly common sun-loving perennials or fruiting plants; they can be found at local or on-line nurseries. Other plants on the list are best found through wildflower or herb seed outlets.
- Fellow gardeners are often a great source of free or low-cost plants – ask anyone you know who grows comfrey, daylilies or yarrow to share some! Note: Some nurseries sell butterfly garden kits. While these may be convenient, remember they are designed to attract butterflies and do not necessarily provide for the needs of many other beneficials. Also, the plants may not be perennial.

Chart 1 - Beneficial Garden Plant List

The chart below contains information on perennial plants that are useful to beneficial animals as well as humans. These are just a few – there are many, many more! The list focuses on flowering plants of the herbaceous layer (generally thought of as garden flowers); a few shrubs are included, as they lend themselves to the needs of birds, but fruit or other trees are not included here. Adding trees to the north side of a garden will greatly increase the food and shelter supply for birds as well as edible pollen for insects. A list of trees can be found in the *Mini-Forest Garden* project.

The plants included here are known to thrive in most climate areas of the US (USDA Hardiness Zones 4 to 9). They do well in garden soils of 6 to 7 on the pH scale, but can generally tolerate a range, unless otherwise noted. They need soils that are medium in moisture, unless otherwise noted.

The “beneficial functions” are explained in the Background Section above. They include benefits for animals as well as for plants.

Latin Name	Common Name	Description	Needs	Flowering Time	Beneficial Function	Human Use
<i>Achillea millefolium</i>	yarrow	small white flowers, 2-3' height	full sun	June-Sept	insect nectar, oviposition for lacewings, overwintering shelter for parasitic wasps, ground beetles, spiders, foliage shelter for parasitic wasps, lacewings, and spiders, dynamic accumulator	medicine
<i>Agastache foeniculum</i>	anise hyssop	small lavender flower, anise scent, 2-4' height	full to part sun	Jul - Sept	insect nectar, oviposition foliage shelter for many invertebrates	tea, medicine
<i>Alcea rosea</i>	hollyhock	Large red, pink, white or yellow flowers, 5-7' height	full sun	Jul - Sept	insect nectar, butterfly host plant	edible greens and flowers
<i>Allium schoenoprasum</i>	chives	purple flower, grows in clumps, 6-20" height	full sun	Jun-Aug	insect nectar, dynamic accumulator	edible greens, flowers, bulb
<i>Amelanchier stolonifera</i>	running juneberry	shrub or small tree, white flowers, 8-10'	full sun	May-June	bird food, bird shelter, insect nectary	sweet edible berries
<i>Antenaria spp.</i>	pussytoes	low-growing mat, 2-10" height, small white flowers	full sun, sandy soil	Apr - June	insect nectary – foliage shelter for parasitic wasps	medicine
<i>Arabis caucasia</i>	rock cress	small white flower, 6-12" height	Full sun, dry soil	Apr- May	insect nectary	edible greens, medicine
<i>Asclepias syriaca</i>	milkweed	small pink-white flower cluster, 3-4' height	full sun	Jul - Aug	insect nectary, monarch larvae host plant	edible greens, medicine

Latin Name	Common Name	Description	Needs	Flowering Time	Beneficial Function	Human Use
<i>Bellis perennis</i>	English daisy	small white and pink flowers, ground-cover plant, 6" height	full sun to light shade	Apr-Jun	insect nectary, foliage shelter for parasitic wasps	edible greens, tea
<i>Caragana arborescens</i>	Siberian pea shrub	shrub, small yellow flowers, 8-20' height	full sun	Apr	insect and hummingbird nectar, oviposition for lacewings, foliage shelter for parasitic wasps nitrogen fixer	edible seeds (beans)
<i>Cichorium intybus</i>	chicory	blue-purple flowers, 1-4' height	full sun to light shade	June- Sept	insect nectary-, oviposition for hoverflies, winter shelter for spiders, foliage shelter for parasitic wasps, dynamic accumulator	edible greens, root as coffee substitute
<i>Claytonia virginica</i>	spring beauty	small white flower striped with pink, 3-6" height	part shade	May	insect nectar, pollen	edible greens, roots
<i>Darmera peltata</i>	Indian rhubarb	tall spikes with clusters of white or pink flowers, 12-28" height	full sun to part shade, moist soil	Apr-May	insect nectary	edible greens
<i>Echinacea purpurea</i>	Purple cone-flower	large purple flowers with prominent brown center, 3-4' height	full sun to light shade	Jun-Aug	Insect nectary, foliage shelter for parasitic wasps	tea, medicine
<i>Epilobium angustifolium</i>	fireweed	magenta flowers in spike, red stem, 4-16" height	full sun to light shade, moist soil	Jul-Sept	insect nectary, hummingbird nectary	greens, medicine

Latin Name	Common Name	Description	Needs	Flowering Time	Beneficial Function	Human Use
<i>Hemerocallis spp.</i>	daylily	large orange or yellow flowers, 2' height	full sun to part shade	June-July	hummingbird nectary	greens, roots, flowers
<i>Heracleum sphondylium</i>	cow parsnip	white flowers in rounded clusters (umbels), 4 to 10' height	full sun to part shade	Apr-Jun	insect nectary oviposition for lacewings, foliage shelter for parasitic wasps	greens, roots, culinary
<i>Lathyrus tuberosus</i>	earth-nut pea	vining plant, bright red flowers, 3-4' length	full sun to part shade	Jun-July	nectary, oviposition for lacewings, foliage for parasitic wasps, nitrogen fixer	Roots (tuber)
<i>Lobelia cardinalis</i>	cardinal flower	spikes of red flowers, 3' height	full sun to part shade, moist soil	Aug-Sept	insect nectar, hummingbird nectary	medicine
<i>Melissa officinalis</i>	lemon balm	Small white flowers, 14-24"	full sun to part shade	Jun-Sept	insect nectar, oviposition for lacewings, dynamic accumulator	culinary, tea, med
<i>Monarda spp.</i>	bee balm	Pink, red, or white tubular flowers, 3-4' height	full sun to part shade	Jun-Sept	insect nectary, hummingbird nectary, oviposition for lacewings	culinary, tea, med
<i>Passiflora incarnata</i>	maypop or passion-flower	native vining plant with tropical look, intricate purple flowers	full sun, should be trellised	Jul-Sept	hummingbird nectary, host plant for Gulf Fritillary butterfly	fruit, tea, med
<i>Potentilla anserina</i>	silver-weed	small yellow flower, low growing, 3-14"height	full sun	Jun-Aug	insect nectary, dynamic accumulator	root, tea, med

Latin Name	Common Name	Description	Needs	Flowering Time	Beneficial Function	Human Use
<i>Rubus fruticosus</i>	black-berry	white flowers, 4-7' height,	full sun	June	Insect nectar, bird food, bird shelter	fruit
<i>Salvia spp.</i>	salvia	blue or red tubular flower, 18-30" height	full sun	July-Sept	insect nectar, hummingbird nectar, host plant for several butterfly and moth species	Culinary herb, tea
<i>Scorzonera hispanica</i>	scor-zonera	yellow or white flower, 1-3' height	full sun to part shade	Jun-Sept	insect nectar, host plant for nutmeg moth	greens, roots
<i>Solidago odora</i>	sweet goldenrod	small yellow flowers growing on top side of stem, 2-4' height	full sun to part shade, dry, acid soil	Aug-Oct	insect nectar, foliage shelter for parasitic wasps and ambush bugs, aromatic pest confuser	greens, culinary herb, tea, medicine
<i>Stellaria pubera</i>	giant chickweed	small white flower, 6-12"	part shade	Apr-June	insect nectary	greens, medicine
<i>Symphytum spp.</i>	comfrey	bell-shaped white, cream, purple or pink flowers, 3' height	full sun to part shade	June-July	insect nectary, oviposition for lacewings, winter shelter for spiders, foliage shelter for parasitic wasps and spiders, dynamic accumulator	tea, medicine
<i>Trifolium pratense</i>	red clover	dark pink flowers, 6-16" height	full sun	June-July	insect nectary	edible flowers, tea, medicine
<i>Viburnum trilobum</i>	highbush cranberry	white clusters of flowers, 6-12' height	full sun	Apr - June	winter bird food, insect nectary	fruit, medicine

Chart 2 - Beneficial Animals in the Garden

Animal	Beneficial Role in the Garden	Garden Attractors	Other Info
Bats	Pollinator, pest control	Large white night-blooming flowers with strong fruity odor such as cactus flowers	Primarily as pollinators in the US southwest and tropical areas; by eating insects, bats assist with pest control
Bees	Pollinator	yellow, purple and blue flowers; small bees are attracted to small clusters of flowers	
Beetles	Pollinator	Wide-open flowers, often white or green	
Big-eyed Bugs	Feed on chinch bugs, small caterpillars, mites, insect eggs	Insect nectary plants with small flowers	Very small, black and white, silvery wings, large, bulging eyes
Birds – Bluebirds, Robins, Sparrows, Wrens	Feed on insect pests: aphids, grasshoppers, caterpillars, grubs, and beetles	Fruit trees; bushes that form thickets; bird bath; bird perch	
Butterflies	Pollinator	Red, orange, yellow, pink, blue flowers with flat tops for landing; specialized host plants for laying eggs and larvae feeding	
Damsel Bugs	Feed on aphids, small caterpillars, leafhoppers, plant bugs, and insect eggs	Insect nectary plants with small flowers	Small, long and narrow, gray, brown, or black
Ground Beetles	Feed on cutworms, armyworms, grubs, root maggots, snails and slugs	Debris, other types of hiding places	Hide during the day, feed at night
Hoverflies	Feed on aphids, scales, and caterpillars	Insect nectar plants	Look like small yellow and black striped bees but have only two wings
Hummingbirds	Pollinator	Nectary plants, particularly with red and orange tubular flowers	
Lacewings	Larvae feed on aphids, whitefly, leafhoppers, mites, mealybugs, scale insects and some moths and caterpillars.	Variety of nectars; lemon balm, bee balm, cow parsnip, yarrow for laying eggs	Green or brown color; they are called “aphid lions” because they suck dry great amounts of insects and eggs quickly
Ladybugs	Feed on aphids, scale, mealybugs and other small soft-bodied insects	Insect nectary plants with small flowers; chives, dandelions	Also called Ladybeetles or Ladybirds; there are many different colors and patterns beside the red-orange and black spots
Moths	Pollinator	Light-colored flowers that bloom at dusk	
Parasitic wasps	Adults lay eggs in a host (pest insect); the larvae hatch and feed on or in the tissue of the host	Insect nectary plants with small flowers	Tiny and black
Pirate Bugs	Feed on thrips, aphids, and spider mites, insect eggs	Insect nectary plants with small flowers	Called “minute” bugs, they are 1/8 inch long but have powerful bite
Predaceous Stink Bugs	Feed on leaf beetle larvae, caterpillars	Insect nectary plants with small flowers	Has a spike on thorax just behind the head
Spiders	Feed on a wide range of insect pests; one of the main controllers of damaging cicadas	Moist areas with vegetation, plants that provide resting places such as comfrey, hollyhock, and yarrow, spaces between plants for web-building	

**Chart 3: Eco-Service and Permaculture Connections
Beneficial Garden**

GEN Departments	Permaculture Principles
<p>Biodiversity Department A beneficial garden is made up of a diversity of plants which attract a diversity of wildlife. Because perennials return year after year, a variety of wildlife will come to count on the garden for many of its lifecycle functions. If well-maintained, a beneficial garden will dramatically increase the overall biodiversity of your school site.</p>	<p>Diversity A beneficial garden is based on diverse relationships between plants and animals and between animals themselves. Including a diversity of plants increases the diversity of relationships.</p>
<p>Food Production Department A beneficial garden specializes in food for wildlife: nectar and fruits are on the “menu” for pollinators; small insects and larvae are available for predators; specific host plants allow caterpillars to feast, and plant debris abounds for ground beetles and worms. Humans get their share, too, from a variety of edible roots, stalks, leaves, flowers, and seeds.</p>	<p>Multiple Functions A beneficial garden has many functions: 1) attracts pollinators; 2) provides pest control for garden plants; 3) provides food and shelter for animals; 4) enriches the soil; 5) yields food and medicine for humans; 6) adds beauty and interest to an outdoor area.</p>
<p>Pest and Disease Control Department Pest control is a beneficial garden’s forte. Included in the garden are plants that attract known pest predators. The predators are drawn into the garden by abundance of nectar, pollen, water, and shelter amongst plants; they – and sometimes their offspring – feast on insects and caterpillars that humans consider pests.</p>	<p>Observe and Replicate Natural Patterns Beneficial gardens highlight several patterns of relationship found in nature: the plant-pollinator relationship; the predator-prey relationship; the plant and animal food relationship; and the plant and animal shelter relationship.</p>
<p>Pollination Department A beneficial garden is a dream come true for this department! It is designed with pollinators in mind, providing nectar, pollen, water and shelter to suit a wide range of needs.</p>	<p>Obtain a Yield A beneficial garden can provide a variety of edible foods, herbs, teas, and medicines.</p>
<p>Soil Department Building a healthy garden bed adds nutrients, air flow, and organic matter to your schoolyard soils. The perennial plants in a beneficial garden are soil builders. They add organic matter and improve the capacity of the soil to hold water. Some fix nitrogen and others draw up nutrients from deep in the ground. In this enriched environment, soil critters thrive.</p>	

A Seed Ball Meadow

Description

Creating a seed ball meadow is a “wild” and fun way to turn a barren area – that ugly place on your school site where almost nothing grows -- into a richly diverse wildflower meadow. Seed balls are simply a mixture of seeds, red clay, compost and water, rolled into a tiny ball. After they harden, they are tossed randomly onto the barren ground (kids love this!) and left to germinate when it rains. In its own natural time, a meadow of wildflowers and grasses will appear, attracting pollinators and other beneficial wildlife to your school site. In among the flowers, you will also find edible and medicinal plants for humans!



Background

Seed balls are believed to have roots in ancient traditions, including Native American, Greek, and Japanese agriculture. This method of reclaiming damaged land has been popularized most recently by

Eco-Standards Check:
Biodiversity Department
Pollination Department
Soil and Recycling Department



Japanese natural farming pioneer Masanobu Fukuoka. Fukuoka used very simple methods of farming, letting nature do most of the work. Using seed balls and other Natural Farming techniques, Fukuoka was able to produce 1300 lbs. of winter grain and 22 bushels of rice on a quarter acre of land!

In nature, flowers send out their seeds and when they find the right conditions, they germinate and grow into flowering plants again. Seed balls mimic natural reproduction, but the ball of clay and compost gives the seeds a little extra boost; the ball protects the seeds from mice and birds, and it keeps them from drying out in the sun. The balls lie on the ground until there is enough rain to wet the seeds and allow them to sprout.

The very young sprouts inside the ball have predator protection as well as soil nutrients and microbes from the clay and compost needed to grow and thrive.

Fukuoka described seed balls as “a whole habitat in a tiny clay ball...a small universe in themselves.”

The seed ball method is now used in many parts of the world to reclaim land that has been damaged. It has been used successfully on desertified lands in Mexico, India, and parts of Africa, as well as on abandoned urban lots in New York City. A seed ball meadow project on your school site can reclaim a large area that has been damaged in site construction or other heavy use and turn it into an ecologically rich “wild” meadow. In time, the meadow will provide nectar for pollinators, food for birds, and shelter for many insects, reptiles, amphibians, and small mammals. (See *Beneficial Garden* for details on many of these relationships.)

How to Create a Seed Ball Meadow Preparation

Step 1: Choose a sunny area of your school site for your meadow. It can be of any size, but seed balls are considered to be a great energy-efficient tool for large, hard-to-cultivate places.

Step 2: Research the types of flowers and grasses you would like in your meadow. Try to find flowers that will bloom from spring to fall. The plant list in the *Beneficial Garden* project will give you a good starting place. Perennial species native to your area are likely to do well in the uncultivated soil and will attract native pollinators and beneficial insects. Check with your local agricultural extension agent or native plant organization to find out more about native plants; some nurseries may also be of help. You can also check the Internet for wildflower seed suppliers that custom-make native seed blends for your particular geographical region. A note of caution: choose your seed source carefully and avoid general wildflower seed mixes. Some commercial seed mixes have been known to contain seeds of plants that grow fast but are considered to be invasive in many areas.

Step 3: Find a source for the clay. Be sure it is *red or brown*; white or gray clay does not have the kind of mineral content the seeds will need for germination and growth. If you do not have a local source of that kind of clay, you can order terra cotta red clay in powder form from a pottery-making or art supply outlet.

Step 4: Gather the compost. If you are using your own “homemade” compost, spread it out in a rain-protected place to dry for a few days.

Step 5: Find a place where you can make a bit of a mess to make the seed balls.

Making the Balls

Step 6: Put the clay in a large bowl or other plastic container. Work the clay so that there are no large lumps in it.

Step 7: In a smaller container, mix the seeds well with the dry compost.

Step 8: Add the seeds and compost mix to the clay. With your hands, mix it all together so that the seeds are well-distributed.

Materials

To make approximately 100 seed balls

- 1 cup wildflower and grass seed
- 3 cups dry compost
- 5 cups red or brown clay
- 2 cups water
- 2 large bowls or plastic containers
- large pieces of cardboard
- cardboard box
- optional: string and small posts for cordoning off meadow area

Step 9: Add ½ cup water to the clay-compost-seed mix. Knead it with your hands as if making bread. Add a little more water and continue kneading. Keep adding the rest of the water gradually. You should feel the mixture get sticky, like very thick cookie dough.

Step 10: Roll the mixture into marble-sized balls, about a half inch in diameter. This recipe should yield over 100 balls. The balls should be firm, with the clay holding the structure. If the balls feel crumbly, add a little more water and work the mixture some more. (Note: If your meadow is going to be on a slope, flatten some of the balls a little so that they will stay on the hill and not roll down). Essentially, you have just “planted” hundreds of seeds!

Step 11: Lay the balls out on a large piece of cardboard. Let them dry and harden for at least 24 hours. If you are not going to toss them out immediately after that, store the balls in a cardboard box in a cool, dry place. (Do not use a plastic container as the balls could mold or sprout too soon.)

Seed Ball Meadow Timeline

Winter

- * Determine the site of your meadow.
- * Research and purchase the wildflower and grass seed.

Early Spring

- * Make the seed balls
- * Toss the balls in the meadow

Spring/Summer/Fall

- * Observe the growth of the meadow
- * Cordon the area off as the small plants take hold

Growing the Meadow

Step 12: Walk through the future meadow area, tossing the seed balls gently onto the ground. This is called “broadcasting.” Scatter the balls randomly, but try to make sure there is at least one ball per square foot. Remember, you have already “planted” the seeds, so no need to bury them in the ground. Let the balls fall where they will and let nature take its course.

Optional: If the area you are planting is a highly trafficked one on your school site, you may want to rope it off.

Step 13: Wait for the rains to come. Generally it takes three good rains for the water to soak through the clay ball and begin the germination process. (Note: Some seeds need to overwinter in the cold before they will germinate; these are better planted in the fall.)

Step 14: Observe what germinates and grows. Just as in nature, not all of the seeds will have all of the right conditions to grow – that’s why you toss out lots of balls with varieties of seeds! Walk carefully through the meadow and explore what has taken root and where during the first year.

Maintenance of the Meadow

If at all possible, ask the school grounds personnel to refrain from mowing your meadow area during the first year.

Continue to observe over the years. Meadows often take three years to be fully established. The strong plants from your seed balls will grow and reproduce on their own and eventually fill the empty gaps. Toss out more seed balls as you like.

Harvesting

Don’t forget that many of the plants have an edible or medicinal benefit for humans! (See *Beneficial Garden* plant list for more information.)

Tips for Managing the Project

- Involve the club members in researching the types of seeds appropriate for your meadow.
- To involve all of the club members directly in mixing the clay-compost-seed mixture, divide them into small groups. Have each group make a small batch of the mixture. Each group might use a different seed combination in the mixture.
- Give clear directions to the club members about how to broadcast the balls; be sure these powerful little balls are not used as weapons.

Questions for Reflection

How does a seed ball meadow represent some of the Permaculture Principles?

- How do seed balls **replicate natural patterns**?
- How do seed balls increase the **diversity** of connections on your school site?
- Why is it important to have **redundancy** in planting a meadow?
- What are some of the **multiple functions** of a seed ball meadow?
- What are the **yields** of a seed ball meadow?

Estimated Budget

If you have red or brown clay and compost on your school site, the only cost to you are the seeds. Wildflower seed costs around \$3.00 per packet or \$10.00 to \$15.00 for 1/4 pound. Native grass seed costs around \$20 per pound.

If you need to buy clay, it is available at art supply outlets for around \$5.00 per pound.

If you need to buy compost, you will need to budget an additional few dollars for organic compost.

Resources

Wesites

- Seed Ball project, www.pathtofreedom.com/pathproject/.../seedballs.shtml - gives basic information on making seed balls
- Jim Bone's Seed Ball Video, <http://www.youtube.com/watch?v=dWYduWsoy8o> – shows how to make and distribute seed balls step-by-step in reforesting an arid area; includes a portion explained by children
- Permaculture Seed Balls – The Fukuoka Method, www.youtube.com/watch?v=ptlttqU1H8Y - Masanobu Fukuoka and a Japanese team make seed balls (in Japanese language)
- Natural Farming, <http://www.permaculture.com/drupal/node/140> -- provides information on Masanobu Fukuoka and his methods of natural farming
- Wildflower Meadow Gardening, http://www.wildflower.org/clearinghouse/articles/Meadow_Gardening.pdf, provides information on wildflower meadows from the Lady Bird Johnson Wildflower Center
- Wildflower Meadows, <http://www.ladybug.uconn.edu/WildflowerMeadows.htm>, includes information on eastern wildflower species

**Chart 1: Eco-Service and Permaculture Principles
Seed Ball Meadow**

GEN Departments	Permaculture Principles
<p>Biodiversity Department By planting flowers and grasses, the biodiversity of a patch of damaged land increases in multiple ways. When the diversity of plants increases, the diversity of life in the soil increases. As the plants grow, they provide shelter for arthropods, reptiles, amphibians, and even birds and small mammals. When the plants flower, they attract pollinators to the area.</p>	<p>Diversity Damaged soil limits the diversity of species and therefore the diversity of relationships in an ecosystem. A seed ball meadow helps to re-establish plant life so that a diversity of relationships can be created naturally.</p>
<p>Food Production Department In amongst the plants of a meadow is an entire food web in action. Insects, birds, reptiles, amphibians, and small mammals can all find food there. Some of the plants can be used as human food, too. And under the soil another food web grows as the meadow grows.</p>	<p>Multiple Functions A seed ball meadow has several functions: 1) restores and enriches the soil; 2) attracts pollinators; 3) provides pest control for garden plants; 4) provides food and shelter for animals; 5) can yield food and medicine for humans; 6) adds beauty and interest to an outdoor area.</p>
<p>Pest and Disease Control Department Some plants in a wildflower meadow attract known pest predators such as parasitic wasps. The wasps are drawn to the meadow by the abundance of nectar and pollen. Some of them feast on insects and caterpillars that humans consider pests in their vegetable gardens.</p>	<p>Observe and Replicate Natural Patterns Nature disperses seeds in the wild rather randomly. Successful reproduction requires a nurturing environment where the seeds fall. Seed balls re-create in miniature a nurturing environment for seeds to grow in damaged soils.</p>
<p>Pollination Department A blooming wildflower meadow will attract a multitude of pollinators to your school site.</p>	<p>Obtain a Yield A seed ball meadow first and foremost yields rejuvenated soil. It can also provide a variety of edible foods, herbs, teas, and medicines.</p>
<p>Soil and Recycling Department Seed balls assist the Soil Department to jump-start the re-establishment of a healthy soil food web in tired soils. The balls contain soil nutrients which nurture plant life in getting a good start; as the plants grow, their roots hold down dry soil and allow oxygen and water to flow through it. This in turn helps to stimulate the microbial growth needed for a healthy underground ecosystem.</p>	<p>Redundancy In nature, plants make and disperse many, many seeds, but only a limited number actually germinate. In a seed ball meadow we also make and toss lots of seed balls, knowing that some will become mature plants and others will not</p>

Berry Garden

Description

A berry garden is a fruit-lover's delight! This garden contains a variety of plants that produce edible berries – edible by humans and by a diversity of wildlife as well. The garden features berries that can be picked and eaten right off the plant, but can also include sour-tasting berries that are typically used in sauces, jellies, and jams. A well-designed berry garden produces fruits at different times of the growing season so that there is something to munch on throughout the summer and early fall.

Background

For humans and wildlife, berries are very “accessible” fruits of flowering plants. They are small, soft, and easy to harvest. Many berries, including the ones listed in the chart below, are suitable for browsing – that is, you can walk right up to the plant, pick the fruit, and eat it. While some wild species of berries (such as blackberries) have thorns that make the fruit more difficult to pick, there are cultivated varieties of these berries that do not. Unlike many fruits, the berry plants below don't even require a ladder to access the sweet, vitamin-filled juiciness.

Berries are also “accessible” in a gardening sense; they are fairly easy to grow. They do best in full sun, but many berries can tolerate some shade. Except for blueberries (which strongly prefer acid soils), most berries do well in slightly acidic conditions but are not too particular about the pH of the soil. Compared to many fruits, berry plants yield fruit quite quickly: many produce during their second year of life, but a few actually bear in the first year. Once established, berry plants are reliably productive.



Sweet, ripe berries attract humans *and* wildlife.

Blackberries, raspberries, strawberries and the like do, however, have their needs. Most berries do best in fertile, well-drained soil with lots of organic matter, so bed preparation is an important step. When planting, it's important to think about how the plant's flowers are pollinated to produce fruit; some berry species are self-fertile, so you can plant only one of a kind and produce fruit, but others require more than one variety for pollination. Some species have a male and a female plant, and both are needed for successful pollination and fruit-production. Berries also require a bit of maintenance. A number of berry species spread through runners or canes, so they need thinning or pruning, and some do best when they are supported on trellises.

Berry Garden Connections

GEN Eco-service Departments

Food Production Department
Pollination Department
Soil Department
Biodiversity Department

Permaculture Principles

Observe and replicate natural patterns
Redundancy
Use edges
Relative location
Diversity
Multiple Functions
Obtain a Yield

Eco-Standards Checks:

Food Production Department
Pollination Department

How to Plant a Berry Garden

Building the Bed

Step 1: Find an open, sunny site for the berry garden approximately 10' x 15', or 5' x 30' if you prefer a long narrow bed. (The size and shape of the bed will depend on the space you have available on the school grounds. It is recommended that you start small and then expand if more space is available.) As noted in the chart below, several species of berries can tolerate light shade, but the garden should not be planted directly under large shade trees. If at all possible, orient the bed so that it runs east-west and its long side faces the south for maximum sun exposure.

Materials

- Shovels
- Slightly acidic soil
- Compost and/or manure
OR materials for sheet mulching (see "Instant Garden")
- Berry plants
- Water
- Mulch
- Posts and wire to support raspberries and blackberries

The space should allow for good water drainage. Consider the availability of water for irrigation of the garden, especially in the early stages as the plants are getting established. You might want to choose a site that invites members of the school community to easily browse on berries when they are fruiting. Or you may prefer a less public site, a "secret" area tucked away only for those humans and wildlife that know about the berry garden. Consider, too, how much you want to invite wildlife to partake; if you plant on the edge of a woods where deer live, you can be sure they will eat many parts of the plant, not just the fruit!

Step 2: In the fall, build a sheet mulch bed (see "Instant Garden") to clear the planting area of grasses or other weedy plants and to build new soil rich in organic matter. OR clear an area the size of your bed and till the soil to about 1 foot deep. Add lots of compost and/or composted manure and mix the soil well.

Planning the Garden

Step 3: Use the chart below to select berry plants that fit the space and shape of your garden. Focus first on the bush and cane plants, but if you have lots of room, consider including one or two of the small trees listed in the chart. Many of the trees can be pruned to keep them small and bush-like. Note: You may want to seek additional resources to find out which plants do best in your area.

Step 4: Draw a map of the garden space. Determine which direction is south, and indicate it on the map. Draw in the plants you want to put in the garden. Think about the height of the mature plants and the direction of the sun; place the plants that are shorter to the south side of the bed and the taller plants toward the north side so that sunlight coming from the south can reach all of them. Consider the width and growing habits of mature plants and space them in your drawing with that in mind. (See the sample Berry Garden diagram.) Plan in pathways to get to the plants to maintain and harvest them.

Berry Garden Timeline

Fall

- * Choose the garden site
- * Build the bed and prep the soil

Winter

- * Design the garden
- * Purchase plants

Early Spring

- * Plant
- * Water and mulch

Summer

- * Keep plants well-watered and mulched
- * Add supports (posts or trellises) as needed

Fall

- * Prune as needed

Step 5: Find out about different varieties of the same species. For example, under red raspberries you might find the Boyne, the Killarney, the Nova, the Newburgh, the Latham, the Prelude, and the Encore. Each has its unique taste, fruiting time, disease resistance, and other qualities. Consider planting several varieties to see which ones do best in your garden.

Step 6: Purchase the plants. Many nurseries carry the most common types of berries (strawberries and blueberries), but look for one that specializes in fruiting plants if possible. You can also order plants through the Internet; websites for fruit nurseries are abundant.

Planting the Garden

Step 7: Plant the berry plants in late winter (in southern areas) or early spring (in more northerly areas). The following are brief instructions for planting some of the most frequently planted types of berries. Each kind of berry requires somewhat different care, so check with the nursery where you buy the plants for specific instructions on planting and maintenance.

- **Raspberries:** Raspberries grow on long, thin canes. The canes need to be supported as they grow by posts or trellises, so they are often planted in rows. Plant red and yellow raspberry canes about three inches deep, spreading out the roots. Space the plants about 18 inches apart. Cut the canes back to ten inches above the ground. Water well and mulch around each plant.

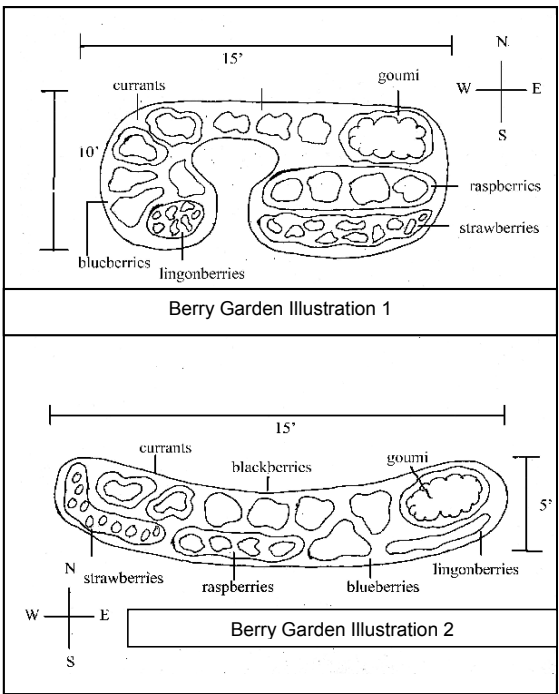
Note: Black raspberries are more like blackberries and should be planted farther apart.

- **Blackberries:** Blackberries grow on long, thin canes. The canes are often planted along walls or trellises for support and ease in pruning. Plant blackberry canes into holes to the same depth they were in the pot from the nursery, four to five feet apart. Cut the canes to where a bud is, six to ten inches above the ground. Water well and mulch around each plant.
- **Strawberries:** Strawberries are low-growing plants that spread by runners. Be sure to plant them in a bed location where they will not be shaded by larger berry plants. Dig a small hole, deep enough to submerge the roots, but keeping the stems above the ground. Spread the roots and cover firmly with soil. Set plants about 18 inches apart. Water and mulch.
- **Blueberries:** Blueberries grow on bushes. Dig a hole slightly larger than the root ball. Place the root ball in the

Estimated Budget

Young berry plants in 1-gallon containers typically cost around \$15 each. Larger, more mature plants run approximately \$30 each. If you order the plants on-line, factor in shipping costs. The approximate cost of the plants in the sample diagrams total approximately \$100.

Other expenses may include soil amendments, garden tools, and trellising materials, depending on what you plant and the resources you have at hand.



middle and pack the soil firmly around it. Plant blueberries approximately three to five feet apart. Water and mulch.

- *Currants*: Red, white, and black currants grow on bushes. For red and white currants, dig a hole the depth of the soil in the nursery container and large enough to allow the roots to spread out. For black currants, dig the hole two inches deeper than the plant was in the nursery container. Fill in the hole firmly with soil. Trim to within two buds (6 to 10 inches) above soil level to encourage root development. Water and mulch. Plant bushes three to four feet apart.

Maintenance and Harvesting

Berry plants generally grow easily, but to encourage maximum fruit production, there is a bit of maintenance involved. The cane plants need to be trained on supports and pruned. During the first year of strawberries, it is recommended that the flowers be pinched off to improve the following year's crop. Blueberries and currants do best when they are pruned. It is recommended that you find out the best maintenance practices for the species and particular varieties you have planted. Nurseries where you purchase the plants are generally the best sources for specific instructions, and there is abundant information available through the resources below.

In general, it is important to keep the berry garden soil fertile and evenly watered. Add compost and finished manures on an annual basis. Keep the soil well-mulched to maintain moisture and to keep the weeds away.

With some care and patience, you will have an abundance of fruit in your berry garden. You'll need to decide how much you'd like to share with the wildlife – particularly the birds! If you want to keep most for humans, you may need to put a net over the berry plants when they are fruiting.

Tips for Managing the Project

- Be aware that the berry garden has an extended timeline. In most climates, you'll need to build the garden bed in the fall and plant in the spring.
- Involve the club members in selecting the garden site and developing the planting plan. Since it will likely take a few years for the berry garden to actually yield fruit, the immediate excitement and learning is in exploring the different kinds of berries, envisioning the garden in full fruition, figuring out which berries to plant and where to plant them.
- Be sure to have all of the materials on the site when you are ready to build the bed.
- Have the club members work in teams to plant, trim the plants (if indicated), water, and mulch.

Questions for Reflection

What are the Permaculture Principles illustrated in the Berry Garden?

- How does a berry garden **replicate natural patterns**? Why is **redundancy** important in food-producing gardens?
- How does a berry garden **use edges**?
- Why is it important to consider **relative location** when planning a berry garden?

Learning in the Garden

- 1) When the plants are in flower, observe which pollinators are attracted to each of the berry plants.
- 2) When the berries are fruiting, observe bird behavior. Learn more about the relationship of birds, berries, and seeds in the wild.
- 3) Research the nutritional value of the berries you have planted in the garden.

- How does a berry garden contribute to **diversity** on your school site?
- What are the **multiple functions** of a keyhole bed?
- What is your **yield**?

Resources

Your state and local Cooperative Extension Service can be an excellent resource for finding out what grows well in your area.

Local nurseries that carry fruiting plants are also an important resource.

Books

- *The Backyard Berry Book: A Hands-On Guide to Growing Berries, Brambles, and Vine Fruit in the Home Garden*, by Stella Otto
- *The Berry Grower's Companion*, by Barbara Bowling
- *Successful Berry Growing*, by Gene Logsdon

Websites

- Growing Berries, http://gardening.about.com/od/berries/Growing_Berries.htm - provides links to more in-depth articles on growing berries
- Growing Raspberries and Blackberries, <http://www.umext.maine.edu/onlinepubs/htmlpubs/2066.htm>
- Peaceful Valley Farm and Garden Supply, Growing Berries Organically, www.groworganic.com – information about growing blackberries, raspberries and currants
- Useful Plants Nursery, www.usefulplants.org – Plant list has detailed information about many berry plants.
- Berries Category Archive, www.harvestwizard.com/berries - Photos and botanical information about many types of berries

Chart 1: Plants for a Berry Garden

The chart below lists potential plants for a school site berry garden. These plants were selected for ease of harvesting: they are fairly low-growing, the fruits are readily edible (though a few require cooking), and they have no or few thorns. The “Hardiness Zone” column indicates the USDA Zones where the plant is generally considered to do best, but note that altitude, humidity, amount of daily sunlight, and soil conditions can also affect plant hardiness. The Pollination column indicates whether a single plant can produce fruit (self-pollinating), or if two varieties are needed to cross-pollinate.

Latin Name	Common Name	Hardiness Zone	Height	Pollination	Months Bearing Fruit	Other Info
<i>Rubus idaeus</i>	Red raspberry	3-9	4-6 feet	self-pollinating	Aug - Oct	Newburgh and Latham varieties have few thorns; need supporting structure (trellis, etc.) and pruning to produce fruit
<i>Rubus occidentalis</i>	Black raspberry	4-8	3-6 feet	self-pollinating	Jul-Aug	Fast-growing; need supporting structure and pruning
<i>Rubus fruticosus</i>	Blackberry	6-8	4-7 feet	self-pollinating	Jul-Aug	Thornless varieties are available; need supporting structure and pruning
<i>Gaylussacia baccata</i>	Black Huckleberry	3-8	3 feet	cross-pollinating	Jul-Aug	Like a small blueberry
<i>Vaccinium corymbosum</i>	Highbush Blueberry	4-8	4-12"	self-pollinating	June-Aug	Needs strongly acidic soil
<i>Vaccinium ashei</i>	Rabbiteye blueberry	7-8	6-18"	self-pollinating	June-Aug	Needs acidic soil; heat-loving
<i>Ribes rubrum</i>	Red currant	3-8	3-5'	self-pollinating	June-Aug	Quick-growing, hardy
<i>Fragaria x ananassa</i>	Strawberry	3-10	6-12"	self-pollinating	May/Jun through Aug/Sep	June-bearing produce fruit once in summer; ever-bearing often produce in late spring and again in fall
<i>Vaccinium macrocarpon</i>	Cranberry	3-8	6"	self-pollinating	Oct	Tart, usually eaten cooked; prefers some shade
<i>Vaccinium vitis-idaea</i>	Lingonberry	4-7	8-12"	self-pollinating	Aug-Oct	Tart, usually eaten cooked; prefers acid soil
<i>Amelanchier stolonifera</i>	Running juneberry	4-8	4-6'	self-pollinating	June	Shrub; produces sweet berries
<i>Amelanchier alnifolia</i>	Saskatoon or Western Serviceberry	2-8	5-15'	self-pollinating	July	Small tree; does well in part shade
<i>Amelanchier laevis</i>	Allegheny Serviceberry	4-7	6-15'	self-pollinating	June-July	Small tree or shrub; does well in part shade
<i>Sambucus canadensis</i>	Elderberry	3-10	6-12'	cross-pollinating	Aug – Sept	Small tree or shrub; small, highly nutritious berry
<i>Eleagnus multiflora</i>	Goumi	5-8	6-8'	cross-pollinating	July-Aug	Can tolerate shade; fixes nitrogen
<i>Morus spp</i>	Mulberry	5-9	35-50'	Some self-pollinate, others cross-pollinate	May-July	Tree, can be pruned to large shrub size

**Chart 2: Eco-Service and Permaculture Connections
Berry Garden**

GEN Departments	Permaculture Principles
<p>Biodiversity Department A berry garden bed may contain a diversity of shrubs, canes, low-growing plants, and possibly even trees. The flowers of these plants attract a diversity of pollinating insects, and healthy soil fosters a wide diversity of insects, worms, arthropods, fungi, and micro-organisms.</p>	<p>Multiple Functions A berry garden: 1) produces fruit for humans; 2) produces food for wildlife; 3) attracts pollinators; 4) increases the diversity of plants and animals on the school site; 5) improves soil; 6) is beautiful, especially during months of flowering and fruiting.</p>
<p>Food Production Department Once it begins to bear fruit, a berry garden is a source of summer and fall food abundance for humans and wildlife, especially birds. Mature berry plants typically bear enough fruit for humans and birds to share. Some berry plants have leaves that are used in medicinal teas.</p>	<p>Observe and Replicate Natural Patterns Wild berry plants are an important source of food in natural settings. They are often found in forests and on the edges of clearings.</p>
<p>Pollination Department Berry plants put out an abundance of flowers, attracting pollinators to the garden. Berries are good illustrations of different pollination strategies: some plants are self-pollinating, others need the pollen of another plant (cross-pollination), and some berry species have male and female plants, both of which are needed for successful pollination.</p>	<p>Relative Location Designing the berry garden means thinking through the location of the garden with regard to the sun, a water source, wildlife, and the school community. It also means thinking about where each berry plant will go in relation to another.</p>
<p>Soil Department A productive berry garden benefits from soil that is rich in organic matter. Building a berry garden bed with the sheet mulch method actually creates new soil. A few berry plants are known to fix nitrogen, such as the lingonberry, or accumulate minerals from deep in the soil, such as the strawberry.</p>	<p>Redundancy Berry gardens typically have multiple plants of the same species. If one plant fails to produce, there are other plants to provide fruit for humans and wildlife.</p>
	<p>Obtain a Yield A berry garden “yields” fruits for humans and wildlife.</p> <p>Use Edges Berry plants can tolerate some shade, so they are excellent plants to have on the edge of a wooded area. Some berry plants need to be trellised, so they can be planted along fences or walls.</p>

Edible Water Garden

Description

An edible water garden is a small pond that features edible aquatic plants. This kind of garden provides an important source of water for your schoolyard ecosystem, attracting insects, amphibians, birds, and maybe even mammals. A water garden provides habitat and nourishment for small aquatic wildlife, and at the same time can provide nutritious food for humans. Water gardens, large or small, add beauty and interest to your schoolyard.

Water gardens range in size, placement, and materials. Some are full multi-level ponds with a variety of plants, while others are simply small basins with some floating aquatic plants. Many are dug into the ground, but a water garden can also be above-ground – in a kiddie pool, an old bathtub, or other container.

The How To section below describes three different ways to build an edible water garden.

Background

Aquatic plants naturally grow at different levels of a pond.

Emergent aquatic plants start completely underwater, but they grow up above the water line. Some root deep down, while others root in more shallow areas. Water chestnuts, for example, do well in shallow water, while the water lotus can root two feet down. **Floating plants** simply float on the top of the pond without attaching to soil; duckweed and water mimosa are examples of these. **Emergent floaters** can float completely, but they can also root themselves into soil below water.



An above-ground edible water garden.

Edible Water Garden Connections

GEN Eco-service Departments:

Food Production Department
Water Purification Department
Pollination Department
Biodiversity Department

Permaculture Principles

Observe and replicate natural patterns
Use edges
Diversity
Multiple Functions
Catch and store energy
Obtain a Yield

Eco-Standards Checks:

Water Purification Department
Food Production Department
Pollination Department
Biodiversity Department

Watercress and water celery are in this category. Many emergent floaters are able to take up excess nutrients in the water for their own growth; for this reason they are often used as biological water purifiers. **Edge or marginal plants** grow on the wet banks of an in-ground pond or in pots that sit with their bottoms in shallow water. These are plants that “like their feet wet.” Ostrich ferns (fiddleheads) are an example of this. Finally, **submerged aquatic plants**, stay completely underwater; they help the aquatic system by using up dissolved nutrients in the water. Coontails and whorled-leaved water milfoil are examples of edible submerged plants.

While not all water gardens can accommodate all of the different types of plants, it is helpful to include as many of the above levels as possible. This means digging the pond so that it has steps or shelves on the sides, or placing various-sized flat rocks on which to set plants at their appropriate levels. Note: If you include a very, very shallow

area (less than ¼ inch deep) on the edge of the pond you can attract butterflies; they can't swim or hover over the water, but they are drawn to drink in pond edges, often called butterfly licks.

Aquatic gardening is generally easy --at least you don't have to water or weed the plants! There are, however, a few things to watch out for. One is the growth of algae; too much algae can deplete oxygen supplies in the water. One way to control this is to make sure that 60 percent of the pond's surface is covered with other plant vegetation; this will shade out the algae. Make sure that the pond does not contain a lot of decaying organic matter; this is food for algae. The submerged aquatic plants can help with filtering water, and water snails can also help to keep algae in balance. Note: A healthy, balanced plant and animal ecosystem will keep oxygen plentifully available in pond water. However, since a water garden is an artificial environment, some form of aeration (a pump or fountain) may be necessary.

Another issue with ponds is mosquitoes; they like to breed in stagnant water. Small fish, such as gambusia, and tadpoles will feed on mosquito larvae, so adding them into your system periodically can help a lot. There are also organic mosquito killers available through aquatic garden supply businesses.

One more thing to consider is winter hardiness. Plants that are native to your area should be able to tolerate the winter, but those that are from warmer climates than yours will need to be brought inside during the colder months.

Finally, be sure to maintain your aquatic plants in population balance. Some of species in the recommended list are quite hardy, and, under the right conditions, can overtake other species. Be sure that the plants remain in your water garden and do not spread into a natural water source, such as a creek, lake, or river; they may be fine in your maintained system, growing in contained pots, but they can upset the ecological balance of a natural waterway.

How to Build an Edible Water Garden

Preparation

Step 1: Find a site for the water garden. It should be in a flat place that gets full sun to part shade. Try to find a site somewhat away from trees to avoid a lot of leaves and seeds dropping into the pond. Be sure that the site is close enough to a source of water to be able to fill the pond and add to it periodically, if necessary.

Step 2: Develop a pond design. Consider the materials you have to use (see Building the Water Garden below), the space, and the aquatic levels you want to include. Develop a planting plan; you can choose aquatic edibles from the chart below. You might also include non-edible pond plants. (There are many websites with aquatic plant lists or consult a nursery or pond supply store.) Try to select a variety of plants that live at different aquatic levels. Consider the climate in which you live and whether you want to include warm weather plants; these often add to the beauty of a pond but can involve more maintenance in the winter.

Materials

- Edible aquatic plants in pots (see chart below)
- Running water source with hose
- Pea gravel
- Flat rocks (for plant shelves and edges)
- Water test kit
 - Hard-shelled kiddie pool
 - OR
 - Used carpet (available from carpet stores), plastic sheeting (6 mil thickness), carpet cutters, and shovels
 - OR
 - Wide, fairly shallow containers that will hold water, such as basins, animal feed troughs, or old bathtubs

Building the Water Garden

Step 3-a: The Kiddie Pool Pond

Hard-shelled kiddie pools provide a simple and inexpensive way to line a pond. Dig a hole to the size and depth of the pool and fit the pool in to create a below-ground pond. Place varying sized flat rocks in the pool to create shelves for the plants to sit on at different levels. Note: You may find that small mammals will come to the pool for water. Be sure that they have a way to get back out; rocks placed close to the pool edges can help with this.

Step 3-b: The Carpet Sandwich Pond

Carpet sandwich ponds use plastic liners, but because the carpet provides protection from punctures, the liner does not have to be the very heavy, very expensive kind typically sold in pond supply stores. The other benefit to carpet sandwiches is that they take thrown away carpet out of the solid waste stream and reuse this valuable resource.

1. Dig a hole 18 inches to 2 feet deep and 8 to 10 feet across. Try to incorporate curves and bulges in the shape; perfect roundness does not occur in nature, and the extra ins and outs create more "edge" – that is, transition zones that include both aquatic and terrestrial life. Include a shallow side of the pond for amphibians to hop in and out, and a very shallow part for butterflies to access.
2. Around the sides of the pond, build in several steps at different levels to form plant shelves. Place a layer of carpet, knap side UP, on the bottom. Place other pieces of carpet knap side up to cover the sides of the pond; be sure that the pieces overlap with each other so that there are no gaps in the lining. The carpet and plastic should extend over the edge of the pond by approximately 2 feet. (This provides for "shrinkage;" when the pond is filled, the wet carpet will be pulled down toward the bottom, leaving only a small stretch of carpet above ground on your pond edge.) This is the bottom slice of bread in the sandwich.
3. Place the plastic liner over the carpet. This is the cheese slice in the sandwich.
4. Cover the whole thing again with more old carpet, knap side DOWN. This is the top slice of bread.

Step 3-c: Above-Ground Container Water Gardens

You can make above-ground water gardens from just about any type of container that will hold water. Large plastic basins, kiddie pools, animal feed troughs, whiskey barrels, and old bathtubs can all be used. (Note: Some materials, such as galvanized metal, can be toxic to fish.) Water gardens have been created successfully on apartment balconies, so if you don't have much space, even a series of buckets can serve to cultivate aquatic edibles. Place flat rocks of varying sizes around the bottom of the container to serve as shelves.

Step 4: Fill the garden with water. Observe to make sure there are no leaks. For the carpet sandwich pond, allow the materials to settle for at least a week. Then cut off the *lower* carpet and plastic to just beyond the edge of the pond, but allow the top carpet layer to extend 6 inches over the edge. Weight the carpet with rocks.

Water Garden Timeline

Winter

- * Design the water garden

Spring

- * Build the pond

Late Spring

- * Introduce plants
- * Add small fish or organic mosquito controls

Summer

- * Maintain consistent water levels
- * Monitor plant growth

Late Fall

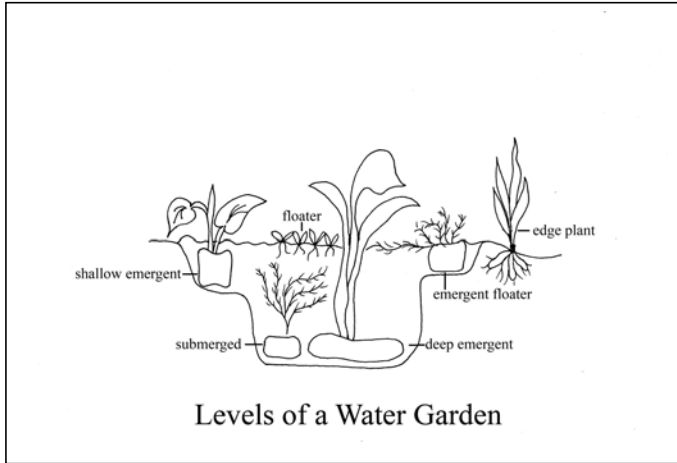
- * Cut off dead or dying leaves
- * Place winter hardy plants at bottom of pond
- * Bring indoors plants that are not cold-hardy

Spring

- * Clean out pond debris
- * Return plants to their original positions in the pond

Spring-Early Fall

- * Repot and harvest plants



Step 5: Place rocks to form a sort of dam along the edge of the pond where rain water is most likely to overflow the pond. The rocks will help to trap some of the floating plants that are not anchored to the pond bottom in the event of a heavy rain.

Step 6: Place the plants at the appropriate aquatic level. Most pond plants are grown in wide, shallow pots. Put a light layer of pea gravel on the top of the soil in each pot to keep the soil

from dissolving into the water. Note: If you are using chlorinated water to fill the pond, wait at least a week before introducing plants to allow the chlorine to evaporate.

Step 7: For in-ground ponds, plant moisture-loving plants around the edges directly into the soil. Leave room for pathways to reach the pond. Consider placing flat stones or small benches around the edges for sitting.

For above-ground ponds, plant plants around the outside edge of the pond. Be sure that they will grow tall enough to obscure the plastic or metal container, giving the pond a more natural look. Leave pathways to get to the container for observation and for maintenance. (If the container is aesthetically pleasing, you may prefer to skip this step.)

Water Garden Maintenance

Observe to make sure the water garden system is functioning and in balance. Make sure the water level remains steady; ideally, rain water will replenish the pond, but in dry times you will need to add water from a local water source. Some aquatic edibles will not produce if the water levels vary too much.

Watch for any signs that oxygen might be lacking in the water. This would include excessive algae growth, lots of plant decay, or fish die-off.

Periodically test the water for pH; it should stay in the 6.5 to 9 range on the pH scale. If you have fish in the pond, test nitrogen levels and dissolved oxygen. Simple test kits are available from pond supply stores.

Clean out debris that falls into the water garden periodically. This is especially important in the fall, after a storm, or in windy weather. Remove dead or dying leaves from the aquatic plants in the pond.

In warm weather, watch for mosquito larvae. Add mosquito-eating fish or organic mosquito controls.

Estimated Budget

The budget for a water garden will depend on the size of the pond, the materials you use, and the "extras" you choose add. (You can literally spend hundreds of dollars at a pond supply store, but you don't have to!) Salvaged materials, such as old carpet, a bathtub, or animal troughs can help reduce costs.

Here are some general figures:

- * Kiddie pool - \$25
- * Roll of plastic sheeting (for carpet sandwich) - \$25
- * Plants - \$7 and \$10 per container.
- * Water test kit - \$15

In the winter, cut off any of the yellow or brown leaves on the plants. For those that are winter hardy, place them at the bottom of the pond so that the roots don't freeze. Bring indoors any tropical or expensive plants you don't want to risk damaging from the cold. In early spring, return the plants to the pond after danger of frost is past.

Repot plants as they outgrow their containers. Add organic fertilizers to the soil in the pot; it's important to remember that this limited soil provides all the nutrients the plant gets. Many water gardeners routinely repot once a year.

Harvesting Aquatic Plants

Leaf crops are generally cut above the water surface. Their flavors are milder during the cooler seasons and are generally much tastier before the plant flowers. Root crops are typically divided as the plant is repotted. However, each plant has its own "preferred" method for harvesting, so when you order the plants, inquire as to best harvesting methods.

Tips for Managing the Project

- Involve the club members in the water garden design. They should consider the site space, materials available, the pond shape, the types of plants they want to plant, and, of course, the budget. Club members can also work together to develop a planting plan that identifies edible plants that live at a variety of aquatic levels.
- Be sure to have all of the materials and tools on site when you build the water garden.
- If you are digging a pond, be sure you have plenty of time and people-power. Have club members rotate so that everyone has a chance to "dig in", and no one gets too tired.
- Celebrate when you are finished!

Questions for Reflection

How does an edible water garden represent some of the Permaculture Principles?

- How does a water garden **replicate natural patterns**?
- How does a water garden **use edges**?
- How does **diversity** help keep a water garden healthy?
- What are some of the **multiple functions** of an edible water garden?
- How does a water garden **catch and store energy**?
- What is your **yield**?

Learning in the Garden

- 1) Keep a log of the wildlife that inhabit your water garden. What kinds of insects and amphibians do you see? Is there any evidence that mammals are visiting the garden?
- 2) Use a microscope to examine the tiny aquatic critters that are in the water. Find out what their relationship is to aquatic plants.
- 3) Watch the growth of each aquatic plant. Observe the relationships between the plants. Look for signs that a particular plant is overtaking the ecosystem. Learn more about why that plant thrives. Learn more about why some plants are considered "invasive."
- 4) Prepare a meal using the harvests of your water garden.

Resources

Books

- *Low-maintenance Water Gardens*, by Helen Nash and Steve Stroupe
- *Plants for Water Gardens: The Complete Guide to Aquatic Plants*, by Helen Nash
- *Edible Water Gardens: Growing Water Plants for Food and Profit*, by Nick Romanowski
- *Perennial Vegetables*, by Eric Toensmeier – contains a section on aquatic gardening

Websites

- Water Gardens, http://www.aquanic.org/publicat/usda_rac/efs/srac/435fs.pdf, contains detailed information on constructing and maintaining a healthy water garden.
- Water Garden, <http://watergarden.com/index.php>, has helpful sections on potting and dividing plants for harvest; also an on-line store
- Container Water Gardens, http://www.all-water-gardens.com/containers_steps.html, provides step-by-step how to's on creating container water gardens
- Information on aquatic plants, http://www.greenharvest.com.au/Plants/waterplant_info.html
- Robyn's Aquatic Plant Information, <http://www.fishpondinfo.com/plants/plant3.htm>, has an extensive list of edible aquatic plants, plus a potting and repotting information table
- Incredibly Edible Aquatics, <http://www.akca.org/library/edible.htm>, with information on how to cook some aquatic edibles
- Edible Pond and Bog, Plants for a Future, www.pfaf.org/leaflets/edibpond.php, contains information on many aquatic edibles.

Plant Sources

There are a myriad of on-line sources for aquatic plants, many of which are edible. Some nurseries and most pond supply stores will also carry some of the common aquatic edibles. (Aquatic vegetables seem to be much more common than most other perennial vegetables.)

Chart 1 - Plants for an Edible Water Garden

Latin Name	Common Name	Sun Needs	Aquatic Level	Edible Parts
<i>Sagittaria Latifolia</i>	Arrowhead	Full sun	Deep emergent (6 inches to 2 feet)	Tubers, cooked like potatoes, have a nutty flavor
<i>Sagittaria graminea</i>	Chinese arrowhead	Full sun	Deep emergent (6 inches to 2 feet)	Tubers, cooked like potatoes, have a nutty flavor
<i>Nelumbo nucifera</i>	Water lotus	Full sun	Deep emergent (1-2 feet)	Roots are eaten boiled. Young leaves are eaten cooked. (Note: they are toxic if eaten raw.) Seeds taste like chestnuts and eaten just before they harden.
<i>Colocasia spp.</i>	Taro	Full sun to part shade/	Shallow emergent (3- 4 inches)	Sweet starchy root, leaves (must be cooked)
<i>Trapa natans</i>	Water Chestnut		Shallow emergent (3-4 inches)	Corms are sweet and crisp
<i>Mentha aquatica</i>	Water mint	Full sun to shade	Shallow emergent (up to 3 inches)	Leaves are eaten, raw or dried; mild mint flavor
<i>Pondertertia cordata</i>	Pickereel rush	Full sun	Shallow emergent (2 to 12 inches)	Tender leaves and seeds are eaten, raw or cooked
<i>Nasturtium officinale</i>	Watercress	Sun to part shade	Emergent floater or edge plant	Leaves used fresh or in cooking; high in Vitamins A, B & C, iron and calcium
<i>Oenanthe javanica</i>	Water celery	Full sun to part shade	Emergent floater or edge plant	Leaves are used fresh in salads or cooked
<i>Neptunia oleracea</i>	Water mimosa	Full sun to part shade	Floater	Leaves have a cabbage flavor, eaten raw or cooked
<i>Lemna minor</i>	Duckweed	Full sun to part shade	Floater	Leaves are eaten raw, often as a garnish on salad
<i>Cornus canadensis</i>	Creeping dogwood	Shade	Edge plant, low creeper	Fruit has a mild, pleasant flavor
<i>Peltandra alba and p. virginica</i>	White arrow arum and green arrow arum	Full sun to light shade	Edge plant	Roots are edible, but must be well-cooked
<i>Typha spp</i>	Cattail	Full sun to part shade	Edge plant	Root can be eaten raw, cooked, or dried and ground into flour. Shoots are eaten like asparagus; stem of mature plants can be eaten raw or cooked. Seeds can be roasted or pressed into oil. The pollen is an excellent source of protein. Flowering spikes can be cooked.
<i>Ceratophyllum demersum</i>	Coontail		Submerged	Good food for wildlife; provides habitat for micro- and macroinvertebrates
<i>Myriophyllum verticillatum</i>	Whorl-leaved water milfoil		Submerged	Good food for wildlife; provides habitat for micro- and macro-invertebrates
<i>Potamogeton pectinatus</i>	Sago pondweed		Submerged	Good food for wildlife; provides habitat for micro- and macro-invertebrates

**Chart 2: Eco-Service and Permaculture Connections
Edible Water Garden**

GEN Departments	Permaculture Principles
<p>Biodiversity Department As a source of drinking water, a water garden can attract a wide variety of wildlife to a school site.</p>	<p>Catch and Store Energy A pond catches and stores the energy of rainwater.</p>
<p>Food Production Department Water gardens provide sources of nourishment for a variety of small wildlife, especially amphibians and insects as well as microscopic organisms. And they provide food for humans!</p>	<p>Diversity A well-functioning pond system relies on a diversity of plants at different aquatic levels.</p>
<p>Pollination Department A water garden can be an important water source for pollinating insects. Pollinators may also be drawn to some of the flowering aquatic plants.</p>	<p>Multiple Functions An edible water garden: 1) provides a water source for wildlife; 2) provides habitat for aquatic wildlife ; 3) yields food for humans; 4) adds beauty and interest to an outdoor area.</p>
<p>Water Purification Department Many aquatic plants act as biological filters in water systems, taking up excess nutrients from decaying organic material in the water.</p>	<p>Observe and Replicate Natural Patterns By including plants that live at different aquatic levels, water gardens mimic natural aquatic systems.</p>
	<p>Obtain a Yield An edible water garden can provide a variety of leaf, stalk, root and seed edibles.</p>
	<p>Use Edges The edges of ponds literally “hop” with activity; the edge is where many amphibians and insects hang out. There are also many plants that prefer to live on the edge, in very shallow water. By designing a pond with lots of curves, you can create more edge.</p>

Perennial Vegetable Garden

Description

While most vegetable gardens require re-seeding every year, a perennial vegetable garden contains edible plants that produce for many years. The garden contains plants with a variety

of edible parts: roots, shoots, stalks, leaves, flowers, and seeds. Temperate perennial vegetables have a variety of sun needs; unlike most annual vegetables, some perennials are quite shade tolerant. A few of the recommended plants, such as asparagus and dandelions, are well-known, but many are less common in the United States, so cultivating this kind of garden is an exciting way to experiment with delicious but little-known foods. Once established, the perennial garden requires minimal care, and it keeps on “giving” year after year

Background

Perennial vegetables have many advantages and benefits.

- They require **minimal human energy**. Once planted, most perennials will grow and yield for many years to come (as opposed to annuals, which must be replanted each year).
- They are **low-maintenance**. Perennials are generally hardy plants and, once established, need little watering and weeding; in fact, some people claim that certain perennials thrive on neglect! Typically, perennials have deep roots which help them find water. They also tend to leaf out earlier than annuals, and their leaf canopies help suppress the growth of weeds.

Perennials, Annuals, and Biennials, – what’s the difference?

Perennials are plants that flower and produce seed for two or more seasons. Many garden perennials die back to the ground each winter, but grow again in the spring. Some perennials remain above ground and are able to tolerate winter frosts. Some perennials only live for a few years, while others can live for a long, long time.

Annuals are plants that germinate, grow, flower, set seed, and die in one growing season. Some annuals are called “hardy” because their seeds overwinter and self-sow, and the plant germinates in the spring.

Biennials are plants that complete their lifecycle in two years. They germinate and produce a cluster of leaves and overwinter in that form; the next year they flower, set seed, and die.

• The y are **soil-builders**. Each year, when annuals are planted, the soil is tilled and the intricate soil food web is disturbed. Perennials are only planted once in a great while, so the soil is disturbed less frequently. And, as long-time “residents”, perennial plants actually add to the organic matter and water-holding capacity of the soil through the decomposition of their roots and leaves.

• The y play a long-term **role in the ecosystem**. Annuals are kind of like travelers in a garden ecosystem – they come and go; perennials, on the other hand, are long-term residents in a garden and can be “counted on” by many life forms for habitat, food, and water storage.

Perennial Vegetable Garden Connections

▲ GEN Eco-service Departments
 Food Production Department
 Soil Department
 Pollination Department
 Pest Control Department
 Biodiversity Department
 Water Department

Permaculture Principles
 Observe and replicate natural patterns
 Multiple Functions
 Catch and store energy
 Obtain a Yield
 See *Chart 2* for more information on CONNECTIONS

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Eco-Standards Checks:

Food Production Department
Pollination Department
Biodiversity Department
Soil and Recycling Department

- They **extend the harvest season**. Since they are already in the ground, perennials have a “head-start” on the traditional annual vegetables planted in the spring; when the annuals are just tiny seedlings, perennial shoots are often growing strong or even ready to harvest.



- They have **multiple functions**. In addition to building organic matter in soil, many perennials actually fix nitrogen or have the capacity to accumulate nutrients from deep in the soil (called “dynamic accumulators”). Some perennials attract pollinators or help with pest control. Other perennials help modify climate by providing shade. Perennial vegetables can be a source of food for humans and for wildlife. And, of course, perennial plants can be simply beautiful!

Perennial vegetables may have a few disadvantages worthy of noting. Some of them take a few years to actually get going to produce an edible. On the other hand, some can become so prolific they will need to be actively contained. It may be, too, that children with less adventurous palettes won’t jump up and down about the taste of some of the vegetables; many of the plants that are hardy in cold climates have strong, rather unfamiliar flavors. (But tastes can be cultivated, too!)

How to Build a Perennial Vegetable Garden

Preparation

Step 1: With club members, select the perennial vegetables you’d like to grow. Chart 1 shows a variety of plants known to do well in most moderately cold temperature climates. This includes areas of the eastern, Midwest, and mountain west of the United States, corresponding with the USDA hardiness zones 4 to 7. You can find further information about plants adapted to warm and humid climates, dry climates, and very cold climates through the resources included below.



As you select the plants, match the plants’ needs to what your potential garden site has to offer. Consider space, sunlight, water drainage, and soil quality. Also consider including a variety of plants that yield different types of edibles; see if you can find plants that have edible roots, shoots, stalks, leaves, fruits, flowers, and seeds to your liking.

Step 2: Purchase the plants. Seedlings are recommended so that club members can see the “fruits” of their labor within a school year, but seeds are fine if that is what is available. Note: The children may or may not actually get a harvest in the first year, but it is important that they see the garden take shape.

Your local nursery will likely not have many perennial vegetables, so expect to make purchases through mail order. This may take a little time and effort; the nurseries and seed companies that stock perennial vegetables are generally small businesses. Some sources are listed below.

Step 3: Find a garden site that has the kind of sun exposure the selected plants need, as well as access to water.

Step 4: Find out as much as you can about the soil at your garden site: the pH, the level of organic matter, the nutrients in the soil, and whether there are any possible contaminants. The easiest way to do this is to send a sample to your local extension service. The results should tell you what is missing and what you need to add to the soil to make it healthy for an active garden.

Step 5: Prepare the bed. You can till up the soil, or make a sheet mulch bed (see “Instant Garden”), or build a raised bed. Any of these will work, just make sure that soil is loosened to allow air flow in the soil. Note: Compaction can be a big problem on school sites. Adding plenty of compost and other organic material can help with that.

Step 6: Be sure that all of the perennial weeds are removed from the soil. If left, they will grow as vigorously as the vegetables – or more! Heavy sheet-mulching (see “Instant Garden”) is the easiest way to do this; by covering with cardboard and lots of mulch, the weeds will die off. You can also hand-pull to remove the whole plant, but be sure to include the roots.

Step 7: Develop a planting plan. Be sure to allow enough space for the plants to grow and not crowd each other out. It is important to remember: these are “long-term” garden residents, so plan for their mature size. Taller plants should be placed to the north side of the bed where they won’t block the southern sun from reaching the shorter plants.

Step 8: Plant! If planting a seedling, dig a hole twice as wide as the seedling’s root ball and deep enough so that the plant is set at the same depth it was in the nursery container. Be sure that the beginning of the plant stalk is even with the top of the hole. Gently break up the root ball. Fill the hole. For seeds, follow directions on the seed packet.

Step 9: Spread compost, composted manure, or other organic soil amendments around the plant. Note: While some people recommend adding amendments directly into the planting hole, others recommend that soil amendments or compost go on the soil surface only. The idea here is that too much rich soil around the roots encourages the roots to stay in the hole and not spread out beyond.

Step 10: Water the plants in and mulch heavily.

Step 11: Celebrate your new perennial garden!

Perennial Vegetable Garden Timeline
<u>Fall</u> *Choose your garden site * Build the bed and prep the soil
<u>Winter</u> *Select plants and design the garden arrangement * Research availability of the plants
<u>Late Winter/Early Spring</u> * Purchase the plants
<u>Spring</u> * Plant * Water and mulch
<u>Summer</u> * Keep plants well-watered and mulched *Weed as necessary

Care of the Garden

Watering - As they become established, the plants will need watering. Water daily for the first three days after planting, every other day for the next week, and then every three days for

another week. Place the hose low to the ground, directing the water gently to the plant. The water will take a while to get through thick mulch, so water longer than you think you need to. Water in the early morning or evening; avoid watering in direct sunlight.

Maintenance - Keep the bed well-mulched to keep the soil moist and to prevent the return of weeds. As the plants grow, you may need to trellis some of the vine plants. You may also need to "hill up" some of the root crops by piling earth on them. And you might want to prune back some of those that grow very vigorously.

Harvesting - Check the plant descriptions to know when and how to harvest. For some of the plants you will harvest the vegetables but keep the plant intact, so it's important to use proper harvesting techniques. Some root crops that grow in colonies, such as sunchoke, can be harvested by pulling up what you want and leaving the rest. For other root crops you will need to pull up the whole plant select the roots you'll eat, and put the remaining roots back in the ground to grow a plant again.

Estimated Budget

Your perennial garden budget will depend on the size of the garden and the types of plants you want to cultivate. Mail-order seeds generally range from \$3.00 to \$5.00 per packet. Bulbs range from \$2 to \$7 each. Seedlings vary widely, but are generally from \$7 to \$10 per plant. Shipping costs are additional.

Other expenses may include soil amendments and garden tools, but most of the garden bed prep should cost little but time and energy.

Tips for Managing the Project

- Since perennial vegetables are very unusual, plant selection is as big a part of the project as the physical bed-building. Involve your club members in researching a variety of plants. Work with them to choose a few that work best for your site and tastes. Make this part exciting by emphasizing that they are "pioneers" in a little-known field – their perennial edible bed may be the only one like it for many, many miles around!
- Whenever possible, involve club members in the many other aspects of the project: site selection, plant purchase, bed preparation, development of the planting plan, actual planting, watering, mulching, and ongoing maintenance.

Questions for Reflection

What are the advantages of a perennial vegetable garden? How does it differ from an annual vegetable garden?

- What are the Permaculture Principles illustrated in a perennial edible garden?
- How does a perennial garden **replicate natural patterns**?
- What are the **multiple functions** of a perennial edible garden?
- How does a perennial garden **catch and store energy**?
- What is your **yield**?

Resources

Books

- *Perennial Vegetables*, by Eric Toensmeier, is an easy-to-read guide to perennial vegetable gardening; includes over 100 profiles of perennial vegetables for a range of US climates as well as some recipes.
- *Plants for a Future: Edible and Useful Plants for a Healthier World*, by Ken Fern, is a guide to temperate climate perennials.

Websites

Organizations with information about perennial vegetables

- Plants for a Future, www.pfaf.org. Plants For A Future is a British resource center for rare and unusual plants, particularly those which have edible, medicinal or other uses. The website includes a database of over 7,000 useful plants, including perennial vegetables.
- Edible Plant Project, www.edibleplantproject.com. The Edible Plant Project is a not-for-profit, volunteer-based group working to promote edible landscaping and local food abundance in North Central Florida.

Plant and Seed Sources/ On-line Catalogs that include perennial vegetables

- Bountiful Gardens, www.bountifulgardens.org – supplier of heirloom seeds; includes a small perennial vegetable starter kit under “collections” section
- Fedco Seeds, www.fedcoseeds.com – a source for edible tubers
- Heronswood Nursery, www.heronswood.com – supplier of plants; on-line catalog lists perennial plants alphabetically
- J.L. Hudson Seeds, www.jlHUDSONseeds.net – a public access seed bank; catalog lists plants alphabetically
- Perennial Pleasures, www.perennialpleasures.net – supplies young plant “starts” and seed; on-line catalog
- Rich Farm Garden, www.richfarmgarden.com – supplies plants and seeds; catalog includes some perennial vegetables
- Seed Savers Exchange, www.seedsavers.org - “Miscellaneous” section has rare perennials
- Southern Exposure Seed Exchange, www.southernexposure.com – supplier of seeds specializing in species for the hot, humid South and mid-Atlantic region; on-line catalog
- Tripple Brook Farm, www.tripplebrookfarm.com - specializes in cold-hardy plants; includes an extensive alphabetical plant index
- Van Engelen Inc., www.vanengelen.com – specializes in bulbs; includes on-line bulb index
- Victory Seeds, www.victoryseeds.com – supplies rare and heirloom seeds; plant list includes some perennial vegetables

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Field Code Changed

CHART 1: Some Perennial Edibles for Moderately Cold Temperate Climates (USDA Zones 4 to 7)

Note: The plants below are listed alphabetically by their Latin names. Plants often have multiple common names, but the Latin name is recognized universally. The Latin name, therefore, is important to know if you are doing further research or for ordering plants for purchase.

Latin Name	Common Plant Name	Edible Parts	Sun Needs	Soil/ Water Needs	Size/ Growing Habits	Other Information
<i>Allium cepa proliferum</i>	Walking Onion	bulb, leaves	Full sun	Moist, well-drained soil	The stalks develop new bulbs on the ends; they fall over with and replant themselves	Leave plenty of room --these are vigorous and appear to "walk" all over the garden
<i>Allium tricoccum</i>	Ramps/ Wild Leeks	bulb, leaves	Part to full shade	Moist to wet soil	6-12 inches high; grow in clumps; spread in colonies	A native plant important in Appalachian culture.
<i>Apios americana</i>	Ground-nut	Tubers used like a potato	Sun to part shade	Moist to wet soil	vines grow 4 to 8 ft long	Need to be trellised or allow plenty of room to sprawl on ground
<i>Asparagus officinalis</i>	Asparagus	Tender young shoots	Full sun	Moist, well-drained soil	Clumping plant; mature plant looks like a fern	Wait until second year to harvest
<i>Bunias orientalis</i>	Turkish rocket	Leaves, cooked as greens have a pungent flavor	Sun to part shade	Moist, well-drained soil	Clumping plant, with multiple broccoli-like heads; can spread several feet	Very hardy, not easy to remove once it's planted
<i>Chenopodium bonus-henricus</i>	Good King Henry	Shoots, leaves, flowers, seeds	Sun to part shade	Moist, well-drained soil	Clumping plant, grows like spinach	Should be eaten cooked (contains oxalic acid, which is destroyed by heat). Seeds are cooked as a grain but must be soaked overnight to remove mildly toxic saponins.
<i>Cicorium intybus</i>	Chicory, Italian Dandelion	Leaves Roots	Full sun	Moist, well-drained soil	Clumping plant, blue flowers on tall stalks	There are many varieties of chicory; some are annuals or biennials. Leaves are tastiest prior to flowering. Roots can be baked, ground and consumed as a hot beverage.
<i>Crambe maritima</i>	Sea Kale	Shoots, leaves, flowers	Sun to part shade	Moist, well-drained soil	Clumping plant, grows to 3 ft high, 3 feet wide	Shoots are used like asparagus; they are often hidden under pots or mulch to "blanch."
<i>Helianthus tuberosus</i>	Sunchoke, Jerusalem artichoke	Tubers	Full sun to light shade	Moist, well-drained soil	Can grow as high as 12 ft., spread to form colonies	Though a native plant, it can overtake a garden; can be hard to get rid of once planted

Latin Name	Common Plant Name	Edible Parts	Sun Needs	Soil/ Water Needs	Size/ Growing Habits	Other Information
<i>Hemerocallis</i> spp.	Daylily	Flower buds, tubers	Sun to part shade	Moist, well-drained soil	Tubers run and spread; flower generally grows 2-3 feet high	Buds are eaten like green beans; flowers are used in salads or battered and fried; tubers are cooked like potatoes but can cause flatulence.
<i>Levisticum officinale</i>	Lovage	Leaves and stalks	Sun to part shade	Moist, well-drained soil	Clumping plant, can grow to 6 feet tall	Very early spring greens with hollow, celery-like stalk; flowers attract beneficial insects
<i>Malva moschata</i>	Musk Mallow	Leaves, flowers	Sun to part shade	Moist, well-drained soil	Clumping plant with pink or white flowers	Leaves are mucilaginous
<i>Matteuccia struthiopteris</i>	Ostrich fern	Shoots (fiddle-heads)	Part to full shade	Moist to wet soil	Large fern grows up to 6 feet; spreads to form large colonies	Tender spring shoots are eaten boiled, steamed, and pickled.
<i>Oenanthe javanica</i>	Water Celery	Leaves and stalks	Sun to part shade	Aquatic to moist soil	Grows 2-4 ft high; spreads to form dense colonies	Eaten raw in salads or cooked. Needs to be controlled, can overtake a garden.
<i>Polygonatum biflorum</i> var. <i>commutatum</i>	Giant Solomon's Seal	Shoots	Sun to shade	Moist, well-drained soil	Can grow up to 7 feet; grows in clumps but sends runners to form colonies	Has beautiful white flowers; shoots taste like asparagus. Small black berries are NOT edible.
<i>Rumex acetosa</i>	French or Garden Sorrel	Leaves	Sun to part shade	Acidic soil	Lance-shaped leaves; flower spikes can grow to 4 ft high	Sorrels are soil builders, accumulating minerals from deep down
<i>Sium sisarum</i>	Skirret	Roots	Sun to part shade	Moist, well-drained soil	Clumping plant, grows to 4 ft high	Flowers look like Queen Anne's lace, are attractors of beneficial insects; roots are sweet
<i>Stachys affinis</i>	Chinese artichoke	Tubers	Full sun to light shade	Rich, well-drained soil	Running plant forming a groundcover carpet 12 to 18 inches high	1-2 inch white tubers have crisp texture, mildly sweet flavor
<i>Taraxacum officinale</i>	Dandelion	Leaves, flowers	Full sun	Moist, well-drained soil	Clumping plant, grows 1 to 2 ft high in cultivation	Harvest leaves before plant flowers. Harvest flowers before they go to seed; flowers can be eaten in fritters

Comment [kss1]: Some of other common names are more descriptive.

**Chart 2: Eco-Service and Permaculture Connections
Perennial Vegetable Garden**

GEN Departments	Permaculture Principles
<p>Biodiversity Department A perennial vegetable garden introduces a diverse array of edible species to your school yard.</p>	<p>Catch and Store Energy Plants “catch” sunlight and store it as energy in the various edible parts of their bodies. Plants also catch the energy of water; their roots help to keep moisture in the soil.</p>
<p>Food Production Department A perennial vegetable bed can provide food for humans and for wildlife.</p>	<p>Observe and Replicate Natural Patterns Stable natural environments, such as a meadow or forest, rely on perennial plants. These plants may die back or go dormant over the winter, but they come back to play their ecosystem roles each spring.</p>
<p>Pest Control Department Some of the perennial plants attract beneficial insects and others are “aromatic pest confusers.”</p>	<p>Multiple Functions A perennial vegetable bed: 1) builds organically rich soil; 2) contains plants that attract pollinators and beneficial insects; 3) provides food for humans and wildlife; 4) can be beautiful.</p>
<p>Pollination Department Some of the flowering plants in the perennial bed are attractive to pollinators.</p>	<p>Observe and Replicate Natural Patterns Stable natural environments, such as a meadow or forest, rely on perennial plants. These plants may die back or go dormant over the winter, but they come back to play their ecosystem roles each spring.</p>
<p>Soil Department The creation of a garden bed adds nutrients, air flow, and organic matter to typically damaged, compacted schoolyard soils. In addition, perennial plants are soil builders. They add organic matter and improve the capacity of the soil to hold water. Some fix nitrogen and others draw up from deep in the ground.</p>	
<p>Water Department The roots of perennial plants help hold water in the soil. Once established, they need less active watering than annual plants.</p>	

Mini-Forest Garden

Description

A forest garden is just as its name suggests: a forest and a garden. A forest garden mimics the structure and function of a natural forest ecosystem, with intricate interrelationships of plants and wildlife. At the same time it is a garden, designed by humans to yield useful “goodies” for humans, too!

A mature forest garden looks more like a park than a dense forest; the tree canopy is light, and there can be many open areas, allowing sunlight in for abundant flowering and fruiting. Within a forest garden you will typically find seven layers of plants: 1) tall trees that form a light canopy, often edible nut trees; 2) shorter fruit trees that are the understory trees; 3) berry bushes and other shrubs; 4) perennial vegetables, herbs and flowers, forming the herbaceous layer; 5) ground cover plants; 6) the root layer under the ground; and 7) vines that sprawl or climb.

The “mini” forest garden described below is a small demonstration of the concepts of forest gardening. With time, interest, and a bigger budget, the mini-garden can certainly be expanded.

Background

Plants in a forest garden are “perennial polycultures of multipurpose plants.” (Ask the children to say that quickly, three times!) Here’s what we mean by that.

Perennial: Perennials are plants that flower and produce seeds for two or more seasons; in other words, when we plant them, we expect them to live for a while. Most plants in a natural forest are perennials. There are many ecological advantages to planting perennials in a garden, as compared to annuals; see Perennial Vegetable Garden for details.

Polyculture: A polyculture is a group of diverse plant species that are interconnected in beneficial ways. The interconnections themselves are widely diverse. Here are some examples of plant relationships within a polyculture:

- a vine uses a tree trunk to support its upward growth;
- a tree provides shade for a shade-loving plant;
- a low-growing ground cover plant shades the soil, keeping it from drying out and/or eroding, as well as possibly preventing an “invasive” plant from taking hold;
- a *nitrogen-fixing plant* does chemical “magic” at its roots, providing useable nitrogen not only for itself but for its plant neighbors, too;
- a *dynamic accumulator* plant reaches its roots deep into the soil and brings up important nutrients that its neighbors can also use;
- an *aromatic pest confuser* plant produces a strong scent that attracts and confuses insect pests, stopping them from finding and eating other garden plants.

Mini Forest Garden Connections

GEN Eco-service Departments

Food Production Department
Pollination Department
Soil Department
Biodiversity Department
Pest and Disease Control Department
Air Cleaning Department

Permaculture Principles

Observe and replicate natural patterns
Multiple Functions
Relative location
Diversity
Catch and Store Energy
Obtain a Yield

Eco-Standards Checks:

Food Production Department
Pollination Department
Biodiversity Department
Soil and Recycling Department

Multipurpose: Some gardeners view their plants with one specific function in mind: an apple tree produces apples for the gardener, for example. But a forest gardener sees each plant as having many functions that benefit the whole garden, thus benefitting the gardener as well. Every plant in a designed forest garden has at least three functions, and often many more. An apple tree: 1) attracts pollinators with its blossoms; 2) draws potassium from very deep in the soil up through its roots and distributes it through its falling leaves; 3) provides branches for birds to perch and, through their excrement, add phosphorus to the soil; 4) provides shade for shade-loving plants; 5) holds the soil with its roots; and, of course, 6) produces apples. And that's not to mention that an apple tree can be a home to many kinds of wildlife, it can provide a source of wood if needed, AND it's simply beautiful in a landscape.



With such intricate “perennial polycultures of multipurpose plants” as its base, a forest garden takes a bit of planning before you begin the planting! It is important to look closely at the existing landscape – the shape and the chemistry of the land – and see what it offers. You’ll need to look, too, at the broader environment -- the sun, the water, the wind, the human uses of the land -- and consider how your new forest garden ecosystem will fit in. Then you can begin to consider which plants to choose, focusing on what each plant needs and what each can give to the little ecosystem you are developing. All of this is called forest garden “design.” Design takes some time, close observation, knowledge, and lots of creativity, but it is not hard, and there are plenty of resources available!

Just as a forest changes over time, a forest garden also undergoes changes. When you first plant your garden, the trees will be very small, and it may look rather bare and not particularly forest-like. Sun-loving plants will thrive in the open light. But be assured that the trees will grow, and as they cast larger and larger umbrellas of shade, the understory plants will change, too. Some will die out, while others will spread vigorously away from the trees, seeking sunlight. This is a natural pattern

occurring in all forests. In this way, a forest garden is quite unlike most other gardens, following the ecological principle of “succession,” and dynamically changing over time.

How to Create a Mini-Forest Garden

Designing the Garden

Step 1: Choose a site for your Forest Garden. Consider the following factors.

- Size: Trees need a certain amount of spacing in order to grow well and be productive; some species also need more than one of their kind in order for pollination to occur. The size of your site may limit how many and which types of trees you can plant. In order to include nut and fruit trees, you will need a space at least 1,200 square feet (30 feet x 40 feet). If such a large clear area is not available, you may not be able to include the canopy layer in your forest garden, but you can still plant a rich orchard with many of the understory layers. In order to include fruit trees, it is recommended that the site be at least 400 (20 x 20) square feet in area.

Note: If your school has a wooded area, you might include those trees as the canopy layer of the forest garden; site the garden to the south or east of the wooded area. (See Sunlight section below.)

- Sunlight: Many forest garden plants need at least 6 hours of sunlight per day during the growing season, so look for a clear, sunny area on your school site. Since the sun in the northern hemisphere shines from a southern direction, any buildings or wooded area should be to the north or west side of the garden; that way, the morning and early afternoon sun is not blocked.
- Water: Eventually, a forest garden will be sustained simply by the rain that it receives, but in the beginning it is important to water young plants. Be sure that you have a water source in or near the garden.
- Topography and Microclimate: While it is easiest to create gardens on flat ground, fruit trees can actually do quite well on slopes. Look for a site that is flat or gently sloping. Avoid any very wet areas and where rain water might flow or pool. Think about whether the site might be particularly vulnerable to heat or cold. Find out where the winds come from and whether they might affect growing fruit trees.
- School Land Use and Travel Patterns: Find out as much as you can about how the school uses the land. Think about where children walk or bicycle on the school grounds, where children play outdoors, where classes might gather outdoors, whether the school has any plans for expansion, etc. Consider how you will work with these other land uses and still protect the growing plants in the garden. Consider, too, how you can make the garden an inviting, accessible place for the school community.

Step 2: Get to know the soil on your site. Use the activities in the Soil Department Module to take a soil profile, test the soil pH, and determine how much organic matter is in the soil.

Step 3: Choose plant polycultures for your garden. Consider your area's hardiness zone, what the plants need to thrive, the amount of space you have, your budget, and your club members' tastes and interests.

Note that many fruiting plants need more than one variety in order to achieve pollination, so you will need to plan for at least two trees. If you are planting a sweet cherry tree, for example, you will need to plant at least one other sweet cherry, but with a different sub-name. This is because the blossoms must be fertilized by the pollen of a slightly different kind. A few species have male and female plants, so you'll need

Materials

- Large paper, pencils for design work
- Materials for sheet mulching - See "Instant Garden"
- Tape measure
- Grass clipper
- Surveyor's marking flags, wooden stakes or stones
- Shovels
- Garden hose and water
- Fruit and nut tree, berry, and other seedlings (per your design)
- Deer protectors for trees and/or supporting stakes (if needed)

Mini- Forest Garden Timeline

Fall

- * Choose the garden site

Winter

- * Design the garden
- * Purchase plants

Early Spring

- * Plant trees
- * Build mulch beds

Spring

- * Plant understory
- * Water

Summer

- * Keep plants well-watered and mulched

Fall

- * Add additional features

Late Winter/Early Spring

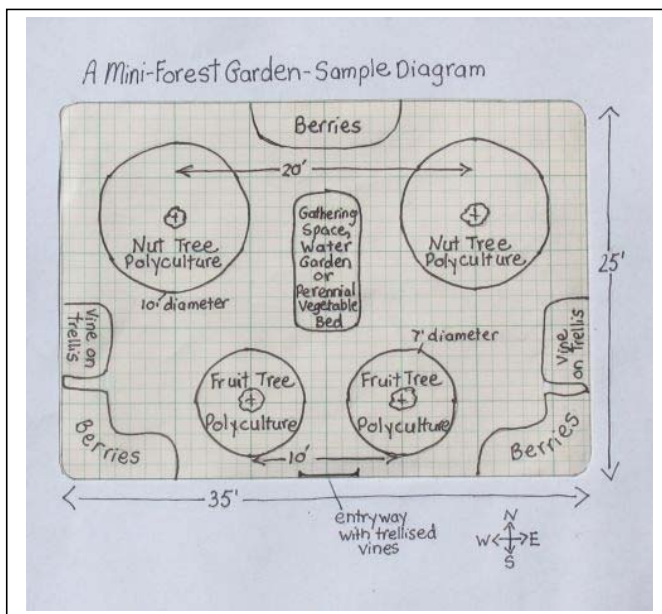
- * Prune trees

to make sure you get one of each. When you go to purchase the trees, the nursery staff can help you with this.

The charts below include a variety of forest garden plants that do well in USDA hardiness zones 4 to 7, considered to be moderately cold temperature climates. (You can find information about plants that do well in semi-tropical climates, dry climates, and very cold climates through the resources included below.)

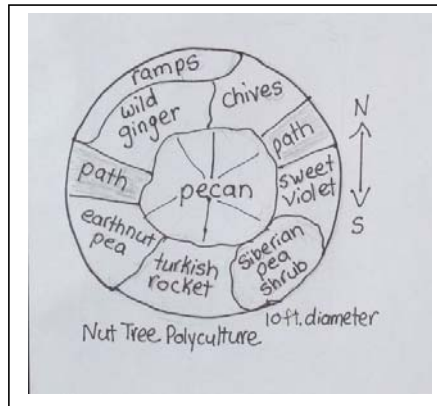
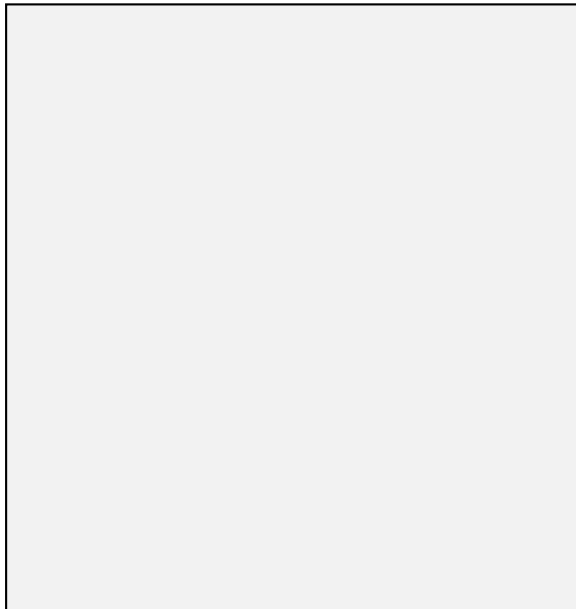
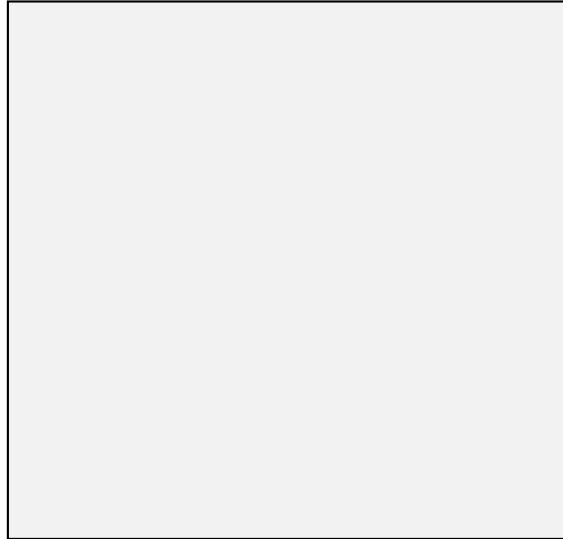
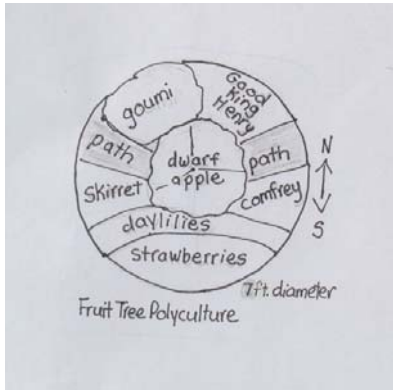
It is recommended that you consult with a nursery or a local cooperative extension agent to find out which plants work well on your site.

Step 4: Draw a map of the garden space. Determine which direction is south, and indicate it on the map. Draw in the plants you want to put in the garden. Remember that you are designing “perennial polycultures of multipurpose plants,” so think about the relationships between the plants and how each plant can serve a variety of functions. Try to include plants from each of the seven layers of a forest garden (but don’t worry if you don’t get them all!). Plan in pathways to get to the plants to maintain and harvest them. The Mini Forest Garden Diagrams below provide an example of two polycultures centered around fruit trees.



Mini-Forest Garden – The diagram above shows a design for a forest garden in an area 25 feet wide by 35 feet long. The garden is oriented so that most of the fruiting plants receive the southern sun. The design includes the 7 forest garden layers: 1) nut trees will one day form the canopy; 2) two fruit trees are the understory tree layer; 3) berries and nitrogen-fixing shrubs make up the shrub layer; 4) a variety of perennial vegetables and medicinal plants under the trees form the herbaceous layer; 5) several groundcovers are included under the trees; 6) root crops are also included under the trees; and 7) vines are trellised along garden borders. Until the nut trees mature, the area in the center may be used for an additional garden bed or water garden; or it can be used as a space for groups to gather to view the garden.

Step 5: Purchase the plants. Many nurseries carry the most common types of fruit trees and berries. A wider variety of plants can be found by ordering through nurseries on-line. Dwarf varieties of fruit trees work well for small sites – and they produce fruit sooner!. Be sure to get planting instructions for each plant.



Planting the Garden

The following are steps for the “quick and easy” sheet mulch method of planting a mini forest garden.

Step 6: Prepare the planting area by cutting back any growing grasses and weeds; leave the cut grasses, small weeds, and any leaves on the ground. Clear away stones or other hard debris.

Step 7: Using the plan you developed, mark the approximate place where the trees will go in the garden. Be sure that the fruit trees are placed 8 to 10 feet apart; nut trees should be spaced 20 to 30 feet apart.

Step 8: To plant a fruit tree, mark out a 7-foot diameter circle where a fruit tree polyculture will go. You can use small surveyor’s flags (available at hardware stores), wood stakes, or stones. Mark the space for planting the tree in the middle of the circle as illustrated in the Mini Forest Garden Diagram below. Plant the tree as indicated by the nursery where you purchased it, adding organic soil amendments as needed to neutralize pH or supply lacking nutrients. To plant a nut tree, mark out a 10-foot diameter circle, then plant the tree in the middle.

Step 9: Water the trees in. Then wet down the areas in the circles around them; allow the ground to become thoroughly soaked.

Step 9a: If you live in an area where there are deer, you will need to put cages or fencing around the young trees to keep the deer from munching on them. You may also need to provide a stake or some other support for some young fruit trees.

Step 10: Follow the steps for an “Instant Garden,” building a rounded sheet mulch bed around each tree, as shown in the diagram. Push away the mulch above the cardboard to clear two small pathways from the circle perimeter to the tree.

Step 11: To plant the other plants in the polyculture, follow the “Instant Garden” steps for planting seedlings.

Step 12: Water thoroughly.

Step 13: Create additional sheet mulch beds along the southern and eastern borders of the forest garden site as space allows. Plant berries and other sun-loving plants into these beds.

Adding Other Features

Once you have your 7 layers of plants in, you may want to add other additional features to the garden. These may include:

- fencing - this can serve to protect plants while doubling as a trellis for berries or vines
- pathways mulched with wood chips
- a designated entryway – arching trellises with vines can make attractive entryways

Estimated Budget

Fruit and nut trees can range from \$8 for a small bare-root seedling to \$45 for a more established tree in a 7-gallon container. Berry plants range from \$15 to \$30 per container. Other shrubs, vines, and herb layer plants also range in cost depending on how well-established the plant is; a general average is approximately \$10 per plant. If you order the plants on-line, factor in shipping costs.

The approximate cost of the plants in the sample diagrams total approximately \$275 if you buy the plants from a nursery. Many gardeners, however, love to share their plants. Look for those opportunities!

Other expenses may include soil amendments, garden tools, and trellising materials, wood chips, deer protection guards, and fencing.

- a compost pile
- bird perches
- a small pond or bird bath as a water source for wildlife
- brush piles, rock mounds, or other niches for small critters
- small pieces of art

Maintenance of Your Forest Garden

Basic organic gardening maintenance rules apply to forest gardens: keep the soil moist, rich in organic matter, and well-mulched!

Forest gardens also require some ongoing and very specific maintenance, especially for fruiting plants. Many fruit trees and some berry plants require pruning, especially during their first three years in the garden. Vining plants and some berries will need to be supported on trellises or other structures. Some fruit trees are prone to fungus or insect diseases and may require an organic dormant oil spray. Many trees need to be protected from deer, and some young trees need protection from rodents. Find out the best organic maintenance practices for the species and particular varieties you have planted. Nurseries where you purchase the plants often recommend particular maintenance strategies; a local cooperative extension agent can also be of great help, and books, videos, and websites abound with information on organic backyard fruit production. (See Resources section below.)

It will take some time and care, but eventually your forest garden will bear its gifts – gorgeous spring blossoms, fresh fruits, greens, herbs, edible roots, and nuts, niches for wildlife, and the satisfaction that you have regenerated a rich ecosystem on your school site.

Tips for Managing the Project

- Forest gardening takes some knowledge of fruit-growing – or a willingness to learn through trial and error! If you are not familiar with fruit-growing techniques in your area, find someone in the community who has that background and is willing to serve as your consultant. A local farmer, horticulturalist, nursery owner, or cooperative extension agent may be happy to put in their two cents.
- Thinking through the design is a big part of creating a forest garden. If your group is receptive, have club members work in groups to brainstorm creative designs. Take your time with this step and make it fun. If your group does not have patience for this, use the sample diagram and modify it to fit your hardiness zone. For example, if apples don't grow well in your area, substitute a small fruit tree that does.
- Be sure to have all materials and tools on hand on planting day(s).
- When you plant, divide club members into four groups; have each group plant a mulch bed.
- Be clear with your club members that parts of a forest garden have a long timeframe for yielding results. It may be three or four years before a fruit tree bears its fruit, and twenty years before a nut is ever seen in the garden. Yet the garden will certainly grow, so help the children tune in to subtle changes and celebrate each one!

Questions for Reflection

What are the Permaculture Principles illustrated in a Mini Forest Garden?

- How does a forest garden **replicate natural patterns**?
What are the **multiple functions** of a fruit tree? a nut tree? an aromatic herb? a mulch bed? a fencepost or trellis?

- How **relative location** of plants help support a polyculture?
- How does a polyculture use **diversity**?
- How does a forest garden **catch and store energy**? (Hint: Think sunlight!)
- What is your **yield** from a forest garden? Think beyond fruit!

Resources

Your state and local Cooperative Extension Service can be an excellent resource for finding out what grows well in your area. Be sure to ask for information on organic gardening methods.

Local nurseries that carry fruiting plants are also an important resource.

Books

- Edible Forest Gardens, Volume I and II, by Dave Jacke and Eric Toensmeier – the most comprehensive exploration of vision, theory, design, and practice of forest gardens available; contains extensive plant lists for all hardiness zones in the U.S. and Canada
- How to Make a Forest Garden, by Patrick Whitfield - includes a discussion of the reasons for forest gardening and how they function ecologically, as well as practical “how to” information
- Gaia’s Garden, A Guide to Home-Scale Permaculture, by Toby Hemenway – an easy-to-read guide to forest gardens, mulch beds, and many other permaculture techniques.
- Plants for a Future, Edible and Useful Plants for a Healthier World, by Ken Fern – provides information on characteristics and growing requirements of trees, shrubs, plants for shade, perennial vegetables, shrubs, and ground covers
- The Back Yard Orchardist, by Stella Otto – provides extensive information on fruit-growing
- The Apple Grower, a Guide for the Organic Orchardist, by Michael Phillips – includes methods for growing fruit trees organically
- Uncommon Fruits for Every Garden, by Lee Reich – features lesser known hardy fruits that can be grown in a forest garden, including pawpaw, persimmon, jujube, currants, gooseberries, hardy kiwi, medlar, and asian pear.

Websites

- Edible Forest Gardens, www.edibleforestgardens.com – an overview of forest gardening, including the ecology of a food forest, design, and practice
- The Fruit Tree Planting Foundation, www.ftpf.org/resources.htm - provides information on planting, pruning, and other maintenance of fruit trees. This organization also has a “Fruit Tree 101” School Grant Program, funding efforts to plant fruit trees on school grounds; see www.ftpf.org/fruittree101.htm for a program description.
- Growing Fruit Trees, http://extension.unh.edu/resources/representation/Resource000585_Rep607.pdf - from the University of New Hampshire Cooperative Extension Service, gives basic information on planting and maintaining fruit trees
- Fruit Trees, www.eartheasy.com/grow_fruit_tree.htm - provides information on selection and planting of fruit trees, pruning and basic maintenance.
- Home Nut Tree Plan, <http://www.utextension.utk.edu/publications/spfiles/SP307-P.pdf>, provides information on growing edible nut trees.

Plant Charts

The following charts contain a list of plants that are known to work well in forest garden polycultures in moderately cold North American climates (primarily USDA Zones 4 to 7). The charts show selected plants for the tall tree, understory tree, shrub, ground cover, and vine layers. Please see the charts for Perennial Vegetables and the Herb Spiral for suggested plants for the herbaceous and root layers.

These lists are by no means exhaustive – there are thousands of plants to choose from!

Chart 1 – Plants for the Tall Tree Layer

Latin Name	Common Name	Hardi-ness Zone	Forest Garden Function	Pollination	Other Info
<i>Castanea dentata</i>	American Chestnut	4-7	attracts pollinators; wildlife food and shelter; edible nuts		
<i>Castanea mollissima</i>	Chinese Chestnut	5-7	attracts pollinators; strong wood; edible nuts	Needs cross-pollination – plant 2 different varieties	Prefers acid soil
<i>Robinia pseudoacacia</i>	Black locust	3-8	light shade, nitrogen-fixer, attracts pollinators, excellent hard wood		
<i>Gleditsia triacanthos</i>	Honey locust	4-9	light shade, nitrogen-fixer, attracts pollinators; edible pods		
<i>Carya illoensis</i>	Pecan	6-9	light shade; dynamic accumulator; wildlife food; edible nut	Needs cross-pollination- plant 2 different varieties	
<i>Carya ovata</i>	Shagbark hickory	4-7	dynamic accumulator; wildlife food and shelter; edible nut		
<i>Juglans ailantifolia cordiformis</i>	Heartnut	5-8	dynamic accumulator; attracts pollinators; edible nut		
<i>Diospyros virginiana</i>	American persimmon	5-9	attracts pollinators; wildlife food; edible fruit and seed	Male and female plants; must plant both for fruit production	Fast-growing
<i>Quercus alba</i>	White oak	4-8	dynamic accumulator; attracts pollinators; wildlife food and shelter; edible nut		
<i>Quercus macrocarpa</i>	Bur oak	2-8	attracts pollinators, wildlife food; edible nut		
<i>Tilia x vulgaris</i>	Linden	4-8	dynamic accumulator; attracts pollinators; edible leaves		
<i>Morus spp.</i>	Mulberry	4-8	wildlife food and shelter; edible fruit	Self-fertile	Can be shade tree or pruned to be an understory shrub

Chart 2 – Plants for the Understory Tree Layer

Latin Name	Common Name	Hardi-ness Zone	Forest Garden Function	Pollination	Other Info
<i>Malus pumila</i>	Dwarf apple	4-9	dynamic accumulator; attracts pollinators; edible fruit	Most need cross-pollination; plant 2 different varieties	
<i>Prunus persica</i>	Dwarf peach	5-9	attracts pollinators; wildlife food and shelter; edible fruit	Self-fertile, only one is needed	
<i>Prunus avium</i>	Sweet cherry (dwarf or semi-dwarf)	5-9	attracts pollinators; food for birds; edible fruit	Need cross-pollination; plant 2 varieties	
<i>Prunus cerasus</i>	Sour cherry (dwarf)	4-8	attracts pollinators; food for birds; edible fruit		
<i>Prunus americana</i>	American plum	3-8	attracts pollinators; food for birds; edible fruit	Needs cross-pollination; plant 2 varieties	
<i>Prunus armeniaca</i>	Dwarf apricot	5-9	attracts pollinators; wildlife food and shelter; edible fruit	Most need cross-pollination; plant 2 different varieties	
<i>Ficus carica</i>	Fig	6-10	attracts pollinators; food for birds; edible fruit	Self-fertile; only one is needed	Easy to propagate
<i>Corylus avellana</i>	Hazelnut/ Filbert	3-9	attracts pollinators; wildlife food; edible nuts; wood for fencing and basketry	Needs cross-pollination; plant 2 varieties	Can tolerate part shade; forms a dense thicket
<i>Pyrus bretschneideris</i>	Asian pear	4-9	attracts pollinators; wildlife food and shelter; edible fruit	Needs cross-pollination; plant 2 varieties	Fruit has apple-pear flavor
<i>Mespilus germanica</i>	Medlar	5-8	attracts pollinators; wildlife food and shelter; edible fruit	Self-fertile	Soft, spicy fruit
<i>Asimina triloba</i>	Pawpaw	5-7	Wildlife food; edible fruit	Needs cross-pollination; plant 2 trees	Native to eastern U.S.; has a tropical custard flavor; can tolerate some shade, prefers wet soil
<i>Sorbus americana</i>	American mountain ash	2-8	Attracts pollinators; food and shelter for wildlife; edible berries	Needs cross-pollination; plant 2 trees	Berries are cooked for human consumption

Chart 3 – Plants for the Shrub Layer

Latin Name	Common Name	Hardi-ness Zone	Forest Garden Function	Pollination	Other Info
<i>Hippophae rhamnoides</i>	Sea buckthorn	3-7	Nitrogen fixer; wildlife food; edible berry	Needs male and female plant to produce fruit	Highly nutritious acid fruit
<i>Caragan arborescens</i>	Siberian pea shrub	2-7	Nitrogen fixer; windbreak; wildlife food; edible bean	Self-pollinating	Very hardy legume
<i>Eleagnus multiflora</i>	Goumi	5-8	Nitrogen-fixer; wildlife food; edible berry	Cross-pollinating	Can tolerate shade
<i>Prunus tomentosa</i>	Nanking cherry	3-7	Attracts pollinators; wildlife food; edible berry	Cross-pollinating	Small, sweet cherries
<i>Rubus idaeus</i>	Red raspberry	3-9	Wildlife food; edible berry	self-pollinating	
<i>Rubus occidentalis</i>	Black raspberry	4-8	Wildlife food; edible berry	self-pollinating	
<i>Rubus fruticosus</i>	Blackberry	6-8	Wildlife food; edible berry	self-pollinating	
<i>Gaylussacia baccata</i>	Black Huckleberry	3-8	Wildlife food; edible berry	cross-pollinating	
<i>Vaccinium corymbosum</i>	Highbush Blueberry	4-8	Wildlife food; edible berry	self-pollinating	Needs strongly acidic soil
<i>Vaccinium ashei</i>	Rabbiteye blueberry	7-8	Wildlife food; edible berry	self-pollinating	Needs acidic soil; heat-loving
<i>Ribes rubrum</i>	Red currant	3-8	Wildlife food; edible berry	self-pollinating	
<i>Amelanchier stolonifera</i>	Running juneberry	4-8	Wildlife food; edible berry	Self-pollinating	
<i>Amelanchier alnifolia</i>	Saskatoon	2-8	Wildlife food; edible berry	Self-pollinating	Can tolerate part shade
<i>Sambucus canadensis</i>	Elderberry	3-10	Wildlife food; edible berry	Self-pollinating	Highly nutritious berry

Chart 4 – Plants for the Ground Cover Layer

Latin Name	Common Name	Hardi-ness Zone	Forest Garden Function	Growth Pattern	Other Info
<i>Trifolium spp.</i>	Clover	3-9	Nitrogen-fixer; attracts insects; prevents weed growth and erosion	Grows in clumps	
<i>Arctostaphylos uva-ursi</i>	Bearberry	2-8	Attracts pollinators; wildlife food; medicinal; prevents weed growth and erosion	Low-growing, spreading shrub	Leaves and red berries are used medicinally
<i>Fragaria spp.</i>	Strawberry	3-10	Dynamic accumulator; attracts pollinators; wildlife food; edible berry; prevents weed growth and erosion	Spreads through runners	
<i>Vaccinium macrocarpon</i>	Cranberry	3-8	Wildlife food; edible berry; prevents weed growth and erosion	Very low shrub	
<i>Vaccinium vitis-idaea</i>	Lingonberry	4-7	Wildlife food; edible berry; prevents weed growth and erosion	Very low shrub	
<i>Phlox stolonifera</i>	Creeping phlox	4-9	Attracts pollinators; prevents weed growth and erosion	Spreads through runners	Tolerates some shade
<i>Viola odorata</i>	Sweet violet	6-9	Dynamic accumulator; edible leaves and flowers; prevents erosion and weed growth	Spreads through runners	
<i>Symphytum grandiflorum</i>	Large-flowered Comfrey	4-8	Dynamic accumulator; wildlife shelter; medicinal leaves; prevents erosion and weed growth	Grows in clumps, must be cut back to maintain low (can also be used in herbaceous layer)	Highly valued among forest gardeners for its ability to draw nutrients to the soil
<i>Stellaria pubera</i>	Star chickweed	5-8	Attracts pollinators; wildlife shelter; edible and medicinal greens; prevents erosion and weed growth	Grows in spreading clumps	Tolerates shade
<i>Asarum canadense</i>	Wild ginger	3-8	Used in cooking and medicines; prevents erosion and weed growth	Spreads through runners	Grows well in shade
<i>Thymus spp.</i>	Thyme	4-10	Aromatic pest confuser; leaves used in cooking, medicines, prevents erosion and weed growth	Very low shrubs	Needs full sun
<i>Achillea spp.</i>	Yarrow	3-10	Aromatic pest confuser; leaves used in medicines, prevents erosion and weed growth		

Chart 5 – Plants for the Vine Layer

Note: These plants must be supported by another plant, a trellis, fence, archway, or other structure.

Latin Name	Common Name	Hardi-ness Zone	Forest Garden Function	Other Info
<i>Passiflora incarnata</i>	Maypop, passion flower	6-10	Attracts pollinators; wildlife food; edible fruit, medicinal	Native to southeastern U.S.
<i>Actinidia arguta</i>	Hardy kiwi	4-8	Edible fruit; makes an attractive archway; shade	Needs male and female plants to produce fruits
<i>Vitis vinifera</i>	Grape	6-9	Attracts pollinators; wildlife food; edible fruit and leaves	
<i>Vitis rotundifolia</i>	Muscadine grape	7-10	Attracts pollinators; wildlife food; edible fruit	
<i>Humulus lupulus</i>	Hops	4-9	Edible greens, used for tea and medicines;	Flower cone is used in making beer
<i>Apios americana</i>	Groundnut	3-10	Nitrogen fixer; wildlife shelter; attracts pollinators; can be used as a groundcover; edible root	Produces edible tubers
<i>Lathyrus tuberosus</i>	Earthnut pea	6-9	Nitrogen fixer; wildlife shelter; attracts pollinators; can be used as a groundcover; edible root	

**Chart 6: Eco-Service and Permaculture Principles
Mini Forest Garden**

GEN Departments	Permaculture Principles
<p>Air Cleaning Department Trees are famous for being effective air cleaners. Unlike so many gardens, a forest garden features trees. Each tree planted adds another air cleaner to our Earth.</p>	<p>Catch and store energy It's a plant's job to catch and store sunlight as energy. Trees are particularly good at this! By planting trees, shrubs, and many supporting plants in a forest garden, you are effectively catching and storing solar energy.</p>
<p>Biodiversity Department A forest garden abounds with biodiversity. It holds a wide array of plants, which in turn shelter and feed a wide variety of animals. The enriched and active soil supports a wide diversity of insects, worms, arthropods, fungi, and micro-organisms.</p>	<p>Diversity Forest gardens are based on polycultures – diverse plants with diverse interrelationships.</p>
<p>Food Production Department Forest gardens produce a variety of food for humans and for wildlife: seeds, fruits, flowers, leaves, stems, and roots of plants are all products of a healthy forest garden.</p>	<p>Multiple Functions Each plant in a forest garden has multiple functions. The garden as a whole also has multiple functions: 1) it produces food; 2) it builds soil; 3) it provides food and shelter for wildlife; 4) it catches and stores energy; 5) it's beautiful!</p>
<p>Pest and Disease Control Department Healthy forest garden systems have multiple strategies for controlling pests and diseases. The garden is biodiverse; its healthy soil fosters healthy plants; it includes "aromatic pest confusers;" and other supportive plant relationships; heavy mulch and vigorous ground covers help keep "invasive" plants from taking hold.</p>	<p>Observe and Replicate Natural Patterns Forest gardens mimic natural forest ecosystems. Both have 7 structural layers (canopy, understory, etc.) and both support an intricate web of interrelationships. Forest gardens, like forests, are also ever-changing and evolving through successional stages.</p>
<p>Pollination Department A forest garden is a busy place for this department! There is lots of pollination to be done to produce fruits and vegetables. At the same time, many of the trees, bushes, and herbs do their best to attract pollinators by putting on a flowery show.</p>	<p>Obtain a Yield A forest garden "yields" food, medicine, and wood for humans. It can also yield rich soil, compost, and mulch. Infinite learning opportunities can also be a yield!</p>
<p>Soil Department Forest gardens need rich, healthy soil and once they get going they help to create more! Plant roots hold the soil, keeping it from eroding. The roots of healthy plants participate in an underground biological network called the "soil food web." Some special plants bring important nutrients to the soil. And of course plants, as they live and die, add organic matter to the soil.</p>	<p>Relative Location Designing a forest garden means thinking about where things will go in relation to others. Where should we put the garden in relation to a water source and the school building? Where will the tall trees go in relation to the smaller ones? Where will the herbs go in relation to the fruit trees? Where can we cultivate certain plants so that many others benefit?</p>