Chapter 15: Optimizing The Understory

The understory of your Forest Garden refers to the various plants that fill in the space beneath the canopy trees. As your Forest Garden mature, the canopy will be made up of the timber trees as well as some of the larger fruit trees you plant. The understory includes all the shorter trees and shrubs, herbaceous plants, vines, and ground covers that, when carefully selected, can provide a wide variety of products while also helping to maintain soil fertility, reduce moisture loss, and protect against pests. By integrating understory plants into your Forest Garden you are continuing to diversify the timing of harvests to provide for more frequent returns while further increasing the total productivity and sustainability of your site.

After you have protected your Forest Garden site, revitalized the soils, and began diversifying your production with fruit trees, timber trees, permagardens and more, it is time to begin optimizing your production. At this point you will take a close look at the layout of your Forest Garden, with an aim of maximizing the use of: space (horizontally and vertically), time, sunlight (or shade), and water. Are there any gaps where other plants can be added to fill the niche? What companion plants can be added that would benefit from or provide benefits to the trees and other plants that are already growing? What plants grow best with full sun? What can grow in partial or dense shade? How can you conserve or better utilize rainwater?

The understory plants that fill in these spaces will help you to make more efficient use of land, labor, and resources. However, it does require careful planning to ensure that you have the right mix of plants in an increasingly complex system. It is important to have an understanding of the needs of the various species, and how they affect other species near them. The most obvious consideration for understory plants is that they will need to tolerate shade. How much shade depends on the spacing and density of the canopy trees above them. The shade also influences more than just the amount of sunlight that reaches below. It also influences air temperature and humidity, soil temperature and moisture, wind movement, and more, which all have an impact on your understory plants. The understory environment provides a number of benefits for plants, including:

- Reduced evaporation of water through the leaves and branches of the plants, which conserves moisture in the plants and reduces water use
- Protection from temperature extremes and fluctuations
- Shielding from winds
- Suppression of invasive weeds, which tend to prefer open conditions and full sun
- Support for a range of beneficial soil microbes that do not thrive in the open.

The Understory is Dependent on the Overstory

The canopy layer, or overstory, plays a critical role in creating the understory environment and thus largely determines which understory plants you will be able to grow effectively. The most influential factors of succession that affect the understory are the canopy tree shape, canopy foliage type, tree spacing, and rooting patterns.

- **Canopy shape –** The canopies of trees can take a variety of shapes. They can have a wide, spreading canopy, a narrow, more conical form, or anything in between. The canopies can be tall and dense, or a thin layer. The shape and form of the overstory trees is an important consideration in planning which plants you can best intercrop into your Forest Garden's understory. The form and canopy shape of the overstory trees will help determine appropriate spacing for the trees and understory crops. In some cases you can alter the shape and form of the overstory trees by training and pruning the branches.
- **Canopy foliage type –** Some types of tree foliage create dappled sunlight or light shade (e.g. *Acacia abyssinica* or coconut) while others develop a thick canopy with dense, heavy shade beneath (e.g. mango). Although you will select understory crops that tolerate some degree of shade, some light must be available for most crops to be productive. The type of foliage should be considered along with canopy shape, to determine the spacing needed to create an optimal understory environment for the selected understory plants.
- **Tree Spacing –** Increased spacing of the overstory trees is important if you want to create a lush understory environment. If you opt for standard, close spaced trees in a monocultural orchard or forestry system, you would need to phase out your understory crops as they would be out-competed for light and space. We do not recommend this as the lack diversity will diminish the resilience and sustainability of your system. Forest Garden systems generally involve a reduced number of trees per acre (anywhere from 25% to 75% less) compared to monocultural plantings for timber or fruit trees. This wider spacing can be in a uniform pattern or in a more random pattern of dispersed trees. What you lose in production of the canopy trees, however, can be more than made up with a diverse and well-planned selection of understory crops. Plan your spacing to optimize the environment for the understory, and minimize competition for space, light, and nutrients.
- **Rooting Patterns –** As the various trees and plants fill in your Forest Garden aboveground, their root systems will likewise fill in belowground space. As such, the root systems of all the plants will also be competing for resources, so you want to be sure you are planting crops and other plants that access different root zones and nutrients in the same vicinity. Around each deep rooted tree, you can plant shrubs, bushes, vines, root crops and others in the same area that will access different layers in the soil horizon. Through careful planning, the integration of various plants with different rooting patterns will allow you to increase the overall

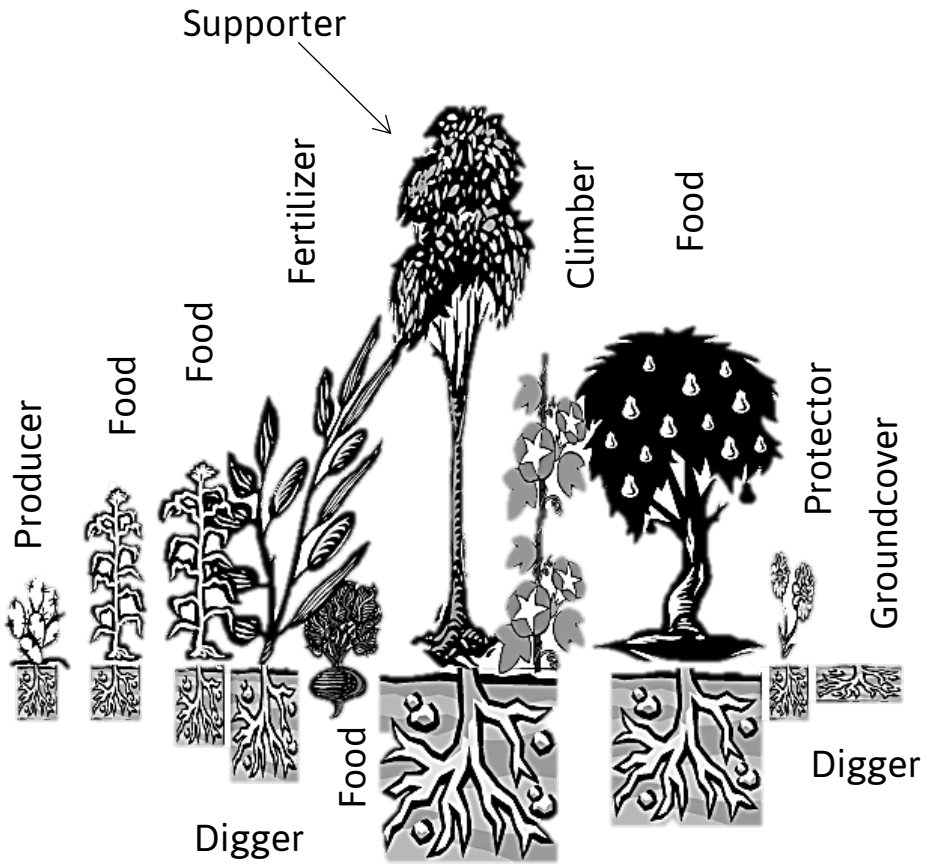
productivity of your Forest Garden considerably while minimizing competition for water, air, and nutrients among them.

Guild Building in Your Forest Garden

Planning your Forest Garden establishment strategy requires a good understanding of the growing requirements and characteristics of the plants you select, and their relationships with other plants near them. When you group different plants together in a system that maximizes the service or production potential of each plant, you are creating a **guild**. A guild is a permaculture concept that seeks to mimic the way plants grow in healthy, natural environment. In the process of optimizing your Forest Garden understory, you are identifying companion plants that exhibit complementary growth and rooting patterns to minimize competition. In doing so you are creating guilds. The list below defines some of the many different functions that you can try to include in the guilds you create:

- **Providers –** plants that provide food and money, e.g. fruits, vegetables, grains, and timber.
- **Fertilizers –** legumes that fix nitrogen into the soil.
- **Miners –** deep rooted plants or tubers that open the soil and bring up nutrients from the deep in the subsoil, releasing them as organic matter in the leaf litter.
- **Climbers –** to take advantage of vertical space.
- **Supporters –** plants that provide support for the climbers.
- **Cover crops –** shallow-rooted, surface-level plants that cover the ground and shade and protect the soil, hold moisture, and retain weeds.
- **Protectors –** plants that protect your site and the crops within, e.g. insectary plants, aromatic pest confusers, and green walls.

See Figure below for an example of a guild.



Succession of the Understory

One of the important considerations in designing guilds and optimizing your understory system is the rate at which the understory environment changes, in a process called succession. Following the Forest Garden Approach, you will begin planting understory plants to create guilds while your canopy trees are still maturing and the overstory is relatively open. The understory environment will continue to change, becoming shadier, cooler, and more humid, as the overstory trees fill in the canopy. Because of this, the composition of your understory plants will need to change over time as well. Earlier on you can grow plants that benefit from more sunshine. As the canopy fills, you will need to transition in plants that are tolerant of shade and a cooler, more humid environment. The understory succession will influence decisions in overstory and understory plant selections and plant spacing.

Understanding how the tree cover and understory conditions will change will allow you to optimize your understory planting schedule. For example, if understory crops cannot tolerate full sun, then you should not plant those shade-loving plants until the overstory trees have grown enough to provide a sufficient canopy. The amount of time that

appropriate conditions for your understory will last influences your decisions for optimum output from understory crops, thus influencing crop selection, spacing, and scheduling. In the Forest Garden Approach, we begin introducing more shade tolerant crops in the third year. Until that time, you can continue planting the annual crops you previously planted, leaving space around the trees you have incorporated into the site to avoid competition. As your overstory trees continue to grow and spread, you can initially maintain the optimum understory conditions by pruning or thinning the overstory trees.

However, if you do not wish to restrict the growth of the overstory too much, you will likely choose to replace some of the early annual understory crops with other perennial crops that are better adapted to a denser overstory. This method of succession planting optimizes the productivity of the understory as the environmental conditions change.

Selecting your understory crops

Whether your understory crops are integrated for continuous yields or in a succession intercropping system, species selection is an important consideration. When selecting species, be sure you understand the compatibility of the growth and rooting habits to ensure the plants are compatible and not overly competitive for nutrients and space. Integrate your companion understory plants in a way that maximizes available light, space, and nutrients, while minimizing competition. In relation to the overstory trees, understory crops should:

- Tolerate partial shade.
- Exploit different soil horizons than the overstory trees as much as possible.
- Be shorter than the overstory trees when mature unless explicitly planned to utilize the shade when growing, but eventually overtaking and creating a higher canopy layer.
- Be less susceptible than the overstory trees to diseases they may have in common.
- Not involve damage to the overstory trees during cultivation or harvest of understory crops.

Avoid competition between the under- and overstory

Understanding the rooting habits, potential allelopathic effects (where plants produce biochemicals that influence the germination, growth, survival, or reproduction of other plants), and growth rates of the overstory species will help you to ensure that the trees you incorporate into your Forest Garden will create a beneficial environment for the understory crops. Some tree species may be too fast-growing or have negative allelopathic effects on crops, making them inappropriate for this kind of system. For example, *Eucalyptus* and *Casuarina* species exhibit allelopathic effects that prohibit the growth of other plants near them. Other trees may simply have aggressive root systems or growth rates that are incompatible with most understory crops. Similarly, be sure to select understory crops that are not overly competitive with your overstory trees.

Selecting and testing local varieties for understory crops

The vast majority of modern agricultural research has, at the expense of sustainability, focused on growing crops in monocutural systems that are fully exposed to the sun. Many new varieties have been bred specifically to tolerate high light intensity. Where possible, it may be beneficial to experiment with traditional, native varieties of understory crops that may be better adapted to the understory environment than modern varieties.

Limitations of understory planting

As with any agricultural practice, it is important to understand the potential limitations of understory intercropping. These include a:

- Shortage of scientific study and information about tree and understory crop interactions
- Risk of unforeseen competition or allelopathic effects
- Greater complexity in management of multiple species and multiple products
- Potential damage to overstory from harvest of the understory, or vice-versa
- Increased challenges of marketing diversified products.

However, with adequate knowledge and good planning, you can overcome them to effectively integrate understory crops with tree crops in your Forest Garden. In doing so you can significantly increase and sustain the overall productivity of your land.

Cover Crops

Cover crops are usually creeping legumes which cover the ground surface between widely spaced perennial crops such as fruit trees and coffee, or between rows of grain crops such as maize. They are most applicable in earlier stages of Forest Garden establishment when the overstory is more open to give them better access to sunlight. Often cover crops are combined with mulching. They are grown to protect the soil from erosion and to improve soil fertility. Cover crops protect the soil from splashing raindrops and too much heat from the sun. They slow down the movement of water on sloped land, and their roots break up the soil and increase water infiltration.

Most of the plants used as ground cover are legumes, such as different varieties of beans and peas. Pigeon peas and other crops with strong tap roots and a longer growing season than maize and beans make a good mix and can be used to break up hard-pans in semi-arid areas. For the cover crop to compete with the main crop as little as possible the cover crop should be of a low yielding variety. Cover crops should be planted as soon as possible after tillage to be fully beneficial. This can be done at the same time as sowing the main crop, or after the main crop has established, to avoid competition at crop nutrition level. Cover crops are not very suitable for dry areas, with annual rainfall of less than 500 mm as they might compete for water with the main crop. Under such conditions it might be better to keep the weeds and natural vegetation as cover.

Advantages of Cover Crops

- Improved soil structure and soil fertility.
- Reduced soil erosion and runoff.
- Suppression of weeds.
- Production of food and animal forage.
- Improved soil moisture and reduced surface crusting.
- Reduced fluctuations in soil temperatures.
- Some cover crops can provide good cash income.
- Cover crops can be a good alternative source of mulch, especially useful in semi-arid lands where crop residues are important animal feed.

Limitations to Cover Crops

- Compete for water and nutrients with the main crop.
- The dense cover crop foliage might serve as a refuge for rodents.
- Involves additional farm labor and inputs.
- Legumes can be sensitive to diseases.

Earthworks

Earthworks (also called soil and water conservation techniques) are physical barriers that you can construct from soil and stones within your Forest Garden site to control and slow the movement of water and soil. It is best to begin building earthworks in your Forest Garden at the start of establishment. Depending on the type of earthworks you build, and the extent to which they cover the site, they can take a considerable amount of time and labor. They are most relevant on sloped sites prone to heavy erosion, but are applicable even on gently sloping sites as even on these you can lose a considerable amount of topsoil over time. In the Forest Garden Approach we encourage those of you with sloping land to begin establishing earthworks in the protection phase through digging channels along the contours of your slopes and planting trees, shrubs, and grasses on the uphill side to stabilize the mounds (see Contour Planting section). As you proceed through the Forest Garden program, you will learn to establish earthworks around your permagardens and higher-value trees to direct water deep into your soils where your crops can access it well into the dry season. The benefits of constructing earthworks are to:

- **Maximize water absorption on a landscape** – Even on land that appears to have no slope, there will be water flow when it rains. Earthworks help you to stop, slow, sink, and spread flowing water so that it can be of use to surrounding vegetation.
- **Control and direct the flow of water** – Rains can be torrential. Sometimes there is simply too much water for your soils to absorb and hold. Earthworks can be used to direct the flow of water to places that need it more without running the risk of creating erosion channels that will damage an agricultural space.
- **Capture topsoil and organic material** – Along with capturing water, earthworks also capture topsoils that wash away, as well as leaf litter and other windblown organic

material. As these materials break down they create a rich layer of topsoil that feeds surrounding vegetation.
- **Stabilize sloped land** – Significantly sloped land is more vulnerable to erosion and topsoil loss than relatively flat land. Earthworks can decrease the slope of your land by creating steps so that it can be better used for agricultural purposes.

There are a number of types of earthworks that you can construct in the process of establishing your Forest Garden to help you to conserve soils and water, and increase tree and crop health and productivity:

Berms and Swales

Berms and swales are the most common types of earthworks you will likely use in your Forest Garden. A swale is a long trench dug out across the ground, along the contour, to catch runoff water, soil, and organic matter. The soil you dig out to form your swale is generally used to create a berm of earth on the up- or down-slope side of your swale. Berms and swales allow water to enter and remain in the landscape more evenly. There are three commonly used types of berms and swales.

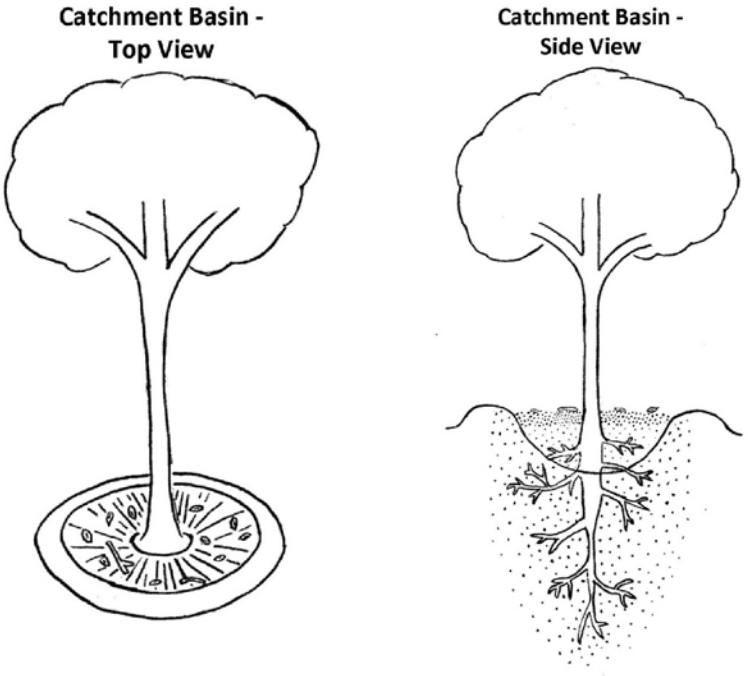
Standard berm and swale – A long, low berm and swale combination that snakes across the contour of your Forest Garden site or surrounds your permagarden, protecting the uphill side from fast-moving runoff, and catching excess runoff on the downside. Standard berms and swales allow for the most uniform collection of organic material across your Forest Garden site, and are commonly used in fields in combination with alley cropping. Standard berms and swales are perfect for slowing down the movement of runoff leading into your permagarden, and for creating a guiding contour line that you can follow for ploughing your site in early years of Forest Garden establishment. It is best to plant perennial vegetation (trees, shrubs, grasses, herbs, etc) along your berms to stabilize them.

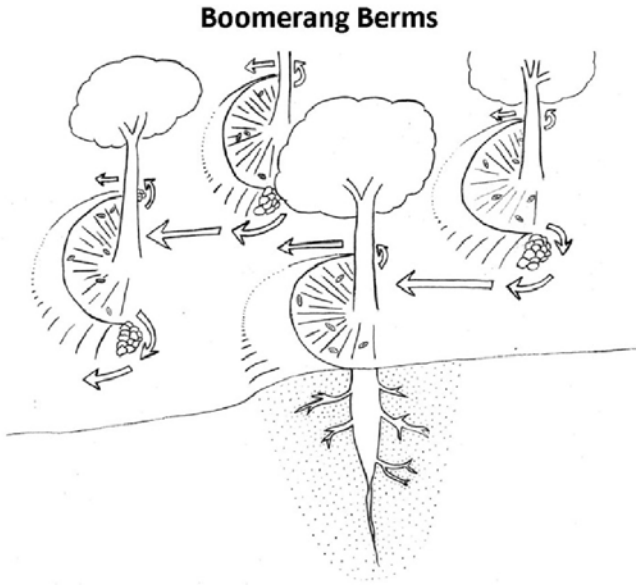
Boomerang berm – A semi-circle or half-moon shaped berm that is placed around an established tree to capture water specifically within the tree's root zone. You can establish a series of boomerang berms so that the overflow from one berm descends into the catchment area of a downsloping berm.

Diversion swales – A berm and swale laid out slightly off contour, designed to slow the flow of water and channel it to a more desirable location. Diversion swales are useful in mitigating flood waters and directing excess water to areas that can hold it better or need it more.

Holes – A deep depression or bowl in the soil that catches any runoff water. Holes are often dug at points along swales when the expected runoff is too much to be stopped and absorbed by the more shallow swales. You can dig holes on the uphill slope of boomerang berms to sink and store more water for the trees planted within them.

Catchment basins – Also known as a *cuvette,* is a shallow depression in a level landscape completely surrounded by a berm. Catchment basins are designed both to hold human delivered irrigation and to prevent excess rain water from drowning a flood sensitive planting.





CHAPTER 15: REFERENCES

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