TECHNICAL NOTE

USDA NATURAL RESOURCES CONSERVATION SERVICE PACIFIC ISLANDS AREA

Forestry Technical Note No. 10

Shade Overstory for Coffee in Hawaii

Why provide overstory shade for coffee?
Coffee trees evolved as an understory forest species. Although coffee can be grown in full sun, it often is interplanted with other trees that provide additional benefits. Shade trees planted for agroforestry on coffee plantations can address a number of resource problems, including, but not limited to:

Soil Erosion: sheet & rill, wind; **Soil Condition:** organic matter depletion, contaminants-commercial fertilizer-N, P, & K; **Water Quantity:** reduced storage of water bodies by sediment accumulation; **Water Quality:** excessive suspended sediment and turbidity in surface water; **Air Quality:** adverse air temperature; **Fish & Wildlife:** inadequate cover/shelter food, habitat fragmentation.

Other benefits of overstory shade on coffee plantations include income and diversification from additional crops, a cooler working environment, addition of nitrogen to the soil by nitrogen-fixing trees, the satisfaction of growing native tree species, and a more varied and attractive landscape.

Nitrogen-fixing gliricidia trees planted within rows of a new coffee plantation.

Yield and Quality

Coffee yields seem to be unaffected by moderate shade levels. The results of a recent Conservation Innovation Grant project indicated that 40-50% shade will not decrease yields below those obtained in full sun. Coffee yields will decrease as shade increases beyond this range.

Overstory shade reduces the chances of "overbearing dieback." When coffee trees are grown in full sun, coffee bean production becomes so high that it can outstrip the uptake of nutrients by the trees, resulting in plant stress, injury, reduced production, and sometimes tree death.

Overstory Species Selection and Spacing

There are many possible overstory tree species that can be planted with coffee in Hawaii. A partial list is provided in Table 1. In addition to fulfilling the requirement that the overstory trees address the resource problems identified on the site, trees may provide additional fruit and nut crops or, in the long term, be harvested for wood. Selection of native tree species should be

based on local suitability and availability. Information on this can be found in Ecological Site Descriptions, where they are available, or contact the NRCS Forest Ecologist.

Koaia, ohe makai, and other native tree species planted within coffee rows. The native trees have not yet attained full stature.

Selection of tree species to provide shade for coffee depends on a number of factors. Different species or varieties of trees have different growth rates, maximum heights, canopy shapes, shade densities, root configurations, and responses to pruning. Information about these characteristics often can be found in the references below. Photographs of trees, found in the references, can help you estimate canopy shapes and shade densities if that information is not in the text.

Initial spacing when planting overstory trees depends on a number of factors. If direct sun on the coffee trees during part of the day is desired, spacing must be wider. If close tree spacing is desired, more pruning eventually may be needed to avoid excessive shading. Growth rate, height, and canopy shape must be considered.

Trees may be planted with a denser initial spacing than is ultimately desired. That way, the benefits of the overstory trees can be gained sooner, before the trees reach full size. As shade from the overstory increases, trees can be thinned (removed) and/or pruned. Many, if not most, coffee farmers with overstory shade trees in their orchards prune the overstory trees regularly in order to maintain desired shade levels.

Table 1. Some overstory trees for coffee and their characteristics

Common name	Scientific name	Other uses	Elevation range (ft)	Growth rate	Maximum height (ft)	Other characteristics
avocado	Persea americana	fruit	0-3000	medium	30-60	dense shade
mango	Mangifera indica	fruit, wood	0-3000	slow	50-100	many varieties; dense shade
jackfruit	Artocarpus heterophylla	fruit, wood	0-3000	medium	75	dense shade; medium-wide canopy
monkey pod	Samanea saman	wood	0-1200	medium	50-80	N-fixer; very wide canopy; produces surface roots
breadfruit	Artocarpus altilis	fruit	0-2400	slow	50-70	medium-wide canopy; shallow roots
madre de cacao	Gliricidia sepium	mulch	0-2400	fast	35	N-fixer; withstands severe pruning
koa	Acacia koa	wood	> 1800	fast	60-100	N-fixer; light shade; shallow roots; wide canopy
ohia	Metrosideros polymorpha	wood	0-8000	slow	60-100	narrow canopy
big-leaf mahogany	Swietenia macrophylla	wood	0-2000	medium	100	medium-wide canopy
Spanish cedar	Cedrela odorata	wood	0-2000	medium	100	medium-wide canopy
pheasant wood	Senna siamea	wood	0-1800	fast	45-60	medium-wide canopy

One strategy is to plant overstory trees at one-third to one-quarter the spacing of your ultimate target spacing. For monkeypod overstory, for instance, a farmer may plant trees at 25 foot spacing (70 trees/acre) and gradually (over a period of many years) thin the trees until they are at 60 foot spacing (12 trees/acre). A standard suggestion to a coffee farmer establishing large trees such as monkeypod or koa for overstory would be to plant the trees at 25 to 30 foot spacing.

Once the average spacing of the overstory trees is established, the total number of trees per acre can be estimated by using the chart in Forestry Technical Note 7. Notice that this chart is for “average tree spacing.” The planner and cooperator should take the trees/acre number associated with the average tree spacing desired and then use their judgment to adapt the tree planting locations to site conditions such as rock outcrops, buildings, roads, orientation to the sun or wind, and the shape of the property. The final planting arrangement does not have to be a square, even grid of trees.

Applying NRCS Practice Standards

Overstory trees for an existing coffee plantation typically would be established under the Multistory Cropping (379) practice. If overstory trees are planted in single or multiple rows with coffee grown in the alleys between rows, Alley Cropping (311) would be the appropriate practice.

Policy allows for cost-shared establishment of trees whose primary purpose is to address the identified resource problems on a site. It is perfectly acceptable for those trees to produce additional products, as long as the resource problems are adequately addressed. The

Multistory Cropping and Alley Cropping standards state: “High value trees or shrubs should be selected to maximize economic returns.” The EQIP Manual (Section 515.81) states: “Practices ineligible for EQIP are those where the sole purpose is to enhance production, without an identifiable conservation benefit or natural resource concern.”

Another possible scenario would be to remove weedy understory vegetation from an existing native tree canopy using the Forest Stand Improvement (666) practice. Under this scenario, the goal would be to address native wildlife resource concerns. Additional native plants would be established under the Tree and Shrub Establishment (612) practice standard; coffee or other non-native understory crop plants would be established at the cooperator’s expense. Approximately 75% of the total area and total number of plants established (native + non-native crop plants) after weed clearing must be appropriate native species that address the specified wildlife resource concerns. The layout of the site should be planned to maximize the value of the newly-created habitat for native wildlife while still allowing for reasonably efficient coffee production.

Ohia overstory from which weedy understory has been removed and replaced with coffee. This was not a cost-shared project; native understory species were not planted.

Examples of Two Coffee Overstory Species

Monkeypod Overstory for Coffee

Data have shown that coffee yields under monkeypod shade increased slightly as overstory shade increased from 0% to 50%. This increase might have been due to nitrogen fixed by the

monkeypods. A grove of monkeypods that are close enough together to produce a closed canopy can have shade levels of 80-90%. Monkeypods that are pruned every year or two will produce shade levels of 50-60%.

Monkeypods have wide canopies in relation to their heights. Twenty to thirty year-old monkeypods can have a height of 35-50 feet and a crown diameter of 35-50 feet. One old monkeypod tree measured on a coffee farm in Kona was about 55 feet tall and had a crown diameter of 90 feet.

Exceptionally straight-trunked monkeypod trees that were initially planted at a higher density and later thinned.

Large, mature monkeypods on productive coffee farms often are spaced about 60 to 125 feet apart. They may be pruned so shade is not too dark right under the trees. Trees that are pruned to stay only 25 to 35 feet tall need to be more numerous in order to maintain desired shade levels.

Koa Overstory for Coffee

Koa trees provide moderate levels of shade and, like monkeypod trees, fix nitrogen in root nodules. This species can be a useful coffee overstory species, although it has some drawbacks.

Koa's thin bark and surface root system, especially when grown in shallow or rocky soils, are easily damaged by human, mechanical, and animal traffic. This can weaken koa trees over

time and compounds the risks of koa wilt, infection by other soil pathogens, and herbicide damage.

Koa trees at relatively low elevations (where many coffee farms are) are likely to suffer from black twig borers and koa wilt. Above about 2000 feet elevation, these pest and disease problems become less prevalent. Both koa and coffee are attacked by black twig borer.

There is not much likelihood of obtaining large amounts of valuable koa timber from harvesting koa overstory trees. Koa plantation trees are almost always poorly formed, and tree form may be even worse on coffee farms due to root damage from traffic and, at lower elevations, to pests and disease. However, there currently is a market for koa wood that can be used for wood carving and other crafts that utilize what otherwise might be considered to be "non-marketable" wood. Also, work is being done to develop straighter-growing varieties of koa.

References

Shade-Grown Coffee for Hawaiʻi: Results of a twelve farm study in Kona, by Craig Elevitch, Travis Idol, J. B. Friday, Chris Lepczyk, Virginia Easton Smith, and Scot C. Nelson. 2009. Permanent Agriculture Resources. Available at http://agroforestry.net/caf .

Agroforestry Guides for Pacific Islands, Craig Elevitch and Kim Wilkinson, eds. 2000.Permanent Agriculture Resources. Available at http://www.agroforestry.net/afg/book.html
Section 2. Multipurpose Trees for Agroforestry in the Pacific Islands contains a table on page 45 that lists growth rate and height at maturity for many tree species.

Traditional Trees of Pacific Islands, Craig Elevitch, ed. 2006. Most field offices have a hard copy. Each chapter can be found at http://www.agroforestry.net/tti/index.html
Contains detailed information and photographs for many species.

Farm and Forestry Production and Marketing profile for Coffee, by Virginia Easton Smith, Shawn Steiman, and Craig Elevitch. Available at
http://www.agroforestry.net/scps/Coffee_specialty_crop.pdf
Contains basic information about coffee growing and sections about overstory and shade.