Toward Sustainable Agriculture:
A Guide for Hawai‘i’s Farmers

Jody Smith and Samir A. El-Swaify
Editors

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Preface

Farming is an ancient art that is necessary for human survival. It has taken many forms, ranging from rainfed shifting cultivation on hill slopes to stable cultivation in irrigated river basins. Where successful and sustainable, farming has supported many well known civilizations.

To cope with ever-increasing human populations and their changing needs, agriculturists and agricultural scientists have created many farming innovations, evolutions, and revolutions. Many of these have come and gone, but their underlying fundamental principles are everlasting. We are now in a position to benefit from the many documented lessons of success and failure in agriculture, and thus we are better able to recommend sustainable land management approaches to farmers. The project titled "New Farmers: Choosing the Road Less Traveled" was funded by the USDA Sustainable Agriculture Research and Education (SARE) program for this purpose. Our specific focus is to assist new farmers in tropical small-island settings by providing a distillation of expert information. As an overview, this publication is neither a stand-alone document nor an end point but rather a beginning that should assist the reader in capturing essential concepts and accessing additional information resources.

Markets for sustainable agriculture products are expanding for many reasons. It behooves new farmers to take advantage of opportunities in this area, and they will happily find ample company and expert assistance.

We at the University of Hawai‘i at Mānoa's College of Tropical Agriculture and Human Resources, and our partner institutions, wish all readers of this book great success, and we look forward to receiving feedback to assist us in evaluating our project's outcome.

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Chapter 1

Choosing Sustainable Agriculture

Hawai‘i is a scattering of verdant islands lying in a vast expanse of Pacific blue. Formed by powerful volcanic forces, these lands possess an inherited abundance. Awe-inspiring cliffs and mountain ridges rise from their shores, harvesting fresh water from the trade winds. Far from any major landmasses, Hawai‘i is home to hundreds of plant and animal species, many of them having uniquely evolved in this remote archipelago. The beauty and luxuriance of the Hawaiian Islands have long stirred people's hearts and enticed adventurers to stay and make their homes "in Paradise." These lands excel in growing food and fiber—agriculture, in many forms, has been practiced here for centuries. From the original Hawaiians, who grew *kalo* (taro), *‘uala* (sweetpotato), and *‘ulu* (breadfruit), through the era of plantations and ranches, and to today's highly diversified agriculture, we have learned much.

How do we cultivate the *‘āina* (land) in these magnificent island ecosystems while maintaining their inherent natural health and wealth in perpetuity? What will agriculture look like later in the 21st century? How will the farmers, especially the new farmers of Hawai‘i, manage the natural resources with which they are entrusted?

The promise of sustainable agriculture

While few will deny the remarkable successes of modern agriculture, which we have enjoyed as a result of high-tech farming and the spread of the "Green Revolution," it has come at a price. The unintended consequences of conventional intensive farming systems have been an accelerated decline of family farming; the degradation of air, soil, water, plant, and animal resources; and lingering concerns about the effects of chemical residues in our food supply and the environment.

General consensus supports the opinion that the future of agriculture, especially in the Pacific islands, must be "sustainable." Sustainable farming systems should be "capable of maintaining their productivity and usefulness to society indefinitely." Such systems should be "resource-conserving, socially supportive, commercially competitive, and environmentally sound."[1]

The primary goals of sustainable agriculture include

- providing a profitable farm income based on a productive enterprise
- promoting environmental stewardship by
  protecting and improving soil quality
  reducing dependence on non-renewable resources, such as fuel and synthetic fertilizers and pesticides, and
  minimizing adverse impacts on food safety, wildlife, water quality, and other environmental resources
- promoting stable, thriving farm families and communities.[2]

Management decisions for sustainable agriculture are not based merely on short-term, "bottom line" profits but also on long-term prosperity.

A good match for Pacific islands

Sustainable agriculture makes sense for Pacific island farmers. Ecology-based farming, which mimics nature, provides long-term protection to our vulnerable land and water resources, to our endangered fauna and flora. It is a good match for island ecosystems for many reasons, including the following:

Human health is protected. Sustainable methods emphasize using the least toxic chemicals available to produce food and fiber. Farmer, farm family, and farm worker health are less at risk.

The natural environment benefits. Island water resources are less likely to be contaminated by agricultural chemicals. Conservation methods reduce soil erosion and sedimentation, protecting fishery resources and keeping reefs productive. Diversified land uses on sustainable farms may improve wildlife habitat crucial to endangered plants and animals.

Sustainable agriculture promotes production and consumption of locally and regionally grown produce. Strong local food production helps protect island food supplies from dependence on external forces. Our food security is enhanced as our dependency on imported foods decreases.

Locally grown fresh food products often command a premium price. They are often considered fresher, tastier, and healthier than imported foods. Fresher foods tend to have more vitamins and minerals.

Sustainable agriculture focuses on getting more of the food dollar directly into the farmer's hands. As a result, sustainable agriculture tends to stimulate rural economies. Sustainable farms bring in more money, hire more people, and contribute to a more economically stable rural community.

There are opportunities for sustainable farms to expand into **agritourism** and to develop product lines for direct marketing to restaurants, hotels, and resorts.

With Hawai‘i’s remoteness and the market forces dictating high petroleum costs in the islands, sustainable agriculture, with its emphasis on **reducing fuel-dependency**, is an appealing choice.

A good match for new farmers

Many beginning farmers are finding that sustainable agriculture is very compatible with their resources and expectations.

New farmers may have limited financial resources. Sustainable agriculture practices tend to reduce reliance on purchased inputs by eliminating them, or substituting less costly or more “home-grown” alternatives, applying management ideals more in line with sustainability principles, and substituting more labor-intensive practices for conventional agricultural inputs and methods. For example, such a farmer may rely more on crop diversification, crop rotations, cover cropping, and rotational grazing.

In the early stages, new farmers usually produce small volumes, and their products must be direct-marketed. Direct-marketing techniques promoted by sustainable agriculture give farmers opportunities to hone their entrepreneurial and marketing skills. For example, farmers can develop niche markets, test new products, and get consumer feedback by selling directly to consumers at farmers’ markets.

A new farmer has the opportunity to make the choice of producing organic products because of his or her personal philosophy relating to nutrition, health, animal rights, environmental stewardship, or social economics.

Agriculture is not for the faint of heart

Farming is not an easy venture. The Northeast New Farmer Network report *Listening to New Farmers*[3] identifies many of the factors required to be successful in farming today, including the following.

Farming requires production skills and knowledge: To be successful, farmers must possess knowledge, information, and skills combined with practical expertise in a wide range of day-to-day tasks required to produce food or fiber products. The requirements vary greatly with each farm enterprise; a farmer needs to know about selecting, planting, and harvesting multiple crops; animal husbandry; controlling pests and diseases; managing soil and water resources; and operating, maintaining, and repairing farm equipment and facilities. Many of these skills are acquired only through experience. Generally, people with farming background (raised on a farm with a farm family) already have many of these skills. Those from a non-farm background can “catch up” through research, reading, taking courses, and farm employment or apprenticeship.

In addition to the practical production skills needed, the successful farmer today must possess (or have access to) strong farm management skills. Farm business, financial, and marketing abilities cannot be overemphasized as requirements for success in today’s agribusiness climate.

Farm management expertise: This includes skills needed to manage finances, people, time, and community relations. Business and marketing skills (budgeting, marketing, publicity, promotion, sales) are crucial. Planning ability for dealing with daily production tasks as well as long-range goals is required. Ability to address legal and regulatory issues related to labor, the environment, and land use is also necessary.

Understanding resources: Knowing how to access resources is of critical importance, particularly land (land ownership, land rental, special lease arrangements), water (for irrigation when climatic conditions require it), capital, labor, and access to markets (both market demand information and actual outlets). Resources also include accessibility to farming support institutions and infrastructure, such as consultants, educational institutions (especially university extension services), input suppliers, repair and market facilities, and credit institutions.

Family and community support, farming networks: Whatever a farmer's background, family and spousal support is of critical importance, as is a peer network for obtaining information and sharing resources and experience and solving common problems. Social support encompasses overall community understanding and encouragement of farming, acceptability and tolerance of farming, and access to farming expertise, including farming advisors and mentors. Social recognition and respect affect resource access, including availability of expertise, land, and credit. Lenders may not provide credit if they perceive farming to be an unacceptable investment.

The challenges

It would be naïve to consider a farming lifestyle without candidly examining some of the negative issues associated with agriculture.

Uncertainty of income. It is often necessary to use off-farm income and life savings in the early stages of a new farm enterprise. During the early years of a new farm business, many have to live with low income.

Risk of losing investment. Your farm could fail. Your new business is weather-dependent and subject to damage from pests such as insects, weeds, plant diseases, and thieves. Consider how likely these risks are to happen, and ways to lower them.

Long hours and hard work. Farming is not a typical employee's 9-to-5 job. It requires stamina and is physically demanding. The types of work and the demands on your time vary significantly with the farming situation and may be continuous or seasonal. During the start-up phase of your farm business, you may have little time or energy for anything else.

Safety concerns. Many farming activities are hazardous, require working with mechanized equipment, and in some cases using agricultural chemicals. Health coverage can be expensive but is necessary.

High levels of stress. Starting and running a new farm business may be stressful. You may be investing all of your assets into the business, confronting unexpected obstacles, needing to borrow large sums of money, and perhaps giving up a steady job.

Do you have what it takes?

While we hope these cautions are not overly frightening, it is very important that you realize just how difficult farming really is. Once actively engaged in agriculture, many beginning farmers note that they had not expected so many challenges. Plan on investing enough time and energy toward research and inquiry to learn about your prospective new career.

Here's some advice from successful farmers on how and where to get more information.

Talk to successful farmers. You should not expect free advice—offer to pay for their time with some form of compensation (your labor, perhaps). Schedule your request for times when the farmer is not busy. Farmer mentorship programs that connect beginning farmers with experienced ones may be locally available in your area through farm bureaus or agricultural industry associations.

Work on a farm. There is no substitute for hands-on training and experience, especially in a farming career. Check into apprenticeship programs at successful farms that are like the one you'd like to own. Attend agriculture field days, workshops, and conferences. Focus on programs that feature farmer panels and farmers as presenters. While there, connect with the speakers and other participating farmers. They can be helpful and supportive.

Join farming organizations. There are farmer organizations for most agricultural commodities and for many niche products as well. Connect with them for sources of information and to attend scheduled conferences and workshops.

Read sustainable agriculture farming newsletters and other publications. Respected sources of information include *Acres USA, Stockman Grass Farmer*, and *Small Farm Today.* These and similar organizations offer a large stock of books on relevant topics.

Surf the Internet. Information on all aspects of sustainable and organic agriculture is abundant. Become proficient with computers and the Internet—they are an integral part of agribusiness today.

Research and study at agricultural colleges and universities. The University of Hawai‘i system provides many opportunities to learn about agriculture. Most community colleges have introductory agricultural courses. Turn to the UH College of Tropical Agriculture and Human Resources (CTAHR) for advanced information about agriculture in Hawai‘i. Consult with CTAHR's Cooperative Extension Service (CES) county offices and USDA Natural Resources Conservation Service staff for practical advice on farming issues.

Resources and recommended reading

Companion website

Use this document in conjunction with the CTAHR website link for new farmers, Sustainable Agriculture in Hawai‘i, <www.ctahr.hawaii.edu/sustainag/index.asp>. Additional information and updates are posted there at <www.ctahr.hawaii.edu/sustainag/newfarmer/links.asp>

Sustainable agriculture

ATTRA (Appropriate Technology Transfer for Rural Areas). The National Sustainable Agriculture Information Service is a comprehensive source of information about all aspects of sustainable agriculture. Major topic areas include what is sustainable agriculture, horticultural crops, field crops, soils and compost, pest management, organic farming, livestock, marketing and business, energy and agriculture, education, and resources. <attra.ncat.org/fundamental.html>

Sustainable Agriculture Research and Education (SARE). Website for the USDA national sustainable agriculture program. <www.sare.org>

Exploring Sustainability in Agriculture (Sustainable Agriculture Research and Education, SARE). Available in both html and Adobe Acrobat versions, this is a helpful introduction to the concept of sustainable agriculture (what is sustainability, elements of sustainability) with ten case studies (farmer profiles) to illustrate how these concepts can be applied. <www.sare.org/publications/exploring.htm>

The New American Farmer (Sustainable Agriculture Research and Education, SARE). A collection of 50 in-depth interviews with farmers and ranchers that illustrate the variety of production methods and the marketing creativity of sustainable farming operations thriving around the country. <www.sare.org/publications/naf.htm>

The New Farm: Farmer-to-Farmer Know How from The Rodale Institute. The Rodale Institute’s farming website features information, articles, products, and services for “regenerative agriculture.” The Rodale Institute works worldwide to achieve a regenerative food system that renews the earth. Their activities include research, training, workshops, and information dissemination. <www.newfarm.org>

Hawaii’s Agricultural Gateway (Hawai‘i Department of Agriculture)
<www.hawaiiag.org>

Magazines

Acres USA, A Voice for Eco-Agriculture. Describing itself as a national magazine devoted to sustainable agriculture, Acres USA’s on-line catalog features a wide array of publications relating to alternative agriculture. <www.acresusa.com>

Books

Exploring the Small Farm Dream: Is Starting an Agricultural Business Right for You? From the New England Small Farm Institute, this workbook uses a series of worksheets to guide you through the decision-making process needed when considering going into farming. <www.smallfarm.org>

Making Your Small Farm Profitable. Ron Macher, published by Storey Books. <www.storey.com>

You Can Farm: The Entrepreneur's Guide To Start and Succeed in a Farming Enterprise. Joel Salatin, published by Chelsea Green Publishing.

Sources for this chapter

K. Griffith. 1991. Finding the Niche: Case Studies of Beginning Small-Scale Farmers. Wisconsin Rural Development Center, Mount Horeb, WI. 37 p.

So You Want To Be a Farmer. 1999. Canadian Farm Business Management Council. Ottawa. 60 p.

Footnotes to this chapter

(1) John Ikerd, quoted in Richard Duesterhaus, 1990. Sustainability's Promise. Journal of Soil and Water Conservation 45(1):4.

(2) Exploring Sustainability in Agriculture. Bulletin, Sustainable Agriculture Research and Education. <www.sare.org/publications/exploring.htm>

(3) S.E. Johnson, et al. 2001. Listening to New Farmers: Findings from New Farmer Focus Groups. New England Small Farm Institute, Belchertown MA. 58 p.

Chapter 2

The Farm as Habitat: Environmental Topics

Hawai‘i’s unique biological heritage and natural resources

Located in the subtropics, 2500 miles away from the nearest continental landmass, the islands of Hawai‘i are the most remote on earth from continental landmasses. The plants and animals now native to these islands arrived here originally by wave (floating on ocean currents), by wind (blown seeds and spores), or by wing (birds and one bat species). Each island was unique and provided the newcomers with a wide range of habitats, from cold, lofty mountain ranges to hot, sunny coastlines. Relatively free of disease pressures or predators, the birds and plants grew and evolved together. Each island came to host its own rare wildlife. Many of the plants and animals required each other for survival. As a result, 97 percent of our native species are found here and nowhere else on earth.

Many of these habitats no longer exist as they did before human intervention in the islands’ ecosystems. Invasive weeds, introduced animals, new insects and diseases, and land use changes to meet dynamic population needs have severely altered many of the habitats and continue to threaten the integrity of the remaining fragile ecosystems and their constituent species. Agricultural activities, urban encroachment, and forestry interventions with exotic species have played a major role in this story.

Hawai‘i’s inland waterways

Hawai‘i’s streams and rivers have three features that distinguish them from those on the U.S. mainland and other large continental areas. They are much shorter—only 28 of them are more than 10 miles long. Their fall is steep and often by way of waterfalls, especially on the younger islands (Hawai‘i, the “Big Island,” being the youngest). They sometimes flow intermittently, but they are often overwhelmed by sudden, intense “flash” flooding as a result of localized heavy storms in their watersheds.

Hawai‘i’s freshwater aquatic animals evolved in response to these attributes. Because the Hawaiian archipelago is so isolated, only two closely related fish families, collectively known as *‘o‘opu* in Hawaiian, are endemic (found only here). One

unusual little Hawaiian fish, the goby, developed a muscular fin, similar to a suction cup, adapted to hold tightly onto rocks during storm events and to climb up waterfalls.

Of five species of native stream fish, four are endemic and one is indigenous (native to Hawai‘i and other locations). Native stream shellfish, all of which are endemic, consist of two crustaceans *(‘ōpae*), and three mollusks (*hihiwai, hapawai*).

Hawaiian fish require uninterrupted access to the full length of a stream system. They lay eggs in the upland (*mauka*) areas of the stream system. Upon hatching, the young migrate downstream (*makai*) and out to sea. They live in the ocean for a time and then return and migrate upstream. Stream channel alterations can interrupt this cycle. Man-made irrigation and stormwater management systems have seriously jeopardized the survival of these unique Hawaiian stream animals.

Hawaiian wildlife

As mentioned above, many of Hawai‘i’s native plants, birds, and insects are truly exclusive to our islands. Some are found on a single island, or in a single valley or hillside of an island. Truly distinctive organisms, they are adapted to one place on earth.

Another distinguishing feature of our wildlife is that many of our birds and plants co-evolved, requiring each other for survival. There are many examples of native birds with bill structures shaped for pollinating native plants. Changes in the composition of plant communities (which provide food, shelter, and habitat for birds) directly affect bird populations. On the other hand, certain native plant species have lost their pollinators and can no longer survive without man’s intervention.

Hawai‘i’s native birds and plants have always suffered from the unintended consequences of man’s activities. Scientists believe that 35 bird species became extinct after the islands were settled by Polynesians. They blame vegetation changes from agriculture, plus the introduction of alien species such as pigs, dogs, and rats. Further harm occurred after the arrival of non-Hawaiians, when native forests were burned and cut to feed a voracious export demand for sandalwood. The forests closest to Honolulu were completely consumed to meet the demands of whalers for fuelwood. Foresters rushed to restore the forest canopy in the upper reaches of the watershed, importing new, fast-growing tree species, often invasive ones. Ranchers raised cattle, goats, and sheep on the islands, further damaging native ecosystems with their hooves and browsing. Of Hawai‘i’s 329 threatened and endangered species, 273 are plants.

The Endangered Species Act applies to many plants and animals in Hawai‘i. As a farmer, if you are managing property where these organisms live, you have certain limitations on what you can do. Funding is available to help you preserve habitat for endangered plants and animals. Some landowners have developed low-impact ecotourism ventures to showcase these Hawaiian plants and animals, and their effort to increase awareness of these treasures is commendable.

Hawaiian wetlands

In the past, wetland areas (swamps, marshes, and occasionally inundated areas) around the country and the globe were targeted for filling and draining so that they could become "productive" for use in agriculture, housing, or other commercial development. As more and more wetlands disappeared, the consequences of this practice became apparent. Flooding increased because wetlands that served as water storage areas during big storm events had disappeared. Water quality declined: nutrients and sediment in storm water were no longer being filtered and purified through the wetland areas. Fish and bird populations declined because nesting and spawning areas required for their feeding and breeding were dried up.

Hawai‘i was no exception. For example, there was once a large wetland area in Waikiki. The wetland was drained by a man-made channel named the Ala Wai Canal, and it then was filled for urban development. Today, water quality in the Ala Wai is sharply impaired. The U.S. Army Corps of Engineers has begun a major study to address flooding concerns for the overlying watershed.

The remaining few wetlands in areas such as the Hanalei Valley, Kealia Pond, Kawainui Marsh, and the James Campbell Wildlife Refuge are also essential for the survival of endangered Hawaiian water-birds. Funding is available for landowners to protect and expand wetland areas on their property. Be aware of state and federal laws that restrict draining and filling of wetland areas on your property.

Interestingly, some innovative farmers on the U.S. mainland have come to view wetland wildlife as a marketing asset. They highlight this and other conservation efforts in their promotional materials for farm products or ecotourism. Certain consumers are willing to pay a premium for products that are "environmentally friendly."

Hawaiian forests

Without forests, we could not live in the Hawaiian Islands. Virtually all of our fresh water, including all drinking water, comes from the watershed areas under forest. The forests also provide us with a comfortable climate, clean air, recreation areas, plants of medicinal and cultural value, habitats for native species, and wood for commercial forestry and fine arts.

Although Hawai‘i may be well known for its lush rainforests, the dry forests found mostly on leeward mountain slopes are also valuable and are in greater danger of extinction. Almost one-fourth of the native Hawaiian plant species are found in these dry forests. An alarming 90 percent of Hawai‘i’s dry forests have been cut down for other land uses, including ranching. What little habitat remains in these areas is highly fragmented.

Invasive plants, many of which have escaped from agricultural fields or urban areas, pose a major problem for Hawai‘i’s forest resources.

Groundwater

Many Hawai‘i residents get their domestic water from wells tapping deep underground aquifers known as the fresh water “lens.” The well known deep volcanic-rock aquifer in the Pearl Harbor and central O‘ahu area and Honolulu supplies more than 90 percent of the island’s domestic water. It is highly permeable to rainfall but confined by cap-rocks at the ocean edges. The U.S. Geological Service reports that contaminants found in some well-drawn water on O‘ahu reflect the historic use of chemicals from military and urban sources, fumigants from pineapple fields, and herbicides and fertilizers from agricultural lands, parks, golf courses, and urban areas. Some of these chemicals persist for several decades. In these cases, drawn groundwater is treated to meet acceptable drinking water standards.

Hawaiian coral reefs

On the U.S. mainland and in other large continental areas, people who work and manage the uplands have often tended to forget about their impact on downstream lands and ocean resources. In small island settings, however, landscapes are compressed, and there is much more direct and immediate interaction between uplands, lowlands, and coastal waters. This is evident in Hawai‘i, where runoff, with its load of sediment and chemicals, arrives quickly to shoreline areas and coral reefs after rainstorms. This problem, called non-point source pollution, is exacerbated by land mismanagement. Because shorelines and coral reefs are central to the island’s ecology and people’s livelihoods and lifestyles, farmers and other land users bear a major responsibility for preventing the impairment of these resources. Reefs protect and stabilize shorelines from seasonal storm damage, white sandy beaches are formed and replenished from their coral, and favorite surfing spots are created by the waves breaking over them. Subsistence, commercial, and recreational fishermen harvest from the coral reef food chain.

Hawai‘i’s marine life is distinct from that of the rest of the Indo-Pacific Ocean. About 25 percent of our reef fish and algae are endemic, existing nowhere else. Most of Hawai‘i’s 1.3 million inhabitants live in close proximity to the shorelines and coral reefs.

Damage to several Hawaiian coral reefs began when livestock grazing and agriculture caused excessive runoff, erosion, and sedimentation. Dredging and filling for construction of residential, commercial, and military uses exacerbated this situation. Most recently, polluted storm water loaded with sediment and nutrients has been blamed for such phenomena as algae blooms in waters off popular beaches.

Problem: Soil erosion and sedimentation

Soil erosion is a natural geological process; however, accelerated soil erosion, exacerbated by man’s activities, is considered a form of land and environmental degradation. It is a cause for serious concern when excessive amounts of suspended soil particles (sediments) wash into the ocean, smothering reef organisms, increasing

water turbidity, and resulting in declines in fish and seaweed populations. Nutrients and pesticides attached to soil particles contaminate streams and bays, causing water quality impairment. Stream bank erosion induced by unwise land uses harms unique endangered Hawaiian stream animals (*ʻoʻopu*, *ʻōpae*, and *hihiwai*). These impacts have already been well documented throughout the islands of Hawaiʻi.

Be aware of local grading ordinances that apply to farming and are designed to protect off-site areas from flooding and sedimentation. Farmers are responsible for the quality of the water leaving their property. You can be penalized if the water is excessively turbid or your downstream neighbor's property is damaged.

Fortunately, farmers agree that the best place for soil to remain is in the farmer's field, and that topsoil is too valuable to be lost off-site. There are many things the beginning farmer can do to prevent soil from moving off the farm by wind, water, or gravity.

For technical advice on controlling erosion in Hawaiʻi, contact the nearest office of the USDA Natural Resources Conservation Service:

<www.hi.nrcs.usda.gov>

The Natural Resources Conservation Service is the nation's main source of information about agricultural erosion control. All of their standards and specification information is available to the public in the form of an electronic field office technical guide (eFOTG), which can be accessed via the Internet or as a written reference publication available at every NRCS Service Center.

Certain areas on your farm are more susceptible to erosion than others, and will require extra erosion protection (or should be avoided for agricultural and ranching uses):

- areas with long and/or steep slopes
- areas with very erodible soils
- areas where water easily forms channels across the property (waterways, streams, diversion ditches)
- areas where the soil is left bare after crop harvest or during the early growth period of new plantings, especially during the rainy season or windy periods.

How to control soil erosion

- Keep exposed, bare soil to a minimum (through mulching, cover crops, buffers, filter strips, conservation tillage, riparian buffers).
- Stabilize soil structure by incorporating crop residues and other organic materials.
- Reinforce areas subject to scouring or channel formation (using grassed and lined waterways, stream bank and shoreline protection).
- Use special land-shaping measures on slopes (contour farming, interception ditches, terraces).
- Use special measures to limit wind erosion (wind barriers, crop residues, cover crops, wildbreaks, shelterbelts).
- Keep vegetated buffer strips between production areas and sensitive features on your property (such as streams, wetlands, wildlife habitat, etc).
- Avoid seedbed preparation or crop harvesting during periods of aggressive climate, such as the rainy season.

Problem: Nutrient pollution

O‘ahu, with its urbanization and large agricultural tracts, has the distinction within our state of having more than 30 streams that are considered “water-quality impaired,” primarily for exceeding state standards for nutrients and suspended sediment. Similar problems have been identified on Hawai‘i, Kaua‘i, Maui, and Moloka‘i. Groundwater supplies under O‘ahu’s central plains have elevated levels of nitrate, attributed in part to over-fertilization of crops. High levels of nitrites in drinking water may affect infants by reducing the oxygen levels in blood, causing what is known as “blue baby syndrome.” Recent research at the University of Hawai‘i has documented widespread problems with excessive use of phosphorous fertilizers on Hawai‘i farms. This problem has been traced to using standard fertilizer formulations that over-apply unneeded nutrients.

Reduce fertilizer nutrient pollution

- Base fertilizer application rates on crop needs and on soil and tissue testing results.
- Properly calibrate equipment for accurate fertilizer application rates.
- Use fertilizer formulations to match crop needs (rather than standard formulations that may over-supply certain nutrients).
- Consider weather conditions before applying fertilizers. Do not apply soluble fertilizers right before or during large storm events. Be more cautious during the rainy season.
- Increase organic matter applications to help retain soil nutrients.
- Do not fertilize buffer areas along water bodies (streams, ponds, rivers, wetlands).
- Be very careful when applying nutrients on sandy soils (which tend to be more prone to leaching) and on shallow soils (over lava).

Organic production highlight

Organic farms can cause the same environmental problems as conventional farms. Environmental concerns associated with organic production practices may be related to

- the transition period from conventional to organic farming
- improper or incomplete nutrient management practices
- improper storage of manure or compost materials
- excessive tillage without adequate soil conservation measures.

Problem: Nutrient pollution from manure

Reduce nutrient pollution from manure

- Develop a nutrient management plan with assistance from USDA-NRCS or the UH-CTAHR Cooperative Extension Service.
- Locate manure storage areas away from wells, waterways, ocean, and public drinking water sources (legal setbacks apply).
- Install vegetated buffer strips between manure storage areas and sensitive rivers, streams, and wetlands.
- Divert clean water away from manure-storage areas.
- Test nutrients in manure to determine appropriate field application rates. Base your manure application rates on crop needs and on soil and tissue testing results.
- Do not spread raw manure within 100 feet of streams or natural drainage swales. Incorporate the manure as soon as possible.
- Watch the weather to avoid spreading raw manure prior to storm events.
- Consider using rotational-grazing pasture management to reduce waste problems.
- Consider composting to reduce the volume of manure, kill parasites, reduce odor, and produce a high-value organic fertilizer and soil amendment.

Problem: Pesticide pollution

Pesticides must be used very carefully to protect farm families and workers, farm animals, native wildlife, and the general public. Much of pesticide applicator training involves understanding the health and environmental risks associated with pesticides and learning how to use them without endangering yourself and others.

Pesticides can move away from the farm field and cause health and environmental damage in several ways. They can be transported by air (drift) in the form of particles, droplets, and vapors carried by wind. Water can carry them off-site through leaching and runoff. Hawai‘i’s fresh water is especially vulnerable to contamination from pesticide leaching through the soil and into the aquifers that we rely on for drinking water. Pesticides have also been discovered in Hawai‘i’s surface waters, carried by runoff into drainage ditches and streams to ponds and the ocean.

Pesticide residues can also pose health and environmental problems. Persistent pesticides, which take a long time to break down in the environment, may subsequently harm people, plants, and animals. The effect of bioaccumulation of pesticides within the bodies of animals and human beings is also of concern and is being researched.

Point-source pollution comes from a specific, identifiable place (a point). Point-source pollution discharges of pesticides can occur from
- wash-water and spills from equipment clean-up sites
- improper pesticide container rinsing and storage
- leaks and spills at pesticide storage sites
- spills while mixing and loading pesticides.

Certain areas are considered to be more sensitive to pesticide damage and require additional caution. These areas include
- zones near schools, playgrounds, and hospitals
- areas where groundwater recharges (wells, sinkholes, gravelly and sandy soils)
- surface waters (streams, rivers, wetlands)
- those near endangered species habitats
- those near apiaries, wildlife refuges, or parks.

Pesticide labeling should alert you to restrictions and precautions about these sensitive areas.

Sustainable agriculture practices for pesticide use

- Use the pest-control strategies outlined in Chapter 3 to help keep your use of pesticides low.
- Get pesticide applicator training from the UH-CTAHR Cooperative Extension Service’s Pesticide Risk Reduction Education Program.
- Read pesticide labels and apply them strictly according to instructions (using protective equipment, correct mixing rates, calibrated sprayer, etc.); the label is the law.
- Mix and load pesticides in an appropriate area (concrete, located away from streams, wetlands, and wells).
- Leave an unsprayed buffer strip area along streams and wetlands.
- Store pesticides in a safe area.
- Dispose of pesticides and their containers safely.

Problem: Invasive species and noxious weeds

One of the major threats to Hawai‘i’s forestry, agriculture, and livestock industries is the spread of aggressively growing plants. Whether they are termed “noxious weeds” by Hawai‘i’s Department of Agriculture or “invasive plant species” by the Department of Land and Natural Resources, these organisms possess growth characteristics that allow them to out-compete and overwhelm our native vegetation and many of our agricultural crops.

Many of these pest plants possess a climbing or smothering growth habit and can virtually choke out shrubs and trees. They may be nitrogen fixing, giving them advantage in low-fertility soils. They tend to be extremely prolific, quickly producing prodigious supplies of seeds or spores. Their propagules can be easily dispersed by animals such as birds and pigs, or by winds. They are very fast growing and can quickly gain dominance in the search for light, water, food, and space.

How did they arrive here? In the past, most of these plants were introduced by foresters, farmers, and horticulturists. The ornamental plant trade accounts for an estimated 90 percent of invasive plant introductions to Hawai‘i. Among the more serious ones currently wreaking havoc are gorse, banana poka, miconia, and ivy gourd.

Plants are not the only invasive species arriving at our shores. Scientists and land managers continue to be plagued by notorious amphibians such as coqui frogs, or stinging insects like the little fire ant. The Hawai‘i Department of Agriculture maintains a pest advisory website to help the public be on the lookout for the latest alien invaders.

How do the alien species get here? They can “stow away” in a cargo container, be sent through the mail, or be carried from a neighbor island on a plant or flower.

Control invasive species

- Stay up to date on the current invasive species of concern (via alerts from HDOA Pest Advisories, DLNR, and DOH).
- Don’t delay in reporting sightings of new plants and animals.
- Be cautious when ordering plant materials by catalog. Before you buy, check the plant in the weed risk assessment website to see if it has been ranked as a pest species.
- Respect the importance of having plant materials screened through the Hawai‘i Department of Agriculture declaration forms and checkpoints; they are there to protect Hawai‘i’s agriculture and environment!
- Apply the sustainable pest management strategies described in Chapter 3 to prevent the spread of pests and to keep pest populations low.

How can we tell whether a new plant will be invasive to Hawai‘i? Short of having a crystal ball, botanists are forced to make a “best guess.” They do that with a screening tool known as weed risk assessment. Using available information, they evaluate a plant’s invasive characteristics, where it came from, and whether it is currently a pest species here in Hawai‘i or elsewhere.

Weed Risk Assessment for Hawai‘i and other Pacific Islands:
<www.botany.hawaii.edu/faculty/daehler/wra>

HDOA Pest Hotline:
643-PEST (toll-free)

DLNR Pest Hotline: 587-0164

HDOA Pest Advisories:
<www.hawaiiag.org/hdoa/pi_pa.htm>

Problem: Poor livestock management

Livestock producers in Hawai‘i have made major changes in recent years in the way they do business, largely in response to health and environmental concerns. If not carefully managed, animal production has the potential to negatively affect surface water quality (by adding pathogens, nutrients including phosphorus and nitrogen, and organic matter). They also can impact groundwater quality (nitrates) and air quality (odors, dust, insect pests, and airborne pathogens). Allowing cattle to water and graze in riparian (streamside) areas can result in loss of vegetative cover due to consumption or trampling, additions of fecal matter and nutrients, and stream bank erosion.

Despite these risks, raising animals can complement many small farming operations and diversify income sources. Some farmers use chicken or geese for chemical-free insect or weed control. Larger grazing animals can be used to control invasive weed species such as californiagrass. Animal manure improves the soil by providing nutrients and organic matter.

Innovative farmers and ranchers are trying management methods such as rotational grazing and pasturing poultry and hogs to keep their neighbors happy, their water resources clean, and their profits up.

Sustainable livestock management

- Locate animal housing, pens, stables, corrals, and exercise yards away from wells, waterways, the ocean, and public drinking water sources; legal setbacks apply.
- Divert flowing water away from pens, barns, corrals, and exercise areas.
- Consider using rotational-grazing pasture management to reduce waste problems.
- Leave untouched vegetated buffer areas along water bodies: streams, ponds, rivers, wetlands.
- Dispose of dead animals appropriately.

Protect riparian (streamside) areas

- Fence livestock out of sensitive riparian areas.
- To prevent erosion, provide appropriate reinforced stream crossing areas.
- Provide animals with alternate water sources.

Problem: Loss of wildlife habitat

Protect Hawaiian plants

Endemic plants are native to Hawai‘i and found nowhere else in the world.

- Grow native trees, shrubs, and other plants wherever feasible.
- Never harvest endangered plants from the wild; many are now commercially available, and the market for commercially produced native plants for residential and commercial landscapes and government-mandated restoration projects is growing.
- Don’t plant a pest; invasive alien plant species disturb Hawai‘i’s distinctive native ecosystems, which support a large array of unique native plants and animals.

Water sources, streams, and wetlands always attract wildlife. Wetlands filter excess nutrients, chemicals, and sediment and provide habitat for a host of native birds, many of which are threatened or endangered. If you are fortunate enough to live near a stream or wetland, you can personally help protect many of Hawai‘i’s endangered aquatic animals and water birds.

Protect Hawaiian stream animals

- Maintain natural water flow levels in streams.
- Do not alter stream channels as they flow from mountains to the ocean.
- Prevent toxic chemicals (such as pesticides) and nutrients (from fertilizer or manure) from entering streams.
- Grow vegetated buffer strips of native plants suited to the area along streams to keep the water shaded, clear, and clean.
- Do not release exotic fish, invertebrates (snails, crayfish, shrimp), or aquatic plants into streams and wetlands—it’s against the law.

Protect Hawaiian wetland animals

- Grow vegetated buffer strips of native plants suited to the area along wetlands.
- Prevent toxic chemicals (such as pesticides) from entering wetlands.
- Do not dump trash in streams or wetlands. Stop other people who do.
- Stay away from stream and wetland areas during the wildlife breeding season.
- Keep rat populations under control. It’s healthier for your family, plus rats eat bird eggs.
- Keep cats indoors and dogs leashed—these household pets can kill a nest of young chicks within minutes.
- Do not release domestic mallards into streams and wetland areas—they compete with native birds for food and habitat.
- Work with your neighbors and conservation agencies to provide a safe wildlife corridor along streams and wetlands. Trapping and removing mongoose and feral animals aids native bird survival.

The USDA NRCS Environmental Quality Incentives Program
(EQIP) provides financial and technical assistance for conservation practices that address

- animal waste management
- sedimentation of surface waters
- noxious weeds
- insufficient water supply for livestock or irrigation
- pesticide or nutrient contamination of ground or surface waters
- at-risk species habitat
- ground and surface water conservation.

<www.hi.nrcs.usda.gov>

Funding sources for conservation

The USDA Natural Resources Conservation Service can provide technical assistance and information about federal cost-share programs that help farmers with conservation efforts.

- The ***Environmental Quality Incentives Program*** (EQIP) is used to implement conservation practices to address statewide natural resource concerns related to animal waste management, sedimentation and erosion, noxious weed control, and water quality and quantity.
- The ***Wildlife Habitat Incentive Program*** (WHIP) helps landowners develop and improve wildlife habitats on private lands. In Hawai‘i, special emphasis is placed on native forest lands, endangered species habitats, and taro lo‘i restoration.
- The ***Wetland Reserve Program*** (WRP) helps landowners and lessees restore, enhance, or create wetlands on agricultural lands.
- The ***Grassland Reserve Program*** (GRP) helps landowners restore and protect grassland, including rangeland and pastureland, while maintaining the areas as grazing lands.

The U.S. Fish and Wildlife Service (Pacific Islands Ecological Services Conservation) administers the ***Private Stewardship Grant Program*** (PSGP), a national program that provides conservation funding on a competitive basis to individuals and groups engaged in private, voluntary conservation efforts that benefit species that are endangered, threatened, candidates for these categories, or species of concern on private lands.

The Hawai‘i Department of Land and Natural Resources (DLNR) sponsors a similar program, the ***Hawai‘i Landowner Incentive Program.*** Private landowners, individually or as a group, are encouraged to submit project proposals for their properties.

The investments that you make in conservation efforts on your farm may expand opportunities for eco-tourism. By starting out small, perhaps with a bed-and-breakfast and guided nature walks, you may be able to diversify your income sources. For additional information, refer to the resources section at the end of this chapter as well as the ag-tourism section in Chapter 6, Marketing.

Resources and recommended reading

General

Agroecology: Ecological Processes in Sustainable Agriculture. 1997. Steven Gliessman. CRC Press.

Technical assistance

USDA Natural Resources Conservation Service (NRCS)
To locate the NRCS office nearest to you, contact:
NRCS Pacific Islands Area, P.O. Box 50004, Honolulu HI 96850-0050;
(808) 541-2600; <www.hi.nrcs.usda.gov>
All NRCS standards and specifications for conservation practices are available to the public in the form of an electronic field office technical guide (eFOTG), which can be accessed via the Internet. Section IV contains standards and specifications.

Pollution control

Protecting Water Quality on Organic Farms
<attra.ncat.org/attra-pub/organicmatters/om-waterquality.html>

Constructed Wetlands
<attra.ncat.org/attra-pub/wetlands.html>

Protecting Riparian Areas: Farmland Management Strategies
<attra.ncat.org/attra-pub/summaries/riparian.html>

Managed Grazing in Riparian Areas
<attra.ncat.org/attra-pub/summaries/riparian.html>

Hawai'i Pollution Prevention Information (HAPPI) Farm Series. Downloadable publications from UH-CTAHR about minimizing pollution from farming:
Water quality and your farm—Introduction to the HAPPI-Farm series
Mapping your farm to identify pollution risks
Minimizing pollution risk from land management
Minimizing pollution risk from nutrient management
Minimizing pollution risk from pest management
Minimizing pollution risk from irrigation management
Minimizing pollution risk from livestock operations
Minimizing pollution risk from pasture management
Minimizing pollution risk from storage and disposal of chemicals and fuel
Minimizing pollution risk from forest and streamside areas management
<www.ctahr.hawaii.edu/freepubs>

UH-CTAHR Agricultural Diagnostic Service Center (ADSC): This laboratory conducts feed and forage analyses, insect and plant disease identification, and chemical analyses of soils, plant tissue, and water and nutrient solutions. UH-CTAHR ADSC, 1910 East West Road, Sherman Lab 134, Honolulu, HI 96822; (808) 956-6706, fax: (808) 956-2592; e-mail: adsc@ctahr.hawaii.edu; <www.ctahr.hawaii.edu/adsc>

Pesticide pollution

Pesticide Risk Reduction Education Program, UH-CTAHR Cooperative Extension Service, contains on-line training manuals to prepare for pesticide certification exams. <pesticides.hawaii.edu/epp/pat.html>

Invasive species and noxious weeds

Weeds of Hawai'i's Pastures and Natural Areas. Philip Motooka et al. 2003. 184 p. Available for purchase from UH-CTAHR.

Hawai'i Ecosystems at Risk Project <www.hear.org>

Weed Risk Assessments for Hawai'i and the Pacific
<www.botany.hawaii.edu/faculty/daehler/wra>

Hawai'i Department of Agriculture, Pest Advisories
<www.hawaiiag.org/hdoa/pi_pa.htm>

Conservation funding resources

For information about the *Environmental Quality Incentives Program* (EQIP), *Wildlife Habitat Incentive Program* (WHIP), *Wetland Reserve Program* (WRP), and the *Grassland Reserve Program* (GRP), contact the ***USDA Natural Resources Conservation Service*** (NRCS).
To locate the NRCS office nearest to you, contact:
NRCS Pacific Islands Area, P.O. Box 50004, Honolulu HI 96850-0050;
(808) 541-2600; <www.hi.nrcs.usda.gov>

U.S. Fish and Wildlife Service, Pacific Islands Ecological Services Conservation, Private Stewardship Grant Program.
<pacificislands.fws.gov/worg/orghc_conpart.html>

Hawai'i Department of Land and Natural Resources (DLNR), Hawai'i Landowner Incentive Program. <www.state.hi.us/dlnr/dofaw/LIP>

Eco-tourism

Making Nature Your Business: Planning and Developing a Nature Tourism Enterprise. <www.tpwd.state.tx.us/nature/tourism/your_business/planning.phtml>

Agricultural Marketing Resource Center (AgMRC): Nature Based Tourism. Links to on-line manuals and success stories on eco-tourism. <www.agmrc.org/agmrc/markets/Tourism/tourism.htm>

Nature-based Tourism Enterprises. Guidelines for Success. Clemson University. 2000. Topics covered in this online document include planning and development, defining your service, start-up costs, administration, operations, creation of an Internet presence, and marketing.
<www.strom.clemson.edu/publications/Potts/nbt2000.pdf>

Sources for this chapter

Stephen S. Anthony et al. 2004. Water Quality on the Island of Oahu, Hawaii, 1999–2001. U.S. Geological Survey Circular 1239, 37 p. <pubs.usgs.gov/circ/2004/1239/pdf/circular1239.pdf>

David Gulko et al. Status of Coral Reefs in the Hawaiian Archipelago. NOAA's National Centers for Coastal Ocean Science.
<www.nccos.noaa.gov/documents/coralreef_state/hawaii_coralreef.pdf>

Division of Aquatic Resources, Hawai'i Dept. of Land and Natural Resources. Hawaiian Streams: The Mauka (mountain) to Makai (sea) Connection.
<www.hawaii.gov/dlnr/dar/streams/index.htm>

U.S. Fish and Wildlife Service, Pacific Islands Ecological Services. Endangered and Threatened Species. <www.fws.gov/pacificislands/wesa/endspindex.html>

Chapter 3

Sustainable Crop Production Methods

Production agriculture defies simple description and encompasses an extensive range of subjects and a variety of practices. By now you must realize that it is impossible to pick up just a single book to find all you need to know about how to produce crops and animals. The following section directs new farmers to some of the information sources that will aid in learning about the biological, chemical, and decision-making principles underlying sustainable and organic practices on the farm.

Organic production highlight

"**Organic farming** is a production system that avoids or largely excludes the use of synthetically compounded fertilizers, pesticides, growth regulators and livestock feed additives. To the maximum extent feasible, organic farming systems rely on crop rotations, crop residues, animal manures, legumes, green manures, off-farm organic wastes, and aspects of biological pest control to maintain soil productivity and tilth, to support plant nutrients and to control insects, weeds and other pests."

—U.S. Department of Agriculture

Also, transgenic organisms (GMOs), human wastes including sewage sludge, and food irradiation are not allowed if products are to be labeled organic.

The farm environment

Beginning farmers in Hawai‘i must recognize that they work within the limits of a fragile tropical ecosystem. They need to match the animals and crops that they grow with the limiting features of the physical environment. They accomplish this by selecting plants and livestock that are adapted to and will thrive in the conditions of the particular region of Hawai‘i where they farm. Hawai‘i’s island environment is not uniform, and large differences in environmental factors such as soil, climate, and weather can occur over short distances, from one elevation to another, from valley to ridge, from side to side of an island, and from island to island.

Water

Productive farming requires a water supply sufficient for growing the plants and animals chosen for the farm. The water supply largely determines what you can grow. The most common water sources for Hawai‘i farms are rainfall, groundwater, ditch water diverted from high-rainfall locations, “county” (municipal) water, and rainfall collected in catchment tanks. Become familiar with the water rights for the farm property and the water rates, if applicable. Get the water tested to determine its quality and suitability for the intended use. Find out how much rainfall the farm receives and the distribution of precipitation during the year. If you will need supplemental water, learn all you can about irrigation systems and designs. Surface, sprinkler, drip, or trickle irrigation systems have different advantages to match your crop and climate needs. Investigate how you can conserve water by using methods such as cover cropping, mulching, terracing, and growing drought-tolerant varieties.

Efficient water management is critical for maintaining optimum plant health and overall farm productivity. Learn to recognize the signs of water stress in your crops. Too much water deprives the plants of oxygen and can promote certain diseases, such as *Phytophthora* root rot. Too little water stresses plants, limiting their growth and yield and making them less resistant to attacks from insects and pathogens.

Climate

The amount of light (day length and effective solar radiation), the average temperature, and the weather pattern (wind, rain, temperature, and humidity) have a strong influence on what you can successfully grow. Any prevailing severe weather also requires that you apply conservation measures to prevent land and soil degradation.

Where to find climatic data

Hawai'i Climate Summaries
<www.wrcc.dri.edu/summary/climsmhi.html>

Hawai'i Crop Weather Reports
<www.nass.usda.gov/hi/speccrop/weather.htm>

Soil

The soil resource on the farm is the major physical feature that will determine what you can produce. Hawai'i's soils are extraordinarily diverse due to the many parent materials, topographic settings, and microclimates found on each island. Use the USDA Natural Resources Conservation Service (NRCS) soil maps to determine the soil types on your farm and to learn about important soil qualities such as nutrient retention, water retention, permeability, drainage, structure, texture, and depth. To identify your farm's soil and its "capability group," see <www.ctahr.hawaii.edu/soilsurvey/soils.htm>.

The beginning farmer needs to have a clear understanding of soil properties and processes. When the soil qualities mentioned above are less than optimal, crop growth is limited. For an introduction to soil science fundamentals, read *Building Soils for Better Crops,* which covers management options such as the use of cover crops, crop rotations, compost, animal manures, and low- or no-till methods.

Soil fertility

The agricultural systems developed since the early to mid-20th century are now referred to as "conventional" agriculture. Based largely on advances in chemistry, these systems emphasize meeting the nutritional requirements of plants primarily by applying readily soluble inorganic fertilizers. High solubility results in these fertilizers providing nutrients that are immediately available for plant uptake. Today, interest in soil biology has increased with broader recognition of the relationships among soil particles, microbes, insects, and plants. Influenced by our increasing knowledge of soil biology, more farmers are embracing the principles used in agricultural production systems referred to as "sustainable" and "organic."

Sustainable and organic systems attempt to meet plants' nutritional needs as much as possible by managing soil biology, chemistry, and structure to optimize soil fertility and nutrient cycling. These systems have the goal of improving the soil habitat to allow beneficial soil microorganisms to flourish. This results in healthy plants that are better able to withstand pest and disease pressures. In addition, by using these methods, some farmers are reporting improved marketability and longer shelf life for their plant products.

To meet crop nutrient needs, organic farmers generally rely on recycled animal or plant products and by-products (e.g., fish emulsion, blood meal, feather meal, bone meal, alfalfa meal, soybean meal), naturally occurring rocks and minerals (e.g., high-calcium aglime, dolomitic limestone, rock phosphates, gypsum, sulfate of potash-magnesia, mined potassium sulfate), and rock powders (e.g., glauconite [greensand], glacial gravel dust, lava sand, Azomite®, granite meal).

Organic matter and the soil food web

Organic production highlight

What can I use?

Certified-organic producers are restricted in what can be used as a fertilizer, soil amendment, or pesticide. The Organic Materials Review Institute (OMRI) provides a list of products and materials allowed and prohibited for use in organic agriculture at <www.omri. org>.

Much of farmers' efforts to maintain and improve soil health revolve around enhancing soil organic matter levels. Organic matter is important for improving soil structure to allow good root penetration, water storage, and internal drainage. It improves the ability of soils to retain plant nutrients and can supply certain nutrients such as nitrogen, phosphorous, and sulfur. Additions of organic matter often stimulate populations of beneficial soil organisms responsible for nutrient cycling. Some of these soil organisms prey on and reduce populations of plant-parasitic nematodes and other plant pathogens.

Common ways to increase and maintain organic matter and nutrient cycling in soils include applying crop residues, green manures, cover crop mulches, livestock manure, and compost.

Green manure crops, which are often nitrogen-fixing legumes, are grown primarily to be plowed under to improve soil fertility and structure. Because they remove a field from production while growing, in the past they have not been popular with Hawai'i's conventional farmers. Increasing appreciation of the benefits of green manures on the soil and the growth of following crops is contributing to their wider use. Another benefit of growing a green manure in a crop rotation is its potential role in breaking cycles of diseases that affect the other crops being grown.

Organic production highlight

Manure guidelines

Section 205.203(C)1 of the Federal Organics Rules gives the following guidelines for manures:
Raw animal manure must be composted unless it is
(i) Applied to land used for a crop not intended for human consumption;
(ii) Incorporated into the soil not less than 120 days prior to the harvest of a product whose edible portion has direct contact with the soil surface or soil particles; or
(iii) Incorporated into the soil not less than 90 days prior to the harvest of a product whose edible portion does not have direct contact with the soil surface or soil particles.

Cover crops are similar to green manures and can have similar benefits. They protect the soil surface during rest periods, and when mowed they can serve as mulch for a following crop. In non-crop areas or in orchard crops, where cover crops are planted to protect the soil surface between tree rows, they can improve trafficability, benefit soil structure and microfauna, suppress weeds, provide a habitat for beneficial insects, and reduce nutrient leaching. *Managing Cover Crops Profitably*, a book available from SARE (Sustainable Agriculture Research and Education), provides a comprehensive introduction to green manures and cover crops. UH-CTAHR has a cover and green manure crop database with information about suitable plants at <www.ctahr.hawaii.edu/sustainag/database.asp>.

Livestock manure, either fresh or composted, is a traditional source of organic matter and plant nutrients. In present-day agriculture, crop and livestock operations are often segregated, making it time-consuming and expensive to transport livestock wastes to farms. The need for manures to be composted or applied 3–4 months in advance of growing edible crops in organic production is another consideration. Because waste disposal is a problem for some livestock producers, farmers who wish to use manures can find opportunities for partnerships that will result in recycling of livestock waste nutrients. Because of the risk of raw manure containing harmful bacteria and viruses, it is important to exercise caution in their use.

Organic farms using manures must follow USDA regulations on allowable practices (see the organic production highlight, p. 25). Those guidelines are also recommended as "best management practices" for all edible crops, including those not marketed as organically grown.

Compost is a reliable means of increasing the soil's organic matter content. It contributes to moderating and stabilizing soil pH, helps with moisture retention, and improves structure. It is also a low-analysis fertilizer for gradually supplying the major nutrients (nitrogen, potassium, and phosphorus), and it usually contains a full range of minor and micro-nutrients, in small amounts. Some compost contains beneficial microorganisms. Finding a steady source of finished compost in Hawai'i can be difficult, so many farmers make it themselves. Refer to the organic production highlight at right for USDA guidelines on composting. Contact the UH-CTAHR Cooperative Extension Service to find out about upcoming compost workshops in your area. Also check with local recycling programs such as *Recycle Hawai'i* on the Big Island and *'Ōpala* on O'ahu. For additional information about animal manures and composting, refer to Chapter 4, Sustainable Animal Production.

Organic production highlight

Organic composting

Section 205.203(c)2 of the Federal Organics Rules states that compost should have been
(i) established [at] an initial carbon to nitrogen ratio of between 25:1 and 40:1, and
(ii) maintained at a temperature of between 131F and 170F for 3 days using an in-vessel or static aerated pile system, or
(iii) maintained at a temperature of between 131F and 170F for 15 days using a windrow composting system, during which period the materials must be turned a minimum of five times.

Soil and plant tissue testing

All farmers are advised to use soil and plant tissue testing to determine what soil supplements may be needed to grow crops successfully. Test results allow the farmer to apply fertilizers at the rates required by the crop. Since nutrient requirements vary from crop to crop, the farmer must become familiar with each crop's nutrient requirements and match them to soil conditions. Consult your local UH-CTAHR Cooperative Extension Service (CES) office to obtain information about nutritional requirements for the crops you wish to grow. Again, a clear understanding of nutrient cycles, especially for nitrogen and phosphorus, is vital for successful sustainable and productive cropping.

With our state's currently accelerating agricultural diversification and market expansion, there are many gaps in knowledge of the nutrient needs of newly introduced crops and varieties. You may wish to plant small test plots and experiment with alternative strategies to provide plant nutrients. By observing plant color, stem structure, overall vigor, and yield, you will gain the experience to predict how plants will respond to a given fertilizer regime.

The UH-CTAHR Agricultural Diagnostic Service Center (ADSC) conducts standard chemical analyses of soil, plant tissue, and water. It also provides plant-disease diagnosis, feed and forage analysis, and insect identification. Fertilizer recommendations from ADSC are adjusted for the diversity of Hawai'i's soils. Organic farmers may need to adjust standard ADSC recommendations for substitutions with organic fertilizers. Alternatively, when samples are submitted for analysis, ADSC should be advised of the type of organic fertilizer that will be used; in cases where its nutrient content is not known, the fertilizer also should be analyzed so that ADSC can make recommendations specific to the material.

Know your plants and animals

Choices about which crops and livestock can be produced are limited by what best matches the land's physical environment, and they should also be guided by what is appropriate based on market considerations, as discussed in Chapter 6.

When considering what to grow, learn everything you can about the biology and physiology of the species. Nothing can take the place of a farmer's thorough knowledge of the life cycle, nutritional needs, water requirements, and pest problems of the crop. You will need to know the lowest and highest temperatures that can be tolerated, how long it takes from planting to harvest, and the optimum soil pH, moisture, and fertility requirements. Much information is available from the UH-CTAHR Cooperative Extension Service. Also, look to other major universities located in similar climatic areas, such as the state universities in Florida and California, for additional sources of information. Commercial seed and other agricultural companies often also provide practical information about their products.

To match plants and animals to your local environment, look into the origin of the species, where it grows naturally, and how it performs commercially. Compare this with the crops and animals already being raised in your area. Ask long-time farmers about what they used to grow and what they are growing now. Make sure you can obtain healthy, locally adapted planting materials or livestock.

Crops that are in excellent health and well adapted to the local environment are more likely to withstand damage from insects and diseases. You decrease the risk of pest damage by selecting the right plants and animals for your conditions. As you gain more experience, you may try to overcome some limitations of your ecosystem and select a product that is more difficult to grow in Hawai‘i so that you can get a price premium for it.

Organic production highlight

Organic certification

If you have not used prohibited products on your farm for three years, you may be eligible for organic certification. To claim to be "organic" (with annual gross sales over $5,000), your farm will need to be inspected and certified by an accredited agency. Be prepared to provide detailed information to document your growing practices and history (pest, disease, and fertilization strategies, land use history, and a detailed map). Your farm will be physically inspected and a report prepared. After receiving final approval, you may label your products "certified organic."

Pest management

Farmers around the world invest considerable time and energy to protect their crops from diseases and pests. In modern conventional agriculture, pest control has often been synonymous with inorganic pesticide use. A more recent approach called integrated pest management (IPM) has developed from acknowledgment that relying exclusively on inorganic pesticides is unwise. Pests can develop resistance to pesticides; pest resurgence, often to higher levels than before, can occur because pesticides indiscriminately eliminate natural enemies of the pest; and pollinator species such as bees can be harmed, resulting in low crop yields. Also, persistent pesticide residues impair air, soil, and water quality.

Both the conventional and organic farming communities increasingly embrace IPM. It emphasizes identifying pests, monitoring pest infestations, encouraging their natural enemies, and controlling pest outbreaks and injury to crops with preference given to the least toxic materials available that are capable of effecting control.

According to the U.S. Environmental Protection Agency, IPM is a series of pest management evaluations, decisions, and practices. In practicing IPM, growers concerned with the potential for pest infestation follow a four-tiered approach.

Prevention: As a first line of pest management, IPM programs work to manage the crop to prevent pests from becoming a threat. In an agricultural crop, this may mean using cultural methods, such as rotating different crops, selecting pest-resistant varieties, and planting pest-free rootstock. These control methods can be very effective and cost-efficient and present little to no risk to people or the environment.

Monitor and identify pests: Not all insects, weeds, and other living organisms require management. Many are innocuous, and many are beneficial. IPM programs identify pests accurately and then monitor them, so that appropriate control decisions can be made in conjunction with "action thresholds," which are triggered by potential for crop loss, of one extent or another. Accurate pest identification and monitoring limits the possibility that pesticides will be used when they are not really needed or that the wrong kind of pesticide will be used.

Set action thresholds: Before taking any pest management action, IPM first sets an action threshold, a point at which pest populations or environmental conditions indicate that management action must be taken. Sighting a single pest does not always mean management is needed. Accumulating knowledge of the level at which a pest will become an economic threat is important, because it will guide future pest management decisions.

Management: Once identification, monitoring, and action thresholds indicate that pest management is required, and preventive methods are no longer effective or available, IPM programs then evaluate the proper management method both for effectiveness and risk. Effective, less risky pest management practices are chosen first; these include specifically targeted chemicals, such as pheromones to disrupt pest mating; mechanical controls such as trapping and weeding; and physical barriers such as sticky tapes. If further monitoring indicates that the less risky practices are not working, then other pest control methods might be employed, such as targeted spraying of pest-specific pesticides or, as a last resort, broadcast spraying of non-specific pesticides.

"**Biological control** is often considered a side benefit of organic matter enrichment of soil fertility. This and the diversity of crops in a well-designed rotation, the use of cover crops, and other practices build a diverse soil biology that works to keep soil pests in check. They also provide a substantial above-ground habitat for beneficial organisms. The absence of pesticides is also likely to favor biological control."

—ATTRA, *An Overview of Organic Crop Production*

Preventing pest outbreaks

The strategies used by successful farmers for pest control are sequential—they first use preventive measures to keep pest populations low.

Site selection: A good site is as pest-free as possible, with no problematic weeds, low levels of plant-parasitic nematodes, and no history of crop loss due to pathogens. Choose plant species and varieties that are well suited to the site. Assess adjacent areas for pest problems as well.

Resistant cultivars: Plant pest-resistant cultivars and varieties if they are available. Plant breeders and genetic engineers are constantly working to produce new plants with resistance to insects and plant pathogens.

Sanitation: Use good sanitation practices to prevent infection of your crops and livestock. Use disease-free seed and vegetative seed-pieces (tubers, rootstock, etc.) for planting. Clean equipment that is moved between sites to prevent spread of pathogens, weeds, and nematodes. Be sure the irrigation water is clean. Remove

crop residues that might provide shelter and food sources to unwanted pests or serve as reservoirs for disease organisms for subsequent crops.

Habitat: Modify the habitat to make it unfavorable for pest species. Areas adjacent to your crops may provide food, shelter, and alternate hosts that allow pest species to survive. Plants that can harbor pests should be replaced with plants that shelter beneficial organisms.

Cover crops: Cover crops can suppress weeds and provide food and shelter to beneficial insects, mites, and spiders.

Organic production highlight

Increasing biodiversity

"Ideally, agricultural landscapes will look like patchwork quilts: dissimilar types of crops growing at various stages and under diverse management practices. Within this confusing patchwork, pests will encounter a broader range of stresses and will have trouble locating their hosts in both space and time. Their resistance to control measures also will be hampered. As plant diversity intensifies above ground, diversity builds in the soil. Through a system of checks and balances, a medley of soil organisms helps maintain low populations of many pests. Good soil tilth and generous quantities of organic matter also can stimulate this very useful diversity in soil organisms."

—"Naturalize" Your Farming System: A Whole-Farm Approach to Managing Pests

Crop rotations: Alternate the crops grown in a field to prevent build-up of populations of soil-borne plant pathogens and nematodes.

Proper irrigation and water management: Pest or disease outbreaks can be triggered by improper water management practices. For example, certain root and crown diseases can be aggravated by excess water. Certain weeds favor areas with poor drainage.

Soil drainage: Prepare the land properly. When tilling and cultivating the soil, be sure to use methods that allow safe disposal of excess runoff, reduce soil compaction, and provide good infiltration and internal drainage.

Fertilizer and soil amendments: Proper fertilization (based on soil and tissue testing) is essential for crop health and productivity. Under- or over-application of fertilizer may enhance infestations by pests and diseases.

Least toxic pesticides

Because pests are managed most effectively when their populations are low, experienced farmers following IPM principles learn to set action thresholds and act before pest problems reach devastating levels. While these thresholds usually involve preventing economic damage to the crop, in the case of landscape plants, aesthetic damage becomes a consideration.

If there is a pest outbreak after using preventive measures and the action threshold is reached, move to the next strategy, using effective low-risk practices to reduce pest populations. If pest populations continue to escalate, use of pesticides may become necessary to prevent further crop damage. Directions and safety precautions given on the pesticide label must be followed to avoid possible harm to humans, farm species, and the environment.

Pesticides differ in their toxicity (with toxicity to humans being a key criteria), selectivity (the range of organisms affected), persistence (the length of time it takes to degrade in the environment), and mode of action (how it affects the target organism). Federal and state laws strictly regulate pesticide use. Some pesticides that are especially hazardous to human health and the environment are classed as restricted-use pesticides and are not available for use without a license issued after passing a certification exam administered by the Hawai‘i Department of Agriculture. The exam tests your ability to interpret pesticide labels and to apply label information to

pest management problems. You are expected to understand proper handling, calibration, storage, and disposal techniques; first aid and emergency response; and the fate of pesticides in the environment. Training materials and classes to educate growers about how to handle pesticides safely are available from UH-CTAHR. Additional information is available at the CTAHR Pesticide Extension website: <pesticides.hawaii.edu>.

Organic farmers will initially try the least toxic pesticide among those permitted under the National Organic Program's *National List of Allowed and Prohibited Substances*. Currently, a variety of organic-approved pesticides is for sale on the market. Most of them are minerals, botanical derivatives, soaps, pheromones, or biopesticides.

Organic production highlight

The pesticides permitted in organic farming fall predominantly into these classes:

Minerals, including sulfur, copper, diatomaceous earth, and clay-based materials like Surround®.

Botanicals, including common commercially available materials such as products derived from rotenone, neem, and pyrethrum. Less common botanicals include quassia, equisetum, and ryania. Tobacco products like Black-Leaf® 40 and strychnine are also botanicals but are prohibited in organic production due to their toxicity.

Soaps include various products labeled as insecticides, herbicides, fungicides, and algicides. Detergent-based products are not allowed for crop use in organic production.

Pheromones are hormones that can be used to confuse and disrupt pests during mating cycles, or to draw them into traps.

Biopesticides, the fastest-growing product group, offer options for organic control of highly problematic pests. An example is *Bacillus thuringiensis* (Bt), which controls lepidopterous pests and the Colorado potato beetle.

—ATTRA, *An Overview of Organic Crop Production*

Insect management

Hawai'i's year-round tropical climate provides excellent growing conditions for many species of insects, mites, and other arthropod pests. Lacking a cold winter season or very hot summer season with temperature extremes that necessitate a fallow period, pest populations can build up rapidly to damaging levels. The war on harmful insect species is continuous, and farmers must constantly monitor their fields and keep records of what they find. In addition, new pests are constantly arriving on our shores.

Insect identification is complicated because many insects undergo major changes between their immature and adult stages. Farmers need to learn what insect pests—and their natural enemies—look like throughout their life cycles. Knowledge of their habitat requirements, their mode of dispersal and movement, and the type of damage they do is helpful. Many resources are available to learn some basic entomology. Plan weekly inspections in the field with a hand lens and a photographic identification key. In the beginning, you may need to hire a trained pest control advisor or scout to help with this task.

Strategies for managing insects, arthropods, mites, and other pests

Cultural controls

- site selection: choose sites and adjacent areas considering pest potential
- use resistant or tolerant cultivars
- habitat manipulation: destroy sections that harbor pests, enhance areas that provide food and shelter for beneficial insects (field borders, insectaries)
- cover crops: select plants to provide habitat for beneficials
- trap crops: use to lure pests away from the cash crop
- crop rotation: alternate pest-susceptible crops with pest-resistant crops to avoid build-up of pest populations
- water management: especially avoid drought stress
- fertilizer management: avoid excessive nitrogen fertilizer application
- fallow period with cover crop to reduce pest populations in the soil (cutworms, root maggots, nematodes)

Mechanical controls

- soil tillage: expose insects to birds and predators
- birds: use chickens, ducks, and geese to control pests
- vacuums: to suck up insects
- barriers: floating row covers, plastic tunnels, sticky barriers, reflective mulches, insect-proof screens
- traps

Biological controls

- conservation and enhancement of natural enemies: predatory arthropods, parasitic insects, nematodes, pathogens, vertebrates (birds, bats, fish)
- augmentation: natural enemies augmented and released

Chemical controls

- less toxic insecticides: mating disruptors
- conventional insecticides
- organic insecticides

Weed management

Weeds are the great competitors of the plant world. They often are capable of abundant seed production, rapid population establishment, dormancy and long-term survival of seeds, adaptation for seed dispersal and vegetative reproduction, and exceptional ability to invade disturbed sites (such as agricultural fields). Weed control can be one of the biggest farm expenses.

Pest Advisories

Check the Hawai'i Dept. of Agriculture website for the latest pest advisories: <www.hawaiiag.org/hdoa/pi_pa.htm>

Alternatives to herbicides for weed control include new types of farm machinery, rotational grazing with weed-eating animals, weed-suppressing cover crops, and modified flame-throwers. All successful weed control strategies include preventing weed introduction, especially by seeding.

Invasive plant species

For information on whether a tree species is likely to become an invasive weed in Hawai'i, see the **Hawai'i Weed Risk Assessment** site:

<www.botany.hawaii.edu/faculty/daehler/wra>

Hawai'i's native forests have been badly damaged by invasive plant species, most of which were introduced by earlier generations of farmers, ranchers, horticulturists, and foresters. Before you introduce a new plant to Hawai'i, carefully consider its weed potential. Does the plant have any aggressive features? Could it become a noxious weed and someday make it onto Hawai'i's invasive species list? Could it jump the fence-lines and get established in adjacent fields and forests?

For more about invasive plants and noxious weeds, refer to Chapter 2, The Farm as Habitat: Environmental Topics.

Strategies for managing weeds

Cultural controls

- site selection: choose sites and adjacent areas lacking weed pests
- sanitation: use clean machinery, clean irrigation water, weed-free compost and manure

- transplants: use to outcompete weeds
- increase crop density: plant the crop closer to outcompete weeds
- smother and cover crops: suppress weeds between rows
- mulches: old hay, straw, wood chips to suppress weeds between rows
- living mulch: cereal, clover, or vetch crops grown between rows and killed before planting the cash crop to avoid competition
- proper irrigation and water management: buried drip tape to minimize water available to weeds
- reduce weed seed bank: no weed allowed to go to seed; off-season weed control

Mechanical controls

- soil tillage: shallow cultivation
- mowing: before weeds set seed, at low soil moisture
- flaming: burning weeds
- stale seedbed: pre-germinate weeds, then destroy by cultivation, herbicide, or flamer
- solarization: plastic mulch over tilled, moist soil to allow solar energy to kill weed seeds

Biological controls

- insects
- pathogens
- vertebrates: fish, birds (weeder geese, ducks), cattle, sheep

Chemical controls

- conventional herbicides
- organic herbicides: acetic acid, citric acid, sodium nitrate, corn gluten

Plant disease management

Plant pathogens are mainly fungi, bacteria, viruses, viroids, phytoplasmas, or nematodes. Although Hawai‘i is remote and naturally relatively pathogen free, the local, regional, and global movement of people, birds, animals, plant materials, and farming equipment have introduced many plant diseases that are now well established in Hawai‘i. The environment allows pathogens to thrive. Introduced pathogens are a constant problem for our agriculture and environment.

Pathogen identification requires specialized knowledge and equipment available from private laboratories and government agencies. The UH-CTAHR Agricultural Diagnostic Services Center is one source of such assistance.

As for all matters of health, prevention is better than cure! The best practices minimize conditions that harbor disease, increase pathogen survival, or promote pathogen multiplication. Specifically, you need to be mindful of good sanitation practices, optimal water management, suitable plant spacing, and new plant materials or farming equipment entering your farm. Crop rotation has also been demonstrated to greatly reduce the pathogen proliferation. Promising new methods to control plant disease using biological agents (such as disease-suppressive composts and compost teas) appear to be on the horizon.

Strategies for managing plant disease

Cultural controls

- site selection: choose sites and adjacent areas lacking a history of plant pathogens and free of plants that are pathogen vectors
- resistant cultivars: choose a resistant or tolerant cultivar, if available
- sanitation: exclude pathogens with sanitation practices at all points in the production cycle (in greenhouses, on equipment, in fields, postharvest)
- habitat manipulation: use green manures and composts to enhance beneficial organisms in the soil food web and promote disease-suppressive soils; adjust plant spacing and irrigation practices to promote natural ventilation, reduce relative humidity, and limit persistence of moisture on crop leaves
- cover crops: select cover crops that are not hosts of nematodes
- crop rotation: alternate non-host crops to avoid build-up of pathogen populations; plant disease-suppressive crops (broccoli, mustards, sudangrass)
- adjust planting and harvesting dates: avoid seasons favorable to pathogen outbreaks, or plant an alternate crop that tolerates these conditions
- proper irrigation and water management: over-watering favors most soil-borne pathogenic fungi; overhead sprinkler irrigation favors foliar disease survival, dispersal, and development; drip irrigation or subsurface irrigation may be preferable; greenhouses or rain shelters keep rain off plants
- soil drainage: poor soil and planting bed preparation can favor damping-off fungi
- fertilizer management: excessive nitrogen fertilizer can promote disease susceptibility; raised pH levels can reduce symptom expression for club-root disease of crucifers
- fallow period with cover crop: reduce pathogen populations by keeping fields free of host plants
- vector control: control weed and insect hosts of viral and bacterial pathogens
- alternate hosts: avoid cover crops, green manures, and rotated crops that serve as alternate hosts of nematodes and other pathogens

Mechanical controls

- soil tillage: deep-plow infected plant residues
- solarization: plastic mulch over tilled, moist soil to allow solar energy to kill pathogens

Biological controls

- myco-pesticides
- composts and compost teas can suppress some diseases
- biopesticides (commercially available *Bacillus subtilis*, *Bacillus thuringiensis*)

Chemical controls

- conventional pesticides
- organic-approved pesticides: copper, sulfur, or bicarbonate based fungicides; oils, plant extracts, compost teas

Resources and recommended reading

Climate

Hawai‘i Climate Summaries (WRCC, NOAA)
<www.wrcc.dri.edu/summary/climsmhi.html>

Hawai‘i and Pacific Island Local Climate Summaries (WRCC, NOAA)
<www.wrcc.dri.edu/summary/lcdpi.html>

Hawai‘i Crop Weather Reports (HASS)
<www.nass.usda.gov/hi/speccrop/weather.htm>

Soils, general

USDA NRCS Hawai‘i Soil Survey. The "Hawai‘i Soils" site features on-line maps and descriptions of the soils found in the Hawaiian Islands. <www.ctahr.hawaii.edu/soilsurvey/soils.htm>

Building Soils for Better Crops from Sustainable Agriculture Publications, available on-line as a downloadable file. <www.sare.org/publications/bsbc/bsbc.pdf>

NRCS Soil Quality Institute Soil Biology Primer is an introduction to the living component of soil and how it contributes to agricultural productivity, and air and water quality. The Primer includes units describing the soil food web and its relationship to soil health, and units about bacteria, fungi, protozoa, nematodes, arthropods, and earthworms. Soil and Water Conservation Society (December 2000). <www.swcs.org/en/publications/books/soil_biology_primer.cfm>

Soil Central. UH-CTAHR webpage about soils of Hawai‘i, includes soil fertility and chemistry information, soil testing, and other useful links.
<www.ctahr.hawaii.edu/ctahr2001/soil>

Plant Nutrient Management in Hawaii's Soils. UH-CTAHR publication containing practical research information on soils, fertilizers, and crop nutrient needs, written for the lay reader for Hawai‘i's crops and soil conditions. Available for purchase from CTAHR; downloadable at <www.ctahr.hawaii.edu/freepubs> under the category Soil and Crop Management.

Soil testing

Testing Your Soil: Why and How to Take a Soil-Test Sample
<www.ctahr.hawaii.edu/oc/freepubs/pdf/AS-4.pdf>

CTAHR's Agricultural Diagnostic Service Center (ADSC): This lab conducts plant disease diagnosis, feed and forage analyses, insect identification, and chemical analyses of soil, plant tissue, water, and nutrient solutions.
College of Tropical Agriculture and Human Resources, University of Hawai‘i at Mānoa; 1910 East West Road, Sherman Lab 134, Honolulu, HI 96822; (808) 956-6706, fax: (808) 956-2592; e-mail: adsc@ctahr.hawaii.edu; <www.ctahr.hawaii.edu/adsc>

Cover crops

Managing Cover Crops Profitably. USDA Sustainable Agriculture Network (SAN). An online pdf version of the book is available, and the second edition can be purchased. <www.sare.org/publications/covercrops/covercrops.pdf>

Sustainable Agriculture in Hawai'i: Cover Crop and Green Manure Database provides information about plants that are suitable for Hawai'i's climate. Includes downloadable publications. <www.ctahr.hawaii.edu/sustainag/Database.asp>

Crop knowledge, general

UH College of Tropical Agriculture and Human Resources (CTAHR) has free and for-sale publications with a wide range of information. Free publications are downloadable and cover producing fruits and nuts, home garden vegetables, ornamentals and flowers, green manures and cover crops, insect pests, plant disease, weed control, and crop and soil management. For-sale publications include production manuals for taro, coffee, tea, onions, corn, and lei plants. <www.ctahr.hawaii.edu>

CTAHR ***Ask the Experts*** Database contains hundreds of questions and answers on a variety of topics. It includes access points for CTAHR's ***Publications Database***, ***Knowledge Master*** (weeds, diseases, and pests), ***Pesticide Information Retrieval System*** (for commercial users of agricultural chemicals), and ***The Farmer's Bookshelf*** (production information about many fruits, vegetables, ornamental plants, and home garden vegetables). <pdcs.ctahr.hawaii.edu:591/ate>

Pest management

IPM in Practice: Principles and Methods of Integrated Pest Management. Mary Louise Fling and Patricia Gouveia. 2001. University of California at Davis. 296 p.

Organic Crop Production Overview. G. Kuepper and L. Gegner. 2004. National Center for Appropriate Technology, Butte MT. 28 p.

A Whole-farm Approach to Managing Pests. Sustainable Agriculture Research and Education. SARE Bulletin. <www.sare.org/publications/farmpest.htm>

Integrated Pest Management (IPM) and Food Production. U.S. Environmental Protection Agency. <www.epa.gov/pesticides/factsheets/ipm.htm>

Pesticides

Pesticide Risk Reduction Education Program, UH-CTAHR Cooperative Extension Service, contains on-line training manuals to prepare for pesticide certification exams. <pesticides.hawaii.edu/epp/pat.html>

Pesticide Branch, Hawai'i Department of Agriculture. <www.hawaiiag.org/hdoa/pi_pest.htm>

Insect management

Knowledge Master is a website for extension entomology from the UH-CTAHR Integrated Pest Management Program containing general information on pest hosts, distribution, damage, biology, and management. It can be helpful for pest identification. The management recommendations are for conventional agricultural practices and will most likely need modification for sustainable systems. <www.extento.hawaii.edu/kbase/default.htm>

Weed management

Steel in the Field: A Farmers Guide to Weed Management Tools, USDA's Sustainable Agriculture Network (SAN), 2001. 128 pp. <www.sare.org/publications/steel/steel.pdf>

Weeds of Hawai'i's Pastures and Natural Areas. Philip Motooka et al. 2003. 184 p. Available for purchase from UH-CTAHR.

Organic production resources

Organic Agriculture at CTAHR <www.ctahr.hawaii.edu/organic>

Hawaii Organic Farmers Association is a nonprofit organization that provides information and education, farm apprenticeship programs, and organic certification for Hawai'i's farmers. They sell a handbook that familiarizes beginning farmers with the federal rules on organic practices ($15).
Hawaii Organic Farmers Association (HOFA)
P.O. Box 6863, Hilo, HI 96720; Phone: (808) 969-7789 toll-free: (877) 674-4632
E-mail: hofa@hawaiiorganicfarmers.org; <www.hawaiiorganicfarmers.org>

Organic Fruits and Vegetables from the Tropics, available from United Nations Conference on Trade and Development (UNCTAD) at <www.unctad.org/en/docs/ditccom20032_en.pdf>

Organic Materials Review Institute (OMRI) <www.omri.org>

Organic Farming Research Foundation (OFRF) <www.ofrf.org>

Organic Trade Association (OTA) <www.ota.com/index.html>

USDA National Organic Program <www.ams.usda.gov/nop/indexIE.htm>

Local assistance

University of Hawai'i—CTAHR Cooperative Extension Service (CES)
To locate the CES office nearest to you, contact:
Cooperative Extension Service
3050 Maile Way, Gilmore Hall 203, Honolulu HI 96822; (808) 956-8397
E-mail: extension@ctahr.hawaii.edu; <www.ctahr.hawaii.edu>

Natural Resources Conservation Service (NRCS)
To located the NRCS office nearest to you, contact:
NRCS Pacific Islands Area, PO Box 50004, Honolulu HI 96850-0050; (808) 541-2600; <www.hi.nrcs.usda.gov>

Sources for this chapter

Fling, L., and P. Gouveia. 2001. IPM in Practice: Principles and Methods of Integrated Pest Management. University of California at Davis. 296 p.

Kuepper, G., and L. Gegner. 2004. Organic Crop Production Overview. National Center for Appropriate Technology. Butte MT. 28 p.

Sustainable Agriculture Research and Education. A Whole-farm Approach to Managing Pests. SARE Bulletin. <www.sare.org/publications/farmpest.htm>

U.S. EPA. Integrated Pest Management (IPM) and Food Production. Accessed 04/25/06. <www.epa.gov/pesticides/factsheets/ipm.htm>

Chapter 4

Sustainable Animal Production

With each wave of immigrants to reach these remote islands, people have brought with them their favorite beasts. Whether pigs transported in Polynesian voyaging canoes, black longhorn cattle or axis deer gifted to King Kamehameha, or domesticated sheep and goats introduced by European settlers, most of these animals are now part of our local culture, history, and economy. Some of them have escaped into the wild and become environmental terrors. The fact remains, we like our animals. Every day most people in Hawai‘i eat high-quality protein derived from livestock and use products derived from these animals. Some are even able to manage their livestock in ways that help reduce human drudgery.

On the farm or within a grassland ecosystem, plants and animals tend to complement each other. Ruminants (such as cattle, sheep, and goats) can convert plant fiber, which is indigestible to humans, into meat, milk, wool, and other valuable products. Domesticated birds scavenge for insects, reducing insect pest pressures on crops. Animal manure fertilizes and increases organic matter and nutrient cycling within the soil, restoring nutrients to the crop or pasture system. Some innovative farmers have their animals to do their dirty work—using pigs to turn compost or ducks to clip weeds or eat snails. The art and science of managing these plant and animal interactions is a challenge for any new farmer to learn.

Hawai‘i’s *paniolo*—a proud culture

The first cattle arrived in Hawai‘i in 1793, a gift of five longhorns to King Kamehameha I delivered to the island of Hawai‘i. The King placed a taboo on slaughtering the cattle, and they thrived. By 1832, wild cattle had grown numerous, becoming a problem. King Kamehameha III arranged to have three Mexican cowboys come to help thin the herds. Hawaiians quickly learned from the cowboys how to ride horses, rope, and tame the wild cattle, and became known as *paniolo*. When Waimea’s Ikua Purdy won the World Rodeo Championship in 1908, the Hawaiian *paniolo* received world-wide recognition. The slack key guitar style was also created by Hawaiian *paniolo*.

Is this really for you?

Unlike crop production, where plants can sometimes be ignored for a while without mishap, caring for livestock is a 365-day-a-year job requiring a great investment of time. Before starting a livestock enterprise, you will need to do extensive research. Be sure to consider the following issues before you make your final decision about getting into the business.

Legal restrictions: First, determine if your property is zoned to allow domestic livestock agriculture. Find this information at your county’s planning department. Learn about other regulations that affect a livestock operation, such as required setbacks for dwellings and wells, restrictions on barns and fencing, and nuisance laws regulating noise, dust, odor, and flies.

Pets or food? Many people enjoy raising animals. An important thing to decide is whether the animals are pets or food. The entire family needs to agree on the answer to this from the beginning, to avoid painful scenes at slaughter time. Of course, a farm may have both—for example, a mother sow or milk goat may be treated as a pet, while the offspring are strictly food, but what happens if the sow or goat is no longer productive? If animals are being kept as pets, choose neutered animals of a small breed. If livestock are being raised for food, be prepared for unpleasant tasks such as castration and slaughter.

Markets: If you are planning to raise livestock to produce food or commercial products, talk to your potential customers first to find out what they will buy and at what price. If you can produce the desired product at a cost below the price offered, you are on your way to a profitable venture. Understanding what the customer wants will help you to make decisions about breeds and crosses, feeding systems, and many other management factors.

Genetics: The best breeds to raise will depend on your market and production needs. Crossbreds will almost always outperform purebreds if a plan that crosses unrelated breeds or families is followed. Animals obtained locally will be best adapted to Hawai‘i’s environment. The best sources are local farms with good production, good records, and few disease problems. Because inbreeding in a small group of animals will quickly lead to reduced performance, unrelated males need to be used for every group of females selected for breeding. Artificial insemination is highly recommended for even the smallest farms to bring in high quality genetics with very little risk of bringing new disease onto the farm. For assistance with artificial insemination, contact the Cooperative Extension Service.

Feed: Understand the nutritional needs of the animals you want to raise. This will differ greatly from one animal to another based on their size and digestive systems. Food requirements also vary with age and the production stage of the animal (growing, breeding, pregnant, lactating, dry).

Your decision about how many animals to raise will partly be based on the volume of feed they will consume. You will need to assess your ability to pay for feed or to produce it.

Generally, animals either are left on pasture, or feed is purchased or cut and fed. In Hawai‘i, transportation costs tend to make feed costs higher than for U.S. mainland competitors. Get a good handle on what your feed costs will be and how they will vary before getting into this business.

If you have access to land, forage from pasture or from orchard groundcover may be an option available for grazing livestock. Several factors determine how much forage the land can produce—climate, topography, soil type and fertility, irrigation availability, and the grazing management system that you use. Pastures can be improved through fertilizer, weed control, pasture renovation, and reseeding. Consult your local Cooperative Extension agent to determine how much forage your land can produce. Consider selecting breeds best adapted to your climate and grazing system.

Animal types

Monogastric animals (pigs, fish, dogs) must consume high-quality balanced diets. Swine need a high-energy, concentrated grain diet low in fiber (cellulose) and supplemented with adequate protein.

Poultry have a monogastric digestive system. Feed rations will vary for meat or egg production.

Nonruminant herbivores (horses, rabbits, guinea pigs, hamsters) need intermediate levels of roughage, high quality protein, and added vitamins.

Ruminants (cows, goats, sheep, elk, deer, bison, llamas, and alpacas) have complex multi-chambered stomachs containing microorganisms that convert cellulose into energy. They can process large quantities of bulky forages to provide their nutrients.

Grazing livestock under orchards

More frequently now, chickens, geese, and sheep are seen foraging or grazing beneath trees in Hawai'i's coffee, macadamia nut, and fruit orchards. Farmers are taking advantage of natural plant-animal relationships by growing nutritious grasses and legumes in their orchards. In addition to providing erosion control and weed suppression, these groundcovers are selected to provide grazing for livestock. Poultry can forage for insects and seeds in the groundcover. The livestock or poultry provide a secondary income source for the farm.

Traditional ranching once employed continuous-grazing systems, but today most ranchers practice rotational-grazing management systems. With this method, pastures are subdivided into paddocks, and animals are moved through these paddocks at frequent intervals, allowing them access to a limited pasture area for a short period of time. This idea is being adapted to other species as well, engendering a market for "pastured" pigs and poultry.

Health: A herd or flock health plan is vital for maintaining the health of your animals. A health plan should have three elements: (1) biosecurity to keep new diseases out, (2) sanitation measures to keep the levels of diseases and parasites low, and (3) a program such as vaccination to keep the level of resistance high. The most common carriers of disease are other animals, so problems can be minimized by starting with healthy animals from a single source. Buying animals locally will ensure that you do not bring any new disease into the area.

Consult a local veterinarian to understand the health care requirements and expenses for your livestock. Be aware that internal and external parasites pose a serious concern in the tropics and subtropics. Establish a parasite control program for your livestock. Health care also includes preventative measures such as proper nutrition, maintaining vaccinations, record-keeping, and quarantining new animals. Become informed about toxic weeds in your area that can harm your animals.

As well as maintaining a healthy herd or flock, it is important to produce safe products for your market and consumers. Most livestock and poultry industry associations have quality assurance programs that outline key measures to ensure quality products free of physical, chemical, or biological contamination. Check with your industry association regarding quality assurance programs and certification.

Water supply: Project how much water your livestock will need, realizing that their water requirements will vary by species, breed, animal age, time of year, and climate. Do research and plan how you will get water to them. Many farmers use "county" water for housed animals. If county water is not available, some options may include:

Hauled water: This can work well for rotational grazing schemes. Move the water source within the pasture to distribute animal damage and manure.

Pipeline systems: A pumping system can be solar-, wind-, gas- or diesel-powered, or gravity-fed to troughs and tanks. Animal-operated drinkers (such as nose pumps and nipple waterers) are also available and keep water fresher and cleaner than water sitting in open troughs.

Stream or pond water: Livestock tend to damage stream banks with their hooves, defecate in the water, and consume streamside plants. To protect riparian areas, control and limit livestock access to streams and build a stable (gravel) livestock access area. (USDA cost-sharing funds are generally available for stream protection measures.)

Springs: If there is a spring on the property, find out if you are legally allowed to use it for a livestock water supply. Test the water to check for contamination.

Shelter: Animals require housing to keep them safe and comfortable. Housing can provide shade, shelter from wind and rain, protection from predators and aggression, and can make it easier to work with the animals. Good layout can help to protect against theft. Shelter structures range from simple pole sheds to full-scale barns. Portable shelters are very practical for avoiding buildup of manure and urine in rotational grazing systems. Before you build, take into consideration installation, cost, appearance, longevity, and maintenance factors. Standard plans for livestock shelters are available for purchase and on-line.

Space: Determine the space requirements of the animals you plan to raise. If you need to erect fencing, consider the advantages and disadvantages of each kind of fencing: installation, cost, appearance, safety, longevity, and maintenance issues. Trees around livestock areas create shelterbelts providing shade and protection from wind in open lots or pastoral systems.

Predator control: Sheep, goats, and poultry are vulnerable to attack by dogs. Young poultry and waterfowl are subject to predation by cats, mongoose, owls, and hawks. They will require a protective shelter or housing. A good perimeter fence line will protect your livestock. In some cases an additional low electric fence may be required to prevent dogs from digging below the main fence.

Manure: One of the most time-consuming aspects of livestock production, manure management, is the aspect of your operation most likely to draw complaints. If you are not familiar with this part of animal husbandry, it is hard to imagine ahead of time just how much manure you will be handling. Before going any further with your plans, work with local agricultural professionals to develop a good estimate of how much manure your new livestock operation will produce.

One option for manure management is to develop a rotational grazing system that prevents build-up of animal wastes.

Good manure management will keep your livestock healthy, return nutrients to the soil, improve pastures and cropland, and protect the environment. Poor manure management may increase insect and parasite populations that can make your livestock sick and may generate angry phone calls from your neighbors. Inadequate manure management may lead to nutrient and bacterial contamination of surface and groundwater resources.

You will need to address how to collect, store, remove, treat and/or apply manure. The Cooperative Extension Service and the USDA Natural Resources Conservation Service can provide information about manure management options. Many farmers use their manure on-site to improve soil fertility. New partnerships are emerging between livestock and crop producers to recycle surplus manure back to neighboring farm fields. There is also a growing market demand for composted manure by gardeners, landscapers, and farmers.

Composting is an environmentally friendly option for managing your manure. A good composting operation will reduce the volume of manure, kill parasites, reduce odor, and result in an excellent soil amendment. Because composting is a biological process that relies on living microorganisms, you will need to learn how to manage compost piles to obtain optimal temperatures, correct carbon to nitrogen

ratios, and adjust adequate oxygen and moisture content. Sales of a high-quality compost product can help generate revenue from a waste product.

On-farm processing and slaughterhouses: Before you enter into livestock production, consider the slaughterhouse and processing options. For some species, such as broilers or sheep, it is difficult to locate commercial processors. If you do not get too queasy about the thought of killing, plucking, gutting, and skinning animals, on-farm processing may be an option for poultry producers. Be aware that there are strict federal processing regulations. Small, independent poultry producers may be exempt from federal inspection rules—but be sure to research this ahead of time. Designs for small on-farm abattoirs and mobile abattoirs are available.

Management and records: Farmers with animals have a responsibility to provide for the care and well being of the animals. This benefits the farmer as well as the animals, because comfortable animals are more productive. The farmer should understand the needs of the animals and have the resources to meet them. Animal identification and records are important because the first sign of a problem is often a slight decrease in growth or production. Industry programs such as the Swine Welfare Assurance Program™ and the United Egg Producers are available to assist farmers to provide the best possible care for their animals.

Farmers need to manage many factors affecting production. As well as the husbandry basics discussed above, farmers need to know about and appropriately schedule management practices such as breeding, weaning, castration, molting, etc.

Starting small

If you have not worked with animals, as a new farmer you should begin with a small-scale facility and gain experience with smaller animals that are generally less expensive to purchase and require less space to manage. Sources of information about raising animals are available at the end of this chapter. Another option for gaining experience is to work with another farmer for a few months.

Poultry and waterfowl

The low investment and small area required for raising a flock of domestic poultry or waterfowl (chickens, ducks, geese, turkeys, etc.) makes these animals a good option for the beginning farmer. Domestic poultry can supplement the family menu, as well as generate several niche products. For example, producers can sell free-range or organic meat and eggs, brown eggs, live birds for ethnic markets, and birds for hobby and leisure.

The market for free-range poultry and pastured poultry (raised in large pens moved rotationally in a pasture) is a growing niche market that taps into consumer demand for more natural and humanely raised protein sources. Consumers who purchase such poultry products are generally willing to pay more. The product is considered by many consumers to be healthier and tastier, as well as more environmentally sound.

Another growing niche market is for "designer eggs"—eggs with higher concentrations of vitamin E or omega-3 fatty acids. By modifying the diet of laying hens, farmers can produce eggs that contain significantly more vitamin E and omega-3 fatty acids than ordinary eggs. Free-range and organically grown eggs are also enjoying growing popularity. Some consumers will pay a premium for brown-shelled eggs. Eggs will most likely need to be processed on the farm.

Swine

You can't have a *lūʻau* without a pig. The *puaʻa* (Hawaiian for pig) has both traditional and contemporary value within Hawaiian culture (as well as within other Pacific and Asian cultures). Ethnic markets demand "hot pork," killed within 12 hours, for its flavor and texture. Local production of swine cannot meet the current demand, so Hawaiʻi imports most of its supermarket pork. Hawaiʻi's pork producers focus on high-priced niche markets.

Demand for swine that are purchased live and slaughtered by the customer for family use is very strong—so strong that theft can be a problem. The pig is the only litter-bearing large animal, and your investment in a sow should produce about 16 pigs ready for market within a year.

Raising swine on a small farm (3–5 acres) is common in Hawaiʻi and fairly easy to do. Pigs can be fed imported feed or food, but they are most valuable for recycling food and agricultural waste products (such as cooked food scraps and culled macadamia nuts, fruits, and vegetables). Farmers feeding food scraps must obtain a free permit from USDA and must thoroughly cook the scraps before feeding them to the pigs. An effective manure management system is needed to avoid problems such as odor complaints. Examples of systems that have worked well in Hawaiʻi and the Pacific include the dry-litter system, composting, drying, flush systems, small digesters, and ponds.

Rabbits

With a minimum investment, relatively limited space, and a modest investment of labor, beginning farmers can start raising rabbits for meat and for the pet market. In Hawaiʻi, locally raised rabbit meat can be found at grocery stores. Pet rabbits are especially popular around Easter and Christmas.

Goats

In Hawaiʻi there is a market for goat meat within ethnic communities, particularly those that celebrate weddings and commemorate religious feasts with goat meat. Locally produced goat milk and cheese products are currently being sold, primarily as high-value products to hotels. Commercial slaughter service is available on Maui.

When raising animals, be a good neighbor

Obey zoning restrictions. Raise animals only where it is allowed.

Manage manure well. Good manure management operations will have little odor and few flies. Be sure your livestock is not the source of other pests (mosquitoes, gnats, fleas, ticks, lice).

Control disease. Don't be the one to bring a new animal disease into your neighborhood. Hawai'i is free of some diseases that are common on the U.S. mainland.

Prevent runoff problems. Use measures to prevent soil and manure from leaving your farm during heavy rains.

Protect groundwater. Be sure that you are not overstocking animals and causing a pollution problem.

Control dust. Dust is harmful to your animals' health and will irritate the neighbors. Use good sod or pasture management.

Keep the noise down. Locate your animals away from your neighbor's bedroom windows.

Keep your operation neat. Use paint and landscaping to keep your farm attractive.

Visit your neighbors and explain what you're doing. Invite them to visit you and your farm.

Sheep

Sheep can be useful to manage grass, but the market for mutton is limited. Commercial slaughter service is available on Maui and the Big Island.

Horses

While it is not uncommon for farmers to keep a few horses, they usually are pets used for pleasure or, more recently, for agtourism. Some innovative farmers may board or breed pet horses, exotic horses, workhorses, miniature horses, or race horses.

Cattle

Beef or dairy cows may be kept on farms for family use or for income. The most popular beef breeds are Angus and Brangus (Brahman-Angus cross). Crossbred cattle will generally out-perform purebred cattle. Although there may be niche markets for exotic breeds, these should be considered with caution. Belgian Blues, for example, have a much higher rate of birthing difficulties than other breeds.

Using pasture to raise a small herd of beef cattle for local consumers is an option for today's *paniolo*. There is a potential to develop niche markets in grass-fed or forage-based beef. For best results, small breeds such as Angus cross cattle are recommended. If cattle are finished on pasture, excellent management is needed to promote fast growth so the animals are slaughtered while young; older animals will be very tough. Grain finishing is generally not cost-effective in Hawai'i, but pasture can be supplemented with by-product feeds to improve growth.

Dairy herds need to be large because processors are not equipped to accept small quantities of milk from small-scale producers. If a cow is kept for personal use, milk should be pasteurized using a commercially available home pasteurization machine.

Larger species have larger acreage requirements. Consult a UH-CTAHR Cooperative Extension Service livestock agent for additional information.

Bees

Honey production tends to be more of a hobby than a commercial enterprise in Hawai'i. Bees can be valuable for pollination. Honey processing costs tend to be high.

Aquaculture

Aquaculture is rapidly expanding in Hawai'i and worldwide and provides many opportunities for small producers. Aquaculture species range from ornamentals to shrimp and finfish. Backyard tanks and aquaria do not require much space. The Sea Grant Extension Program can provide more information.

Resources and recommended reading

General

Hawai'i Cattlemen's Council <www.hicattle.org>

UH-CTAHR Beef Initative <www.ctahr.hawaii.edu/paniolo>

Midwest Plan Service. Iowa State University <www.mwps.org>

Composting resources

On-Farm Composting Handbook. 1992. NRAES (Natural Resource, Agriculture, and Engineering Service), (607) 255-7654, nraes@cornell.edu. <www.nraes.org/publications/nraes54.html>

Composting Resources: A Series. This 3-tape video program covers the benefits and costs of agricultural composting, ongoing research, and practical farmer interviews. To order contact Agricultural Education & Extension Education, Video/Distance Learning Group, P.O. Box 442329, University of Idaho, Moscow, ID 83844-2329, (208) 885-7985.

Cost-share assistance

The USDA NRCS Environmental Quality Incentives Program (EQIP) provides financial and technical assistance to farmers and ranchers who install conservation practices to address pasture improvement, animal waste management, and insufficient water supply for livestock. Contact your local USDA Natural Resources Conservation Service field office or see <www.hi.nrcs.usda.gov>

Dairy

Home Pasteurization of Raw Milk. 1999.
South Dakota State University <agbiopubs.sdstate.edu/articles/ExEx14054.pdf>

Exotics

Ratite Production: Ostrich, Emu and Rhea. ATTRA. <attra.ncat.org/attra-pub/ratite.html>

American Ostrich Association, PO Box 163, Ranger, TX 76470 <www.ostriches.org>

American Emu Association, PO Box 224, Sixes, OR 97476 <www.aea-emu.org>

Grazing and rangeland management

UH-CTAHR Forages Website. <www.ctahr.hawaii.edu/forages>

Grazing Livestock Under Orchards. Glen Fukumoto. <www.ctahr.hawaii.edu/ctahr2001/InfoCenter/Forages/extensionResearch/GrazingUnderOrchards.doc>

Grazing Management: An Ecological Perspective. Rodney K. Heitschmidt and Jerry W. Stuth (editors). 1991. Timber Press, Inc., Portland, OR.

Rangeland Ecology and Management. Harold F. Heady and R. Dennis Child. 1994. Westview Press, Boulder, CO.

Range Development and Improvements (3rd edition). John F. Vallentine. 1989. Academic Press, Inc., San Diego, CA.

Range Management Principles and Practices. Jerry L. Holechek, Rex D. Pieper, and Carlton H. Herbel. 1989. Prentice Hall, Englewood Cliffs, NJ.

Range Economics. John P. Workman. 1986. Macmillan Publishing Company, NY.

Intensive Grazing Management: Forage, Animals, Men, Profits. Burt Smith, PingSun Leung, and George Love. 1986. The Graziers Hui, P.O. Box 1944, Kamuela, HI 96743; (808) 885-7553. 350 p.

Manure management

Farm-Scale Composting Resource List
<attra.ncat.org/attra-pub/farmcompost.html>

A Portable Dry-Litter Pig Pen. Glen Fukumoto and Jim Wimberly. 2004.
<www.ctahr.hawaii.edu/oc/freepubs/pdf/AWM-2.pdf>

Swine Waste Management for Pacific Islands. A series of downloadable publications from the UH-CTAHR Agricultural Development in the American Pacific project, <www.ctahr.hawaii.edu/adap2/information/pubs/adap_publications.htm>

Poultry

American Pastured Poultry Producers Association, APPPA, P.O. Box 1024, Chippewa Falls, WI 54729; (715) 577-5966; e-mail grit@apppa.org; <www.apppa.org>

The Breeders Directory, Society for the Preservation of Poultry Antiquities, lists breeders of rare and antique poultry, their stock, and delivery methods. Contact Glenn Drowns, 1878 230th Street, Calamus, IA 52729-9659; (563) 246-2299.

Pastured Poultry Profits by Joel Salatin (book and how-to video). Available from Acres USA, (800) 355-5313. <www.acresusa.com/magazines/magazine.htm>

Profitable Poultry: Raising Birds on Pasture. This Sustainable Agriculture Network (SAN) bulletin features the latest research in a new "how-to" guide to raising chickens and turkeys using pens, movable fencing, and pastures, plus farmer experiences. <www.sare.org/publications/poultry.htm>

Pastured Poultry Production: An Evaluation of Its Sustainability in Hawai'i. G. Fukumoto and J. Replogle. 1999. <www.ctahr.hawaii.edu/oc/freepubs/pdf/LM-1.pdf>

Growing a Small Flock of Turkeys. 1981. Pub. 2733.
Raising Ducks in Small Flocks. 1977. Pub. 2980.
Raising Geese. 1975. Pub. 2225.
Starting and Managing Small Poultry Units. 1975. Pub. 2656. Includes information on selection of birds, feeding, housing, and health care.
University of California, Agriculture & Natural Resources <anrcatalog.ucdavis.edu>

Small Scale Poultry Production. Tobushi Tanaka. UH-CES Circular 480. 1982. Available from Hawai'i libraries or the UH-CTAHR Department of Human Nutrition, Food and Animal Sciences.

Guidance for Determining Whether a Poultry Slaughter or Processing Operation is Exempt from Inspection Requirements of the Poultry Products Inspection Act (updated April 12, 2006; pdf only). USDA Food Safety and Inspection Service <www.fsis.usda.gov/Home/index.asp>

Swine

Hawai'i Pork Industry Association. e-mail <val.kane@hawaiiantel.net>

Swine Welfare Assurance Program: Swine Care Handbook. National Pork Board <www.pork.org/Producers>

Pork Industry Handbook. Purdue University <www.ces.purdue.edu/pork/pihtoc.htm>

Profitable Pork: Strategies for Hog Producers. This Sustainable Agriculture Network (SAN) bulletin showcases examples of alternate ways to raise pork profitably—in deep-straw bedding, in hoop structures, and on pasture. <www.sare.org/publications/hogs.htm>

What do you need to raise pigs? Halina M. Zaleski. 2002. <www2.hawaii.edu/~halina/432/swinestart.pdf>

Rabbits

The Rabbit Handbook. 1989. Pub. 21020.
Rabbit Reproduction. 1982. Pub. 2887.
Two-Unit, All-Wire Rabbit Hutch. 1983. Pub. 2737.
University of California, Agriculture & Natural Resources <anrcatalog.ucdavis.edu>

Goats

American Cheese Society, 34 Downing St. New York, NY 10014; (212) 727-7939, is a non-profit organization for the promotion of natural specialty cheeses.

Home Pasteurization of Raw Milk. 1999.
South Dakota State University <agbiopubs.sdstate.edu/articles/ExEx14054.pdf>

Goats for Home Milk Production. 1976, Pub. 2899.
Nutrition and Feeding of Dairy Goats. 1979. Pub. WREP14.
Your Dairy Goat. 1981. Pub. WREP47.
University of California, Agriculture & Natural Resources <anrcatalog.ucdavis.edu>

Sheep

A Handbook for Raising Small Numbers of Sheep. 1985. Pub. 21389.
University of California, Agriculture & Natural Resources <anrcatalog.ucdavis.edu>

Sheep Raiser's Manual. William K. Kruesi. 1985. Charlotte, VT, Williamson Publishing. 288 p.

Bees

Hawai'i Beekeepers' Association <www.hawaiibeekeepers.org>

Chapter 5

Agroforestry

Hawai'i Forestry Extension Program. This UH-CTAHR website has comprehensive information on forestry, including the following topics:

Agroforestry, tropical and temperate

Forest tree species, including information on species suited for Hawai'i

Native Hawaiian trees and alien and invasive species

Production information: forest tree seeds, soils and fertilizers, pests and diseases, weed control and use of herbicides, measurement of standing trees and cut logs, wood and other forest products, forest certification

Economics and financial aspects of forestry, including cost-share and financial assistance

Urban forestry and ornamental trees

Forestry agencies and organizations: Hawai'i, national, and international.

<www.ctahr.hawaii.edu/forestry>

For information on whether a tree species is likely to become an invasive weed in Hawai'i, see the ***Hawai'i Weed Risk Assessment*** site, <www.botany.hawaii.edu/faculty/daehler/wra>.

Agroforestry, the integration of trees into a farming system, is an ancient practice that is enjoying a revival today. Pacific islanders have depended on tree-based farming systems for millennia. Their tree gardens often include breadfruit, a staple crop on many islands, along with other essentials including yam, sweetpotato, kava, fruits such as banana, medicinals, and other trees and plants providing useful materials. In contrast to the complex polyculture of the developing world's agroforestry, farmers on the U.S. mainland lately are practicing simpler agroforestry, amenable to mechanization and suiting the economic conditions of their agriculture. These systems may include planting windbreaks for crop and livestock protection, or growing field crops in alleys between rows of high-value timber trees, such as walnut.

In all agroforestry systems, the trees have some influence on the crops. Integrating trees into a cropping system can help conserve soil, prevent wind damage, improve soil fertility, and provide wildlife habitat. Tree crops can provide an additional source of income. However, trees will also compete with crops for light, water, and nutrients, may provide a hiding place for crop pests, and can complicate farm operations. Whether agroforestry is successful depends on whether the economic and ecological benefits of integrating trees into the farming system outweigh the drawbacks.

Agroforestry is a sophisticated way of farming that involves complex interactions among sunlight, soil, water, plants, and animals. Far less formal research has been conducted on agroforestry than on traditional cropping, so relatively less is known about the dynamics of agroforestry systems. Farmers and tree growers must rely on on-farm experimentation and research to determine what works best for them.

Hawai'i differs from most other island areas in the tropics and subtropics in having more of a developed-country economy. While the same plants may grow in Hawai'i, the highly labor-intensive agroforestry common in other areas with similar climate may not be economically viable in Hawai'i because of the high cost of farm labor, either as a direct cost or an opportunity cost for the farmer.

One other important precaution is to ensure that trees used in agroforestry in Hawai'i do not escape and become problem weeds in native forests. The same properties that

make multipurpose trees useful on farms—for example, the ability to grow rapidly, fix nitrogen, or reproduce quickly—also make them likely to become invasive.

Multi-purpose windbreaks and border plantings

Hawai'i's tradewinds can damage certain crops, reducing yields and crop quality. Farmers here learned long ago to use plants of various heights in windbreaks to create optimal conditions for growing crops. From towering *Erthyrina* trees grown along field borders on Moloka'i to rows of tall sudangrass planted to shelter taro fields in Waimānalo, windbreaks have many benefits for the farm:

- Windbreaks protect vegetable, orchard, vine, cereal, and row crops from wind damage, and also improve water use by the protected crop. This results in higher crop yields (ranging from 5 to 45 percent) and in better quality fruits and vegetables, which bring a premium price.
- Windbreaks can be designed to include plants that produce fruits, nuts, timber, and other products, diversifying farm revenue. In addition, animal fodder, mulch, fuel wood, and poles can be harvested from windbreaks for sale or on-farm use.
- Sheltering livestock with windbreaks can help reduce animal stress while providing a visual barrier for neighbors. Buildings used to shelter animals can be kept cooled by a well designed windbreak.
- Windbreaks reduce wind erosion and can provide habitat for beneficial insects and for wildlife.
- Rural residences and farm and ranch buildings can be sheltered from wind and cooled by the shade of windbreaks, making work and living conditions more comfortable for farm families and workers.
- Windbreaks and border plantings can serve as screens and buffers. They can divide conflicting land uses, such as residential areas and industrial zones, serving as visual and noise screens. Salt spray from the ocean or dust and pesticide drift from agricultural lands can be reduced with windbreaks.

Windbreak design

Windbreaks have been well researched and field-tested—information about design considerations is plentiful. In addition to selecting trees that will yield marketable products and are adapted to the site's soil and climate, the farmer will need to factor in windbreak height, length, continuity, density, and orientation. Here are some basic design considerations:

- Windbreaks should be oriented perpendicular to the prevailing winds.
- A windbreak protects at a distance of about 10 times its height. Thus a 40-foot tall windbreak protects crops at ground level for about 400 feet, on flat land.
- Thin-canopied trees such as Norfolk Island pine (*Araucaria heterophylla*) and Cook pine (*Araucaria columnaris*) make good windbreaks because they filter the wind, reducing its velocity, rather than block the wind, which causes turbulence. Canopy density in windbreaks should be 50–80 percent.
- Poorly designed windbreaks can cause wind damage if they funnel high winds through gaps in the windbreak.

The ***USDA Natural Resources Conservation Service*** has Hawai'i-based information available in their technical guide about herbaceous wind barriers and windbreak/shelterbelt establishment, tree/shrub establishment, vegetative barriers, upland wildlife habitat management, wetland wildlife habitat management, and riparian forest buffers. Their guide is available on-line at <www.nrcs.usda.gov/technical/efotg> or in printed form at NRCS service centers.

Silvo-pasture

When animals and forage crops are introduced into a timber production system (or alternatively, timber crops are introduced into a forage production system) to produce both timber and livestock products, this is called silvo-pasture. The short-term goal of this system is to have efficient forage and livestock production; the long-term goal is high-value timber and forest products. The rancher/tree farmer needs to understand and be able to manage the animals, the forage crop, and the timber crop.

In contrast to concentrated livestock operations, silvo-pastoral systems tend to have fewer problems with odors, dust, noise, herd disease, and water pollution. In addition, when well managed they can increase wildlife diversity, improve water quality, and reduce soil and wind erosion.

Grazing for weed control?

Forest tree plantations at lower elevations often have understories of escaped forage grasses such as kikuyugrass (*Pennisetum clandestinum*), meadow ricegrass (*Ehrharta stipoides*), or guineagrass (*Panicum maximum*). These grasses compete with the trees for water and nutrients and may provide fuel for wildfires. Grazing is one way of controlling undesirable grasses in tree plantations.

Before making a decision about adopting silvo-pasture, consider the following background advice:

Livestock: Be sure animal production is compatible with the land-use regulations for your property. Choose marketable livestock and forage species compatible with the climate conditions and the desired tree species. Cattle, sheep, goats, horses, turkeys, chickens, ostriches, emu, and rhea have been successfully raised in silvo-pasture. Your animals will also require clean water, feed and nutrient supplements, parasite control, and predator protection. Generally, an evenly distributed tree canopy will provide adequate shelter from sun, wind, and rain; however, trees can be grouped into rows to form fence lines, or in clusters to serve as "outdoor living barns."

Forage: Establish a nutritious forage ground cover that is compatible with site conditions and able to handle controlled grazing. The plants used should not be aggressive or twining (characteristics that suggest invasiveness). Shade-tolerance may be required, depending on the amount of light that will reach the ground through the tree canopy. Drought-tolerance is a plus, as there generally is competition between the forage and trees for water, especially during dry periods. Plan to manage your animals intensively using a rotational grazing system that allows the forage plants a recovery period. Some forage and grass species currently being grown in Hawai‘i orchards include ‘Tropic Lalo’ paspalum (*Paspalum hieronymii*), St. Augustinegrass (*Stenotophrum secundatum*), carpetgrass (*Axonopus compressus*), and perennial peanut (*Arachis pintoi*, *Arachis glabrata*).

Trees and shrubs: The timber component (or non-timber forest products) of the silvo-pasture system should be selected for high value, high quality, and good marketability.

Management of silvo-pastoral systems

Browsing animals (such as cattle, goats, and sheep) can debark and severely damage trees. Larger grazers (cattle) tend to damage small trees by stepping on them. While grazing animals will initially eat the grass or other forage crops under the trees, they will turn to the trees themselves once the groundcover forage is consumed in a given area, especially during dry spells. For a successful silvo-pastoral system, it is essential to be able to control the animals in a managed grazing system

and remove them before the tree crops are damaged. Until the trees are well established, the farmer may have to limit animal access or install tree-protection measures (electric fencing, protective wrap). However, with good grazing management, certain costs for tree maintenance, such as herbicide and mowing, may be reduced or eliminated. Soil quality tends to improve, with increased fertility and organic matter, under good management (however, compaction must be avoided).

Permanent Agriculture Resources is a Hawai'i-based organization that publishes on-line guides to nitrogen-fixing trees, alley cropping, windbreaks, and more, focusing on Hawai'i and the Pacific, including ***Agroforestry Guides for Pacific Islands,*** available at <www.agroforestry.net>

Koa and cattle

Most cattle pastures in Hawai'i were formerly koa (*Acacia koa*) forests, and some ranchers are interested in re-establishing koa in silvo-pastoral systems. Cattle eat koa leaves readily and must at all costs be kept out of young koa stands until the trees are above browse level. Cattle have been used in managed grazing systems to thin out dense koa stands that grow up naturally and to remove banana poka (*Passiflora mollissima*) vines from young koa stands. Wean-offs and horses have proven less damaging to trees than mature cattle. In times of drought, cattle will ride down or debark even larger koa trees, and they therefore should not be allowed access to forested areas. On rocky soils, cattle's hooves damage koa roots, and it is possible that injured roots can be entries for disease organisms.

The UH-CTAHR Cooperative Extension Service has foresters and rangeland specialists who can advise the beginning farmer about silvo-pasture systems suitable for Hawai'i. In addition, the USDA Natural Resources Conservation Service also has information available at their service centers and within their technical field guides.

Shade trees

Many tree crops such as coffee, cacao, and tea are often grown under shade trees. Shade trees may reduce water stress in hotter areas and provide an additional source of nitrogen for the crop if they are nitrogen-fixers. Most Hawai'i coffee is fertilized, watered, and grown in full sun, but in countries where access to fertilizer is limited, growing coffee under shade trees reduces overbearing and the risk of dieback. Shade trees may also provide habitat for wildlife and an eventual timber crop. In choosing shade trees, it is important to avoid trees that are alternative hosts of crop pests, especially the black twig borer (*Xylosandrus compactus*) in the case of coffee.

Non-timber forest products

Forests and agroforests yield many products other than timber. On the mainland, forest-cultivated ginseng may sell for $200–400 per pound, and shiitake mushrooms may bring in $3.50–10.00 wholesale ($9.00–12.00 retail). In Hawai'i, *hula halau* (schools) make trips into the forest to gather *palapalai* ferns (*Microlepia strigosa*) and *maile* vines (*Alyxia oliviformis*) to complete outfits for festivals and competitions. *'Awa* (or kava, *Piper methysticum*) may be grown in partial shade or in forest clearings. The leaves of *māmaki* (*Pipturus albidus*) and *ko'oko'olau* (*Bidens* spp.) make delicious teas, and *pepeiao* (or wood-ear fungi, *Auricularia cornea*) is a

popular addition to local dishes. The state tree, *kukui* (candlenut, *Aleurites moluccana*), grows wild in Hawai‘i’s forests and produces an oil nut used in making cosmetics. Any of these products might be grown in planted agroforests or planted within native forests. In other Pacific island regions, people rely on their agroforests for plants for medicine, fiber, and building materials.

Alley cropping

In many warm-climate developing countries, farmers use alley cropping systems, hedgerows of nitrogen-fixing trees planted in crop fields or orchards. The trees are pruned frequently to provide mulch and green manure for the associated crops and fodder for livestock. On sloping lands, the hedgerows are planted across-slope to prevent erosion. These systems were initially designed to replace slash-and-burn farming systems and provide some nutrients for the crops. They are labor-intensive systems and must be managed carefully so that the competition from the tree hedgerows does not reduce crop yield. Trees used for alley cropping should be nitrogen-fixing and able to withstand frequent cutting. Leucaena (*Leucaena leucocephala*), calliandra (*Calliandra calothyrsus*), and madre de cacao (*Gliricidia sepium*) are the most popular species used in alley cropping worldwide, although the wild, shrubby type of leucaena has escaped and become a weed in many areas. On the U.S. mainland, farmers grow row crops between widely spaced rows of high-value trees, such as walnut and pecan. These trees are allowed to grow to full size and are not pruned for mulch, and the alleys are wide enough that the crops receive almost full sunlight.

Tree farming

Farmers always have the option of growing trees on one part of their farm and crops on another. Although the trees and crops may not have any physical interactions, both may be part of the economic life of the farm. Tree farming is a very long-term option but may work well with other farm operations. Although timber harvests are far in the future, costs per acre to establish tree farms are very low compared with costs to establish orchards or row crops. Labor needs for tree farms are also comparatively low, and farmers can usually maintain their tree farms during seasons when they are not busy with other farm activities.

Only a few native Hawaiian trees are suited for timber production in tree farms. Koa, the most valuable timber in Hawai‘i for fine woodworking, is limited to higher elevations, generally above 2500 feet. Kou (*Cordia subcordata*) is prized by bowl turners but grows only in coastal areas. Most tree farmers in Hawai‘i are planting non-native or exotic timber species such as mahogany (*Swietenia macrophylla*), teak (*Tectona grandis*), and eucalypts. Milo (*Thespesia populnea*) and kamani (*Calophyllum inophyllum*) are coastal trees that were brought to Hawai‘i by early Polynesian settlers and are highly valued for craft woods. Faster growing trees tend to be less valuable than slower growing hardwoods. Economic rotations for fast growing timber trees may be as short as 12–15 years, whereas higher value hardwoods might best be left to grow for 30–50 years.

Currently, market demand for Hawai‘i-grown timber is from small, local sawmills and craftspeople. Local woods supply furniture makers, cabinetmakers, and woodworkers; lower value timbers are milled into flooring and interior finishing elements. Hawai‘i-grown woods give houses “a Hawaiian sense of place.” Markets for Hawai‘i-grown wood may improve in the future as technology improves, but local timber will always face competition from imported wood.

Some landowners devote a portion of their land to native forests or plantings of native trees and understory plants to provide watershed protection and habitat for rare and endangered plants and animals.

General forest products
- high-value timber (e.g., koa)
- firewood
- biomass
- fodder
- fenceposts
- smokewood
- decorative wood (e.g., burls)

High-value specialty forest products
- fruits, nuts, berries
- honey and other hive products
- mushrooms (e.g., *pepeao*)
- herbs and medicinal plants (e.g., *‘ava*)
- materials for crafts (e.g., *wauke* for *kapa*)
- plant materials for dried or fresh ornament
- aromatics
- dye materials
- seeds, seedings, cuttings

Markets

The beginning farmer with small acreage will most likely consider trying to produce multiple high-value specialty crops simultaneously. Tree farmers should be sure to have done a market analysis and business plan first—identify the market and crunch the production numbers before going ahead with the planting.

Is agroforestry right for your farm?

If agroforestry appeals to you, it’s always a good idea to begin small. Consider your existing farm business and physical resources, and determine if there are areas on your property where you can try it out. For example:
- Plant or enrich your windbreaks to include high-value trees.
- Grow understory forest products in an existing woodlot.
- Plant a riparian forest buffer with understory crops.
- Do some alley cropping field trials.
- Add trees to your pasture areas.
- Establish forage groundcovers beneath the trees in your orchard or woodlot.

Cost-share and financial assistance programs

The Hawai‘i Department of Land and Natural Resources’ Division of Forestry and Wildlife administers several programs to assist landowners in Hawai‘i who are restoring native forests or establishing tree farms, including the state Forest Stewardship Program, the Watershed Partnership Program, and the Landowner Incentive Program. The Kaulunani Urban and Community Forestry program assists community groups and non-profit organizations in urban forestry projects.

The USDA Natural Resources Conservation Service in Hawai‘i runs several cost-share programs for private landowners for specific purposes, including enhancing environmental quality, improving wildlife habitat, and producing timber.

The U.S. Department of the Interior’s Fish and Wildlife Service in Hawai‘i administers the Conservation Partnership Program for landowners who wish to restore and improve habitat for threatened, endangered, and rare native Hawaiian species, both plant and animal.

Resources and recommended reading

Financial Analysis for Tree Farming in Hawai'i. J.B. Friday, Carol Cabal, and John Yanagida. 2000. UH-CTAHR publication RM-9. <www.ctahr.hawaii.edu/oc/freepubs/pdf/RM-9.pdf>

Government Incentive Programs for Tree-Planting or Forest Management on Private Lands <www.ctahr.hawaii.edu/forestry/data/incentives.html>

The Overstory, a free e-mail agroforestry journal.
Agroforestry Guides for Pacific Islands.
Traditional Trees of Pacific Islands: Their Culture, Environment, and Use.
Permanent Agriculture Resources, <www.agroforestry.net>

Hawai'i Forestry Extension Program <www.ctahr.hawaii.edu/forestry>

Chapter 6

Marketing

Agriculture is a highly competitive industry, and farmers need to be market-savvy to survive. Direct marketing is an option, growing in popularity, that allows farmers to receive a higher return on their products by selling directly to customers. To achieve the higher return, the farmer takes over the "middleman" services of packaging, transporting, and brokering the product. Other direct marketing benefits to the farmer include cash sales, immediate payment, and more control over price. Often linked with direct marketing is agricultural tourism ("agtourism"), which benefits Hawai'i's tourism sector by diversifying the mix of services and products available, increasing visitor satisfaction, and possibly helping to lengthen the average visitor stay.

Control over price means being able to settle on an appropriate price rather than being a "price taker," accepting whatever price is offered by the middleman. If your product has special characteristics that are of value to consumers, you may be able to set a price that recognizes this extra value. Wholesalers or large stores may not be willing to pay more than their standard price for products, even though the products are superior.

Certified organic

With consumers showing increasing concern about how their food is grown and avoiding pesticide residues, retail sales of organic products has grown steadily over the past ten years. New farmers wishing to capitalize on this movement may opt for getting organic certification.

National Organic Program
<www.ams.usda.gov/nop/indexIE.htm>

Hawaii Organic Farmers Association (HOFA)
<www.hawaiiorganicfarmers.org>

Many marketing options

Wholesalers are traditionally the farmer's link to the marketing chain. Generally, wholesalers package and grade a wide variety of agricultural products, assemble them into economically sized lots, and transport them to a wide range of retailers. Wholesale prices are generally lower than retail or direct-sale prices.

If you can provide a reliable supply of high-quality product, graded and packaged, and deliver it directly to the retailer, direct retail sales might work for you. Investigate whether institutional buyers such as school systems, the prison system, hotel chains, retail store chains, warehouse stores, cruise lines, or the military are good outlets for your product. If you have a niche-market product, specialty stores may be a good option.

Refer to UH-CTAHR's publication *This Hawaii Product Went to Market* for helpful introductory information about these and other marketing options.

Market research

It is beyond the scope of this manual to provide in-depth information about how to conduct market research. It is helpful, however, to understand that market research is not difficult and can in large part be accomplished fairly easily by even the most novice farmer. It is, at its core, research and information gathering. It should be done *before* you decide what you want to produce. Following are questions and steps to take along this path.

Who will be your clients? Consider the demographics of the area where you are located to determine who your potential clients may be. Are your clients city dwellers who attend farmers' markets? Will you sell to chefs at local high-end restaurants? Do you hope to draw local residents to your farm to purchase locally grown produce or to enjoy a farm experience? Would you like to sell to a particular ethnic group? Are your clients health-conscious individuals who demand high-quality organic produce?

Learn everything you can about your potential clients. Find out their buying habits and their preferences. Observe them. Talk with them. Interview them. Survey them. Read about them. Try to determine if there is a need they have that you can fill. What products can you grow and produce that they would buy? How can you make your agricultural product uniquely different or superior to those of other farmers? Can you identify a lucrative niche?

Visit local stores. Take a trip to local supermarkets, ethnic shops, food clubs, health food stores, and gourmet shops. Observe what is selling and what makes an agricultural product appealing. Talk to customers about what they want and what they would like to purchase that is not currently available.

Research food trends. Visit up-scale restaurants to get an early read on upcoming food fashions. Read food and food trade magazines. Women's and lifestyle magazines can also be valuable resources. Keep an eye out for articles in popular and health magazines about the nutritional and health benefits of specific foods.

Check out the competition. Examine what your future competitors are doing. Think about ways they could improve.

Decide what to grow. The answers to the questions above will help direct your final decisions about the variety of agricultural products that you will want to produce. Avoid competing with corporate farms—try to identify products that are not usually found in supermarkets or that do not travel well. Look for varieties that are attractive, colorful, and diverse in size and texture. Emphasize diversity in your agricultural product line to spread your economic risks. For new products, start small, with a limited field trial. Experiment with new varieties. Keep records to remember how well they grow. Then test your new products before you commit large amounts of your energy and resources to growing them.

Test your product. Get consumer feedback on your agricultural products by giving samples to your customers. For example, at farmers' markets, craft shows, or agricultural fairs, you can meet your customers face-to-face and get their reactions.

Direct marketing opportunities

The following pages will give you an overview of some of the most popular direct marketing options being used by farmers. As you read, try to pick out the marketing venues that best match your current level of expertise and resources.

Farmers' markets

Hot products at the farmers' market

- fresh products (tree- or vine-ripened, fresh from the farm)
- specialty items not found in supermarkets (new, unusual, exotic)
- heirloom varieties
- salad mix
- herbs
- ethnic
- organic items
- fresh flowers
- value-added products

—*The New Farmers' Market*
by Vance Corum, Marcie Rosenzweig, and Eric Gibson

One of the best direct marketing venues for new farmers is the farmers' market. This direct-sales approach allows beginning farmers to establish their customer base, develop their marketing skills, test new products, and get purchaser feedback at low cost. It requires little to get started (your best clean produce, a table, a vehicle, insurance) and incurs little debt. At the farmers' market, small-scale producers can hone their business skills.

To excel at farmers' markets, you must enjoy people—and you'll be answering a myriad of questions about nutrition, your favorite recipes, and your farming philosophy, among other food-related topics. An eye for presentation is invaluable. Projecting an image of abundance with the creative use of color, signage, and multilevel product placement will draw customers to your stand. Use the farmers' market to help develop and test your niche products. Talk to clients. Match what you grow the best with what your clients like to buy. Take time at the farmers' market to network with other farmers as well. They're often your best teachers.

Aside from the farmers' market, you may discover opportunities to sell your products at agricultural fairs, craft shows, and trade events as well.

Some marketing prospects that may arise from your contacts at the farmer's market include direct sales, subscription farming, and value-added sales.

Farm stands

If your farm is well located, along a major roadway with lots of traffic, or close to an urban area or tourist attraction, you may want to try building a farm stand to market your produce. The marketing and display skills that you learned from farmers' markets can be directly applied to your farm stand venture.

Road stands can give a farmer an excellent start-up marketing outlet. You can start small with a modest seasonal stall and, as opportunity and ambition permit, expand to a year-round country attraction with an expansive product line. Here are some considerations you should take into account.

Location: Consumer studies from the U.S. mainland indicate that most people will drive only 10–25 miles to shop at a roadside stand. If your farm isn't located within this distance from a population center, consider partnering with other farmers who have better locations.

Zoning restrictions: Check to see if the zoning ordinances for your property allow farm stands.

Building permits: Farm stands range in design from the most simple, open-framed stall to elaborate buildings with extensive amenities. Initially, you may wish to keep your costs down and start small (but keep room for expansion should your farm business prove to be successful). If you erect a structure, check first to determine if you need building permits. Be sure your roadside stand parking lot is convenient, level, and safe. There may be regulations that apply to your farm stand signage as well.

Government and local regulations: Be sure you research and understand the state and local laws that affect on-farm sales. You may be subject to business licensing regulations, health and sanitation codes, weight and measures specifications, employment regulations, and fire and police ordinances.

Insurance: Once you allow the public access to your property, you expose yourself to greater liability risk. Check with your insurance carrier to be sure you have adequate coverage.

Security: Roadside stands are vulnerable to theft and vandalism.

Your farm stand may eventually evolve into a roadside market (or a farm store), a direct-market outlet that operates year-round and sells a wide variety of products. You would most likely be re-selling products from other farms in addition to your own agricultural products. Often, these businesses use fresh produce as the major draw but diversify by adding food sales (such as a bakery, ice-cream parlor, or similar outlet for value-added products) or an entertainment component (animal petting zoos, mazes, hayrides, etc.). Read more about agtourism further on.

U-pick

Also known as "pick-your-own," U-pick farming once seemed like a farmer's dream come true—free labor. Customers would drive out to your farm, harvest and pack your produce, and then pay you for the experience! Actually, U-pick does have a down side—your customers may damage plants, your liability insurance cost increases, and product prices tend to be low. However, U-pick may still be a marketing option for some new farmers.

U-pick farming's popularity appears to be tied to the economy and to the amount of time available to the cook of the household. Traditionally, U-pick flourishes when money is tight. Customers come to the farm to harvest lower-priced foods that can be canned, frozen, or preserved at home, helping keep the family food budget down. With more people working, time is now more at a premium, and U-pick revenue has declined. In today's market, successful U-pick operations now generally include a component of agtourism.

Agtourism

As urbanization increases and the hustle and bustle of city life ratchets up stress levels, many people are turning to nostalgic farm visits to spend their vacation dollars. A growing number of tourists seek rural experiences to escape crowded

urban centers, to enjoy natural environments, to try out a less commercialized vacation experience, or to satisfy their interest in the farming lifestyle and heritage.

Entrepreneurial farmers exploiting this trend can access recreational dollars in various creative ways. Some host events such as seasonal festivals (e.g., the Kona Coffee Festival) or agricultural fairs complete with cooking and crafting demos. Others may offer educational tours to appeal to local K–12 school students, showcasing processing demonstrations and providing displays and animal petting areas. Certain farms lend themselves to being rented for weddings, corporate picnics, or birthday parties. Farm families may open their homes to offer farm vacations or bed-and-breakfast stays. This marketing movement, known as entertainment farming, agri-tourism, or agtourism, is helping many farmers to stay in business.

Hawai‘i farmers are fortunate to have a large tourist population the year round. Out-of-state visitors are already in vacation mode and need only to be convinced that an agtourism attraction is an attractive option. In-state residents are not in vacation mode most of the time but still are a potential market for school tours, ag entertainment (e.g., corn mazes, pumpkin patches), and other recreational activities.

Several Hawai‘i farmers have gotten a start in agtourism via a bed-and-breakfast. If your county permits this form of business, if your farm or home has comfortable facilities to accommodate visitors, and if you and your family have the personality to interact cheerfully with the strangers who will be your guests, this may be a great option for your farm. Local farmers who are in the B&B business strongly recommend being affiliated with a B&B association, as it provides time-saving marketing services (such as brochures and Internet sales) that enhance B&B revenue. Expect to give a tour of your property, and plan to have some products to sell to your guests.

In many cases, agtourism represents an evolutionary step for farmers who already have extensive experience with direct marketing via retail sales, value-adding, and food service. As described earlier, when you bring the public to your property, you must address additional issues such as zoning restrictions, building and business permits, adequate parking, health code requirements, and increased liability risks.

Some benefits of agtourism include
- diversifying farm operations
- using farm-based products in new and innovative ways
- developing new consumer market niches
- channeling additional on-farm revenue directly to family members
- improving farm living and working conditions and recreational opportunities
- developing managerial and entrepreneurial talents
- increasing long-term sustainability of farm businesses.

Agtourism challenges include
- understanding agtourism market needs and behaviors
- assessing agtourism’s fit with current farming operations
- dealing with government policies
- establishing effective marketing programs

- developing customer-friendly service programs
- creating responsive risk-management programs
- establishing credible product and service quality standards
- building strategic partnerships
- managing niche agtourism product development opportunities.

In Hawai‘i and some other parts of the Pacific, tourism is a major economic sector. Agtourism can open a new niche market for the visitor industry. Contact the Hawai‘i Department of Business, Economic Development, and Tourism (Product Enrichment Program) and the Hawai‘i Department of Agriculture (Marketing Division) for assistance in setting up an agricultural-based tour product such as a farm festival or on-farm tour.

Subscription farming

In subscription farming, farmers contract with customers to provide a range of goods for a defined time period (a “season” in temperate climates). Customers prepay, allowing the farmer to cover production costs in advance and guaranteeing a good price for the produce. In exchange, clients periodically receive a box of fresh, high-quality produce, usually delivered to a central pickup spot. Customers have the satisfaction of knowing where their food comes from and that they are supporting a local family farm. Another similar concept is “community-supported agriculture” (CSA), where “shareholders” additionally commit time and energy on the farm to help with labor. People who relish the occasional experience of being on the farm and working the land may prefer to join a CSA.

In her book, *Selling Produce to Restaurants*, Diane Green of Greentree Naturals describes how serving her farmers’ market customers evolved into a small **subscription-farming program**:

“Initially, we targeted our established farmers’ market customers who often showed up too late to get the items they wanted. A lot of people want to shop at the farmers’ market for farm fresh, certified organic produce, but don’t want to spend their first day of the weekend having to show up early to get the best choice. So, I suggested that they give me their weekly grocery list, and I would bag it up and save it for them to come to market later. From this beginning, we then researched the CSA model, and began a local subscription service.”

Subscription farming enterprises thrive where small farms can provide a diverse array of consumer-ready products such as vegetables, fruits, herbs, meats, honey, milk products, and eggs to large urban populations located close to the farm. In Hawai‘i, apartment and condominium dwellers may prove to be a good market for this type of venture.

When you consider entering subscription farming, consider the following:

Product diversity: To keep subscribers happy, the farmer will need to provide a consistent supply and a wide range of fruits and vegetables. This requires a level of experience and production skills that may take a couple of years for an entry-level farmer to learn. Partnering with several other farmers may be necessary to provide the variety of produce needed to satisfy your customers.

Planting times and successive plantings: The farmer needs planning skills to ensure a constant supply of popular fruits and vegetables. If you are just starting out in farming, start small and keep the initial crop list fairly simple. With time and experience, you can add more variety to your produce boxes.

Deliveries: A common pick-up point, easily accessible to your customers and preferably equipped with refrigeration, can be hard to come by. It is best if you can find a group of subscribers who are located close together, such as in a common neighborhood or at a place of business. Try to avoid home delivery, which is expensive and time-consuming.

Shareholders: Word-of-mouth tends to be the best form of advertising for subscription farming. Often, satisfied shareholders will recruit for you. Be sure you have a brochure that explains what subscription farming is all about and sets realistic expectations for your subscribers.

Restaurant sales

The culinary connection

The Culinary Institute of the Pacific is a network of seven culinary education centers within the University of Hawai'i system, located on the islands of O'ahu, Maui, Hawai'i and Kaua'i. Kapi'olani Community College has premiered a culinary tour, "A Taste of O'ahu – A Hands-On Culinary Experience" for the visitor industry; it includes a visit to a local farm.

The Hawai'i Regional Cuisine movement has initiated some very beneficial relationships between talented local chefs and exceptional local farmers. While it may look easy to the outsider, in reality only farmers with a certain level of expertise are able to supply the consistently high-quality produce demanded by restaurants and resort hotels. In addition, these chefs expect premium service as part of the product.

Before deciding to direct-market your products to local restaurants, consider this:

Highest quality produce: To command a price premium you must provide a product that is superlative—fresh, delicious, and reliably delivered. You must be able to consistently provide restaurant clients with excellent produce over the course of the year (despite weather or pest problems). Guarantee your products and replace them if needed.

Highest quality service: Part of the product that you will provide includes reliable deliveries as determined by the chef's schedule and terms. You must establish a good relationship with both the chef and the business manager to be successful. Keep up with gourmet food trends and meet periodically with the chef to discuss what to grow and how to specialize your produce for their restaurant.

Value-adding with processing

"Dean Okimoto, the owner-operator of Nalo Farms, has built a highly successful business by supplying excellent quality salad greens and fresh herbs to many of Hawai'i's top restaurants. Dean started with one restaurant in the early nineties and has expanded to where his client list today includes most of Honolulu's top restaurants and chefs, who in turn have won international recognition and numerous culinary awards for innovations such as Pacific Rim cuisine and Hawai'i regional cuisine. Many establishments prominently feature Dean's signature product, Nalo Greens, a premier salad mix, on their menu."

—From *Nalo Farms: Servicing High-End Restaurants*

Once you've gotten some experience, you might want to add some value-added products to your line-up of merchandise. Perhaps your less-than-perfect produce can be made into pickles, relish, salsa, chutney, jam, or jelly? Value-adding means that the farmer processes the product in some way (by cleaning, cooling, cooking, drying, handcrafting, spinning, weaving, etc.) and then labels, packages, and sells it through direct-marketing techniques. Value-adding is a great way to diversify your product line and to cushion your income during times of crop loss or off-season slowdowns.

Expanding from fresh products into a processed-food product line may appear simple, but that is deceptive. Many of the steps along this path are intertwined with complex government regulations.

Recipe development: You may have a good recipe already for your fruits or vegetables. If you don't, consider partnering with a local chef or with a culinary school program to develop one. Your next step is to "commercialize" your recipe—to make necessary modifications so that it still tastes great in larger batches. Your recipe will be a proprietary secret.

Processing facility options: To sell to the public you need to prepare your product in an approved food-processing facility (or invest to build and maintain a commercial kitchen on your farm). Specific federal, state, and county laws regulate regarding the processing of farm products, including livestock and poultry, and produce handling, cooking, and packaging.

Ingredients and packaging: You will need to locate suppliers of reasonably priced additional ingredients and packaging required for your product.

Labeling: In addition to the marketing considerations you need to think of when designing your labels, food-product labels have certain government-required elements that must be met.

Product costs and product pricing: To determine your pricing strategy so that you make a profit, you need to know your costs of production, both fixed and variable.

Value-adding is an excellent way to grow and diversify your farm business. Successful agricultural entrepreneurs emphasize that you should start small and grow this aspect of your business slowly.

Internet marketing

Many farmers find that having a website greatly enhances their direct-marketing strategies and is especially helpful in attracting out-of-state visitors to their agtourism enterprise (such as a bed-and-breakfast). Another successful use for websites is to facilitate repeat sales from satisfied customers from the U.S. mainland and overseas.

USDA's Agricultural Marketing Service has an online guide to Internet marketing:

<www.ams.usda.gov>

Designing and supporting an eye-catching website that rises above the crowd requires an unusual combination of journalistic ability, graphic design talent, and computer savvy. It is very time-consuming. If this sounds intimidating to you, your first step may be to sign on with a website, such as Local Harvest, <www.localharvest.org>, or FoodRoutes.org, that will give you a free listing. Link up with a Hawai'i-based non-profit food organization that promotes sustainable agriculture (for a mainland example, visit Community Involved in Sustaining Agriculture, CISA, at <www.buylocalfood.com>).

Farmers can collaborate to design a group website relating to a common marketing theme with individual Web pages featuring a unique story about each member farm. Alternatively, you may be able to access professional assistance by joining a marketing cooperative, several of which provide websites as one of their services.

Island Fresh
Buy Fresh Buy Local

UH-CTAHR is partnering with the Hawaii Farm Bureau Federation and the Hawai'i Department of Agriculture in a statewide effort to help increase demand for, consumption of, and familiarity with locally grown commodities. This joint effort, "Buy Fresh, Buy Local – Island Fresh," familiarizes Hawai'i residents with the benefits of purchasing locally grown products.

Cooperative marketing

An excellent way to combine talents and resources is for a group (*hui*, in Hawaiian) of farmers to organize into a cooperative to carry out some of the marketing functions done by middlemen. A marketing cooperative is an organization owned and operated by a group of farmers who produce similar products. Marketing co-ops may perform certain functions such as grading, packing, storing, cooling, shipping,

promoting, and selling. They may be able to negotiate volume discounts for purchasing production supplies (seed, fertilizer, containers, etc.) for their members.

Co-ops give participating farmers the opportunities and benefits of pooling products by grade and size, presenting a uniform product, and accessing services and economies of scale not available to the individual producer.

This Hawaii Product Went to Market

—UH-CTAHR

This resource introduces basic business skills and then expands into marketing in great detail. Some of the topic areas include

- marketing strategy
- production and market statistics
- Hawai'i's livestock products and markets
- government assistance in marketing
- grower and trade associations
- marketing cooperatives
- trade show basics
- elements of package design
- transporting your product
- quarantine regulations
- going commercial with a kitchen recipe
- adding value
- marketing to local retail florists, chefs, the military, institutional buyers, airport shops, and specialty stores
- exporting to a foreign market.

There are many existing Hawai'i marketing cooperatives. The USDA Rural Development/Rural Business–Cooperative Service provides technical assistance to producers interested in forming a cooperative.

A cooperative can be organized to take on other business functions. There is a new trend for farmers to organize both formal cooperatives and informal partnerships to share the cost and use of expensive equipment (such as poultry processing equipment and refrigerated "portable stores") and for building commonly shared facilities (such as freezers and commercial kitchens). These new alliances are allowing farmers to be more competitive and to stay in business.

Resources and recommended reading

General

Sell What you Sow! The Grower's Guide to Successful Produce Marketing. Eric Gibson. 1994. New World Publishing, Placerville, CA. 304 p. <www.nwpub.net>

This Hawai'i Product Went to Market: The Basics of Produce, Floral, Seafood, Livestock, and Processed Product Businesses in Hawai'i. James R. Hollyer, Jennifer L. Sullivan, and Linda J. Cox (editors). 1996. University of Hawai'i at Mānoa, CTAHR. 168 p. <www.ctahr.hawaii.edu>

North American Farmers Direct Marketing Association is an organization exclusively dedicated to promoting farm direct marketing. They offer publications, conferences, trade shows, newsletters, and a special website (The Back Forty) for members only. <www.nafdma.com>

UH-CTAHR publications. College of Tropical Agriculture and Human Resources, University of Hawai'i at Mānoa <www.ctahr.hawaii.edu/freepubs>

Locally grown

FoodRoutes.org is a website devoted to assisting people to purchase locally grown produce. Their website offers a toolkit for food and farming advocacy work and several excellent downloadable promotional sheets such as Buy Locally Grown, It's Thousands of Miles Fresher. <www.foodroutes.org/localfood>

Local Harvest supports sustainable and organic farmers by providing a website with a clickable map for consumers to link up with nearby food producers. <www.localharvest.org>

Farmers' markets

The New Farmer's Market: Farm-Fresh Ideas for Producers, Managers and Communities. Vance Corum, Marcie Rosenzweig, and Eric Gibson. 2001. 272 p. Excerpts available online at <www.nwpub.net>.

Growing for Market Magazine is a national monthly newsletter for direct-market farmers. It is a source of information about growing and marketing produce, herbs, and cut flowers. <www.growingformarket.com/>

Hawaii's Agricultural Gateway **(**Hawai'i Department of Agriculture**)** has a list of Hawai'i farmers' markets.
<www.hawaiiag.org/Markets/WelcometoMarkets.html>

Roadside stands

How to Establish and Operate a Roadside Stand. UC Davis Small Farm Center <www.sfc.ucdavis.edu/Pubs/Family_Farm_Series/Marketing/roadside.html>

U-pick

Should I grow fruits and vegetables? Pick Your Own Markets
<ag.arizona.edu/arec/pubs/dmkt/Upick-ShouldIgrow.pdf>

Agtourism

Cultivating Agritourism: Tools and Techniques for Building Success. Peter W. Williams, Kathryn Lack, and Kim C. Smith. 2004. Canadian Farm Business Management Council, Ottawa. 230 p.

Direct Farm Marketing and Tourism Handbook. <ag.arizona.edu/arec/pubs/dmkt/dmkt.html>

Agtourism in Hawaii: From Farmer to Visitor. UH-CTAHR website.
<www.ctahr.hawaii.edu/agtourism>

Entertainment Farming and Agri-Tourism. This on-line article about agri-entertainment includes tips and ideas from successful entertainment farming enterprises and techniques (farm recreation and hospitality businesses). Also available as a downloadable PDF file. <attra.ncat.org/attra-pub/entertainment.html>

Agricultural Tourism Fact Sheets from UC Davis. <www.sfc.ucdavis.edu/agritourism/factsheets.html>

Agricultural Marketing Resource Center (AgMRC): Nature Based Tourism. Links to on-line manuals and success stories on eco-tourism. <www.agmrc.org/agmrc/markets/Tourism/tourism.htm>

Subscription agriculture and community-supported agriculture

Community Supported Agriculture: Making the Connection. University of California Cooperative Extension. 1995.

Sharing the Harvest. Elizabeth Henderson with Robyn Van En. 1999. Publisher:

Chelsea Green. This manual provides an overview and step-by-step description of community-supported agriculture, including how to start and operate a CSA, management and production issues, sample documents from working CSA farms, pitfalls, and extensive resource and materials lists.

Restaurant sales

Selling Produce to Restaurants. Diane Green. Greentree Naturals. <www.greentreenaturals.com>

Chefs Collaborative, <www.chefscollaborative.org/>, is a national network of more than 1,000 members who promote sustainable cuisine by celebrating the joys of local, seasonal, and artisanal cooking; it hosts the ***Farmer-Chef Connection*** website, <www.farmerchefconnection.org>.

Value-adding

From Kitchen to Market: Selling Your Gourmet Food Specialty. Hall, Stepthen F. 1992. Upstant Publishing Co., Chicago. 190 p. (800) 235-8866.

From Kitchen to Consumer—The Entrepreneur's Guide to Food Production. Nelson-Stafford, Barbara. 1991. Academic Press, Inc. San Diego. 343 p.

Value-Added Strategies: Taking Agricultural Products to the Next Level. Kent Fleming. 2005. 2 p. <www.ctahr.hawaii.edu/oc/freepubs/pdf/AB-16.pdf>

Some Costs and Considerations for Establishing an Entrepreneurial Community Shared-Use Kitchen or "Test-Kitchen Incubator"; The Examples of the Hamakua Incubator Kitchen & Crafts and the Honokaa Ohana Kitchen Project. James Hollyer et al. 2000. 15 p. <www.ctahr.hawaii.edu/oc/freepubs/pdf/FMT-2.pdf>

e-Commerce

Feasibility Assessment for an e-Commerce Cooperative to Market Hawaii's Agricultural Products. Sabry Shehata, Linda J. Cox, and Tim O'Connell. 2006. 4 p. <www.ctahr.hawaii.edu/oc/freepubs/pdf/ET-6.pdf>