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

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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.

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.

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).

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>

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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>