Chapter 5
Human Dimensions of Agroforestry Systems

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The success of agroforestry in adapting and mitigating climate change depends on many human dimensions surrounding agroforestry. This chapter reviews research on the adoption of new practices by landowners and examines cultural perspectives on agroforestry. Diverse and complex motivators for conservation decisionmaking reflect the diversity of landowners, land management practices, and ecosystems and provide a variety of opportunities to encourage agroforestry adoption.

The chapter also reviews tribal and indigenous systems as models for modern resiliency. Affirmation of time-tested traditional agroforestry practices will help raise awareness and appreciation of traditional knowledge, with due respect to its indigenous origins. These diverse practices can play a vital role in reducing food insecurity, particularly on U.S.-affiliated tropical islands where the majority of food is imported. Practices by American Indians across the United States and practices on U.S.-affiliated tropical islands are highlighted and discussed in terms of building resilient operations, landscapes, and communities.

Agroforestry Adoption Constraints and Opportunities

Land managers are the gatekeepers to the realization of agroforestry's climate mitigation and adaptation potential. Understanding how land managers make decisions is central to determining what role agroforestry can and will play in climate-smart strategies. Few studies focus on the adoption of agroforestry practices in the United States (e.g., Raedeke et al. 2003, Valdivia et al. 2012). Information can be gleaned, however, from research on land managers' decisionmaking regarding other types of conservation practices. This research suggests diverse and complex motivators and factors for conservation decisionmaking, reflecting the diversity of landowners and land managers, land management practices, and ecosystems involved (e.g., Baumgart-Getz et al. 2012, Knowler and Bradshaw 2007, Napier et al. 2000, Pannell et al. 2006, Prokopy et al. 2008). The decision to adopt and implement conservation practices is made by land managers for economic and cultural objectives and is influenced by knowledge from other practitioners and available technical guidance. Several models that describe the adoption of conservation practices and can help to explain agroforestry adoption are presented in the ensuing paragraphs.

Climatic variability and climate change make conservation-related decisionmaking more complex. Understanding farmers' attitudes toward climate change-motivated adoption of conservation practices has been found to be important in the United States (Barnes and Toma 2011, Prokopy et al. 2015). Farmers, in general, are more interested in adapting to climate change than mitigating greenhouse gases (Prokopy et al. 2015). Arbuckle et al. (2013) found that farmers may be willing to adapt to climate change, even though they may not think it is human caused or may not think it is happening at all. In their study, 62 percent of Iowa farmers surveyed said they would need to do more to protect their land from climate change in the future, but only 33 percent thought the government should do more to reduce greenhouse gases and other causes of climate change (Arbuckle et al. 2013). These findings suggest that farmers and other land managers could be better engaged by focusing on the impacts of climate change (and agroforestry's adaptive capacities) rather than on mitigation.

Practitioner Motivations To Use Agroforestry

When discussing how adoption of agroforestry practices happens, it is important to consider who makes the decisions to implement these practices. Current and potential adopters of agroforestry practices are not a uniform group (fig. 5.1). Climatic variability and climate change are only two of many possible motivators and considerations that influence a land manager's decision to change his or her practices. Other factors in conservation practice adoption models include landowner and land manager demographics, farm characteristics, and landowner attitudes (Skelton et al. 2005). Farm structure, with variables such as the size of the farm, crop and product diversification, land tenure, and existing conservation practices, drives other models of adoption of conservation practices (for American Indians, see Mondou 1998). Landowners' economic bottom lines and climate change mitigation are among many factors of adoption. Categorizing potential agroforestry adopters can offer basic guidance for targeting adoption strategies (table 5.1).

Barriers to Agroforestry Adoption

Many of the barriers to agroforestry adoption by land managers in the United States are the same as the barriers to other types of change. Theories about adoption of conservation practices are typically focused on economics (for more information on economics and agroforestry, see chapter 4). Although profit is a key motivator (Cary and Wilkinson 1997), profit maximization alone is not a reliable predictor of implementation of a particular agroforestry practice (Skelton et al. 2005). Decisionmaking about profit is mediated by other considerations, such as income diversification and reducing income risk (Zinkhan and Mercer 1997). Other factors besides economic considerations can be barriers to adoption (table 5.2).

Lack of information about how to implement and integrate agroforestry systems into their existing enterprises may be one of the most significant barriers for landowners. Survey results in Pennsylvania revealed that, although many landowners were interested in agroforestry (90 percent), most respondents did not have enough information about implementation, management, and marketing to follow through with adoption (Strong and Jacobson 2005). In a survey of U.S. extension professionals with responses from 32 States, about one-half of respondents (23 of 45 respondents), representing 16 States, provided programs in agroforestry (Jacobson and Kar 2013). These survey results suggest many States lack capacity in agroforestry. Information on revenue-generating specialty crops within agroforestry systems is also lacking (Gold et al. 2004a, 2004b). Enterprise budgets and decisionmaking models for these specialty crops are also limited, which makes it harder to get loans from traditional farm lending organizations.

Figure 5.1. Agricultural producers are a diverse group, each with their own motivations, characteristics, resources, and attitudes that can influence decisionmaking regarding agroforestry. (Photos (L-R) courtesy of Lynn Betts, Bob Nichols, Ron Nichols, Ron Nichols, Tim McCabe, Bob Nichols, USDA Natural Resources Conservation Service and USDA Office of Communications).

Table 5.1. Generalized list of potential agroforestry adopters and some of their common motivations and characteristics that can influence adoption of agroforestry practices.

Potential adopters	Common motivations and characteristics	Reference
Large-acreage farmers	• Avoid potential environmental regulation by using practices to reduce negative offsite impacts. • Increase yield and profit.	Skelton et al. (2005)
Small-acreage farmers	• Diversify farm operations and income sources. • Lower risk to volatile markets and extreme weather events. • Meet increasing interest in local and organic markets. • Often have nonmanaged woodlands with agroforestry potential.	Jordan (2004), Lasco et al. (2014), Raedeke et al. (2003), Workman et al. (2004)
Limited-resource farmers	• Increase food security. • Diversify farm operations and income sources. • Reduce input costs by relying on agroforestry practices to provide biological services.	Raedeke et al. (2003)
Beginning farmers and ranchers	• Easier to integrate agroforestry into new operations. • More likely to participate in cost-share programs that can be used to implement agroforestry practices. • More likely to implement agricultural best management practices.	Mishra and Khanal (2013), Prokopy et al. (2008), USDA NASS (2014)
Tribes and indigenous groups	• Sustain culturally significant food and fiber systems. • Diversify farm and ranch operations and income sources. • Encourage economic development. • Increase food security.	Mondou (1998)
Ranchers, confined animal operations	• Avoid potential environmental regulation by using practices to reduce negative offsite impacts. • Enhance public relations by using sustainable practices. • Increase production and profit.	Gillespie et al. (2007)
Ranchers, free-range or pasture-based operations	• Diversify ranch operations and income sources. • Increase interest in local and organic markets. • Lower risk to volatile markets and extreme weather events.	Gillespie et al. (2007), Workman et al. (2004)
Woodland owners	• Provide income independent of timber harvesting activities. • Diversify income for part-time or nontraditional owners.	Valdivia and Poulos (2009), Vaughan et al. (2013)
Public and nonprofit land managers	• Accomplish public goals for natural resources. • Provide demonstration sites and opportunities for learning.	Garrett and Buck (1997), Garrett et al. (2004), USDA (2015)

Table 5.2. Barriers to agroforestry adoption by land managers.

Barrier	Description	Reference
Cost	• Tree and shrub establishment is perceived to be costly.	Valdivia et al. (2012)
Labor	• Agroforestry practices can involve more labor to manage.	AFTA (2000)
Lack of crop insurance	• Crops produced from agroforestry systems may be perceived as riskier than commodity crops if crop insurance is not available for the agroforestry crops.	Young et al. (2001)
Lack of support for traditional tribal agroforestry systems	• Government programs have favored intensive commodity crops rather than tribal agroforestry practices.	Cleveland et al. (1995), Teel and Buck (1998)
Time	• Agroforestry practices require a longer management timeframe and have a longer expected period for return on investment.	Raedeke et al. (2003), Valdivia et al. (2012)
Climate change impacts	• Uncertainty about future climate can inhibit landowners from investing in longer term agroforestry systems.	Kirilenko and Sedjo (2007)
Uncertain land tenure	• Land renters have less incentive to install practices that take time to return benefits of which they may not receive value.	Raedeke et al. (2003)
Complexity	• Agroforestry increases agricultural production system complexity and landowners are generally averse to adding complexity. • Agroforestry practices may be incompatible with farmers' existing equipment or other fixed capital assets. • Adding complexity is particularly challenging when existing production systems are fairly simple.	Valdivia et al. (2012)
Lack of information	• Agronomists and farmers generally have little experience in planning and managing agroforestry practices.	Coggeshall (2011), Finn et al. (2008), Gold et al. (2004a), Gold et al. (2004b), Jacobson and Kar (2013), Warmund et al. (2010)

Support for Agroforestry Adoption

Significant support exists for increasing agroforestry adoption. Some of this support directly addresses barriers discussed in the previous section, and other support provides a starting point for addressing those barriers. The various types of support include—

- Policy support.
  - U.S. Department of Agriculture (USDA) Agroforestry Strategic Framework.
  - USDA Departmental Regulation on agroforestry.
  - Whole-Farm Revenue Protection (WFRP) pilot program.
- Partnerships.
  - Association for Temperate Agroforestry (AFTA).
  - Landowner associations.
  - Tribes and intertribal consortia.
  - Crop-processing cooperatives.
  - Crop-specific support groups.
- Agroforestry education and technical support.
- Incentives.

Policy Support

Policy support for agroforestry at the Federal level is primarily through the USDA and its agricultural and forestry-based agencies. Increasing support from the USDA has been helpful in addressing the cost, time, complexity, and information constraints to agroforestry adoption. In 2011, the USDA released its *USDA Agroforestry Strategic Framework Fiscal Year 2011–2016*, which outlines the USDA's approach to agroforestry (USDA 2011). This framework created the Agroforestry Executive Steering Committee (which includes eight USDA agencies) to guide framework implementation. These actions increased Department-wide knowledge of agroforestry, enhancing the accessibility of agroforestry-related USDA lending and cost-share programs as USDA employees grow more knowledgeable about the risks and benefits of agroforestry. The USDA Departmental Regulation on agroforestry also created a consistent definition of agroforestry for all agencies to refer to, allowing for more programs to explicitly mention agroforestry in their guidance (Vilsack 2013).

As an outcome of this strategic framework, the first comprehensive report on agroforestry was released by USDA in 2013—*Agroforestry: USDA Reports to America, Fiscal Years 2011–2012* (USDA 2013b). A more comprehensive version was released in 2015 (USDA 2015). This report quantifies current agroforestry activities taking place both on the American landscape and within USDA, creating a baseline of information on agroforestry at the Federal level. One question in the 2012 Census of Agriculture addressed the adoption of silvopasture and alley cropping (USDA Census of Agriculture 2014). Inclusion of this question adds to the baseline information about agroforestry adoption in the United States. Other Federal policy changes, such as the WFRP pilot program—a USDA Risk Management Agency program for specialty and diversified crop producers—may also decrease risks for agroforestry producers with multiple crops. This program provides insurance coverage for the whole-farm enterprise, rather than for a single crop. It also insures farms with specialty or organic commodities (both crops and livestock) and those marketing to local, regional, farm-identity preserved, specialty, or direct markets (USDA RMA 2014). This coverage may be useful for agroforestry producers, who tend to have diversified operations.

In other instances, Federal policies affecting tribes have pushed for commercialization and modernization of tribal agriculture, which has been at the serious detriment of traditional and sustainable agroforestry systems (Cleveland et al. 1995, Mondou 1998). The American Indian Agricultural Resource Management Act (AIARMA 1994) has implications regarding how tribes maintain traditional and adopt modern agricultural systems (Mondou 1998). This act, which defines "agricultural product" to include crops, livestock, forage and feed, grains, and any other marketable or traditionally used materials, may be a vehicle to support tribal agroforestry (Mondou 1998). The U.S. Department of the Interior (DOI) Secretarial Order 3289, *Addressing the Impacts of Climate Change on America's Water, Land, and Other Natural and Cultural Resources* details governmental programs that might be used to support tribal agroforestry under climate change (Salazar 2009).

Partnerships

Social networks are known to play a significant role in the diffusion of agricultural innovations (Jackson-Smith and McEvoy 2011, Prokopy et al. 2008). Factors affecting diffusion include exposure to information from institutional and noninstitutional sources, including opinion leaders in the farm community and extension agents (Skelton et al. 2005). Agroforestry proponents and practitioners have embraced this social network-based approach by forming a variety of partnerships through peer-to-peer networks of either agroforestry landowners or agroforestry extension professionals or both.

Some of these networks and working groups exist at the regional level, sharing information on crop varieties, markets, policies, and programs that come from a shared political, ecological, and economic situation. Like organic producers, agroforestry producers have developed this knowledge collaboratively (Parker and Lillard 2013). Farmers get most of their important information about agricultural conservation practices from family, friends, and neighbors (Jackson-Smith and McEvoy 2011) and are more dependent on farmer-to-farmer networks than information that comes from the top down from organizations (Valdivia et al. 2012).

This peer-to-peer approach can be effective in facilitating farmers' decisionmaking by helping to diffuse information about particular practices and support (Ingram 2008). Many of the peer-to-peer networks related to agroforestry advocate for a variety of conservation practices. This approach is helpful because landowners tend to integrate agroforestry into their existing operations in conjunction with other conservation practices and maintain nonagroforestry systems on their farms. Many of these national networks are connected to one another through national and international organizations, such as AFTA, that seek to promote the wider adoption of agroforestry by landowners in temperate regions of North America.

Landowner associations, specialty crop-processing cooperatives (i.e., cooperatives that share processing infrastructure), and crop-specific support groups (e.g., North America Aronia Cooperative, the Upper Midwest Hazelnut Development Initiative) can also be helpful to landowners interested in agroforestry. Many specialty agroforestry products are economically viable only with processing, which can require equipment a single landowner may not be able to afford.

Many programs seek to improve conservation outcomes at a landscape scale across "all lands" (including public, tribal, and private lands). At the Federal level, some of these programs include the Two Chiefs' Joint Landscape Restoration Partnership, the Collaborative Forest Landscape Restoration Program, and the Joint Fire Science Program. Agroforestry provides a way for these programs, which are often primarily focused on forest lands, to achieve conservation outcomes on private agricultural lands as well.

Agroforestry Education and Technical Support

Along with increasing information shared through partnerships, technical capacity related to agroforestry can be increased through education supported by Federal, State, tribal, and academic programs (e.g., Cooperative State Research, Education, and Extension Service, Federally Recognized Tribes Extension Grant Program). These programs generally target landowners and technical service providers. Deficiencies in the availability of formal and informal agroforestry training in temperate areas have long been noted (Nair 1993). Numerous training events have taken place during the intervening years that address this issue of increasing technical capacity (USDA 2015). Many of these training events target technical service providers who work with landowners. AIARMA (1994) provides opportunities for Federal training of tribes and members interested in an agricultural study program. Programs include, but are not limited to, agricultural economics, animal science, biological sciences, geographic information systems, horticulture, range management, soil, and veterinary science, all of which pertain to agroforestry practices and systems (Mondou 1998).

Although some studies have shown that education may be a more effective motivator than financial assistance for some landowners, the overall efficacy of education campaigns on the adoption of best management practices is still inconclusive (Prokopy et al. 2008, Skelton et al. 2005). Lassoie et al. (1994) noted the importance of education that not only addresses the mechanics of "how to" but also includes information on landowner motivations and effective integration of agroforestry into existing systems. Additional understanding related to how educational efforts should be structured to impact agroforestry adoption is needed and is being carried out through existing Sustainable Agriculture Research and Education grants.

Postsecondary education and training in agroforestry are available, though limited, with fewer than 20 colleges and universities offering graduate coursework in the field (Gold and Jose 2012, USDA 2015). Increasing postsecondary education capacity may be necessary. A need also exists to support tribal colleges to increase agricultural, forestry, and range educational programs as a means for expanding tribal agroforestry opportunities (Mondou 1998: 410):

> Unless the education of Native American Indians in all facets of agriculture is made available and accessible, the possibility of revenue generating agricultural enterprises is remote for tribes that lack sufficient capital to fund the education of willing and able students.

Creating a certification program for agroforesters has been proposed to address the lack of information among technical service providers (Mason et al. 2012). This proposed program would be developed jointly among the Society of American Foresters, American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America.

Incentives

Because cost is an important constraint to the adoption of agroforestry systems, financial assistance programs have been developed for conservation practices, including agroforestry practices. Although financial assistance alone is not enough to motivate farmers to adopt conservation practices, conservation practices that are profitable are more likely to be implemented (Napier et al. 2000). A variety of government incentive programs support agroforestry practices at the Federal, regional, and State levels. Details about Federal incentive programs are described in chapter 6. At the regional level, additional incentives may exist to address particular natural resource concerns, such as the Chesapeake Bay Program that provides implementation funds for riparian forest buffers to address nutrient management problems in that region. Market incentives through ecosystem services markets may also encourage agroforestry practice adoption.

Indigenous Systems as Models for Modern Resiliency

Although agroforestry is a relatively new scientific field, indigenous agroforestry systems have been cultivated for centuries—if not millennia—in much of the world, including in North America, the Pacific Islands, and the Caribbean (Clark and Nicholas 2013, Clarke and Thaman 1993, Ffolliott 1998, Lepofsky 2009, Smith 1929) (fig. 5.2). There is much to be learned from the adaptation strategies of indigenous peoples that have been developed in response to environmental changes over millennia and not just decades (Wildcat 2014). The long-term presence of agroforestry in much of the world is indicative of its resilience to extremes in temperature, precipitation, and storm wind, all of which are projected to become more frequent (Australian Bureau of Meteorology and CSIRO 2011, 2014; Keener et al. 2012; Kirilenko and Sedjo 2007).

Traditional indigenous multistrata agroforestry systems are models for sustainable agroecosystems (Kumar and Nair 2007, Soemarwoto 1987, Torquebiau 1992). Indigenous multistrata homegardens, which provide family food security throughout the tropics, are considered to be "the epitome of sustainability" (Kumar and Nair 2004). These multistrata systems that include a multitude of crop species and cultivars with varying tolerances to drought, waterlogging, wind, salt spray, and other climatic variables increase the resilience of their overall productivity when impacted by episodic environmental stressors (Barnett 2011). Crop and cultivar selection is crucial for the ability of the practice to tolerate sporadic environmental extremes. For example, in coastal buffer agroforestry for windbreak, erosion control, and food production, plants are chosen for their high tolerance to salt spray and storm surges (Wilkinson and Elevitch 2000).

After European/Western contact, colonization destroyed many of these traditional agroforestry systems, or they became neglected in favor of plantation-type agriculture in a process known as "agrodeforestation" (Thaman 1992). Today, up to 90 percent of food consumed in the previously self-sufficient island states of the Pacific and Caribbean is imported (FAO

Figure 5.2. Indigenous agroforestry systems have a long history in North America, the Pacific Islands, and the Caribbean. (A) A multistory cropping agroforestry system in Palau. (Photo by J.B. Friday, University of Hawaii). (B) Agroforestry system with coconut and taro on an atoll in the Pacific Islands. (Photo by John Quidachay, USDA Forest Service). (C) Ron Reed of the Karuk Food Crew collects gooseberries. (Photo by Colleen Rossier, University of California, Davis). (D) A member of the Alabama-Coushatta Tribe harvests longleaf pine needles for basket weaving. (Photo by Beverly Moseley, USDA Natural Resources Conservation Service).

2005). Loss of indigenous systems has led to environmental degradation and food insecurity for many developing small island states (Pelling and Uitto 2001). Residents of some low islands of the Pacific are some of the first climate change refugees in the world due to rising sea levels and amplified storm surges (Park 2011).

These threats, combined with rising awareness of the expected climate-related stressors, have resulted in renewed interest in protecting, expanding, and reestablishing agroforestry systems modeled after local indigenous systems (fig. 5.3). Trosper and Parrotta (2012: 1) wrote, "The role of traditional knowledge—and the bio-cultural diversity it sustains—is increasingly recognized as important by decision makers, conservation and development organizations, and the scientific community." Historical forced displacement, land seizure/cessions, and migration of indigenous people combined with social, economic, and land-use alterations with modernization have led to losses in traditional knowledge of systems and cultivars (Clarke and Thaman 1993, Falanruw 2009). Conversely, the remnants of traditional systems—and even virtually intact indigenous systems—that still exist represent a widespread and diverse reservoir of experience, species, and knowledge from which to draw in building adaptive responses to climate change.

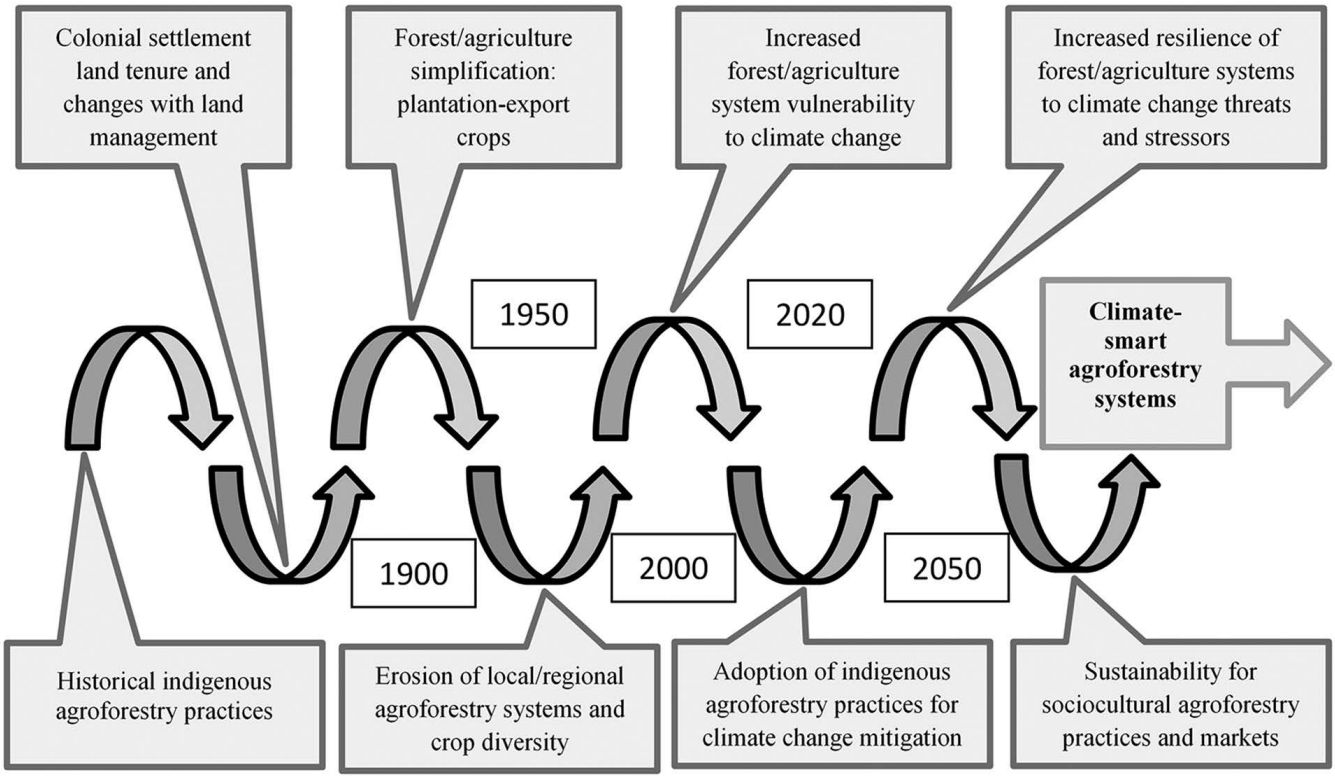
Affirmation of traditional practices, based on cultural aesthetics combined with scientific and economic validation of their productivity and practicality as an adaptation strategy, will help raise awareness and appreciation by producers, researchers, policymakers, and the general public. This increased awareness and appreciation will, in turn, lead to retention and use of traditional knowledge with due acknowledgment of its indigenous origins (Williams and Hardison 2013) as a viable and important component of climate change adaptation.

Agroforestry Practices, American Indians, and Climate Change

American Indians across North America have been using and adapting traditional management practices to maintain and enhance food, fiber, and medicinal resources over millennia for their livelihoods and economies (Anderson and Parker 2009, Cleveland et al. 1995, Parlee et al. 2006). Many tribal programs and communities are implementing agroforestry practices to achieve resource objectives that integrate local values. These practices are locally adaptive and responsive to particular agricultural, range, and forestry systems that reflect tribal traditions (Mondou 1998).

American Indian land tenure arrangements are diverse. Tribal trust lands broadly include an array of designations ranging from reservations, rancherias, and individual allotments. Tribes also hold lands in fee, lease private property, and, in turn, lease tribal lands to nontribal entities, or they have arrangements and agreements to work on public lands within their ancestral territory. During early European settlement and development,

Figure 5.3. Timeline depicting influences on indigenous agroforestry systems and their adaptive responses to change.



many tribes were displaced, relocated, or moved out of their ancestral territory. Engaging in agroforestry practices can foster the integration of traditional values with modern resource management on tribal lands (Mondou 1998, Teel and Buck 1998). As Norton-Smith et al. (2016) indicate, adaptation methods may include initiatives that foster cultural identity and connection to place.

Agroforestry land management practices implemented by tribes and tribal members include forest farming, alley cropping, riparian forest buffers, windbreaks, and silvopasture. Other land management practices implemented by tribes and tribal members include forest/woodland grazing; fuelwood, biofuel, and fiber production from agricultural land, forest land, and rangeland; wild harvest (pine nuts, acorns, berries, mushroom, etc.); edible landscaping; intercrops as beneficial insect refuges; and groundwater and irrigation drainwater management (Bainbridge 1995, Rossier and Lake 2014). Tribes or tribal individuals use these practices to produce traditional foods, fibers, basketry/art materials, and medicinal plants or to maintain traditional customs and practices. These practices are often at a small scale, however, when compared with tribal work on conventional forestry, range, or agricultural operations. The distribution of many traditional food, fiber, and other species is shifting as the climate changes, accelerating the complexity of access and making traditional subsistence harvesting and storage practices more challenging (Norton-Smith et al. 2016). Adaptation strategies should recognize the cultural importance of these species as well as their political context (Lynn et al. 2013). This context is important when considering agroforestry as an adaptation strategy as well.

Tribal Examples of Agroforestry

Many tribes across the United States have established a range of different agroforestry systems that integrate indigenous knowledge and stewardship practices with contemporary restoration and economic development opportunities (Cleveland et al. 1995; for tribal agriculture, see Mondou 1998; Rossier and Lake 2014). (Several regional examples are provided in boxes 5.1 to 5.4.) Peer-reviewed literature that describes these systems, particularly in the context of climate change, is sparse. As a result, these examples outline a limited set of known examples of agroforestry systems based on the information that is available. Tribal agroforestry pilot projects that started in the past 20 years could be evaluated for the potential success as applicable climate change adaptation strategies (Luna 2000, Rossier and Lake 2014, Mondou 1998).

In addition, many tribes across the United States are engaged in nursery greenhouse projects to support restoration of culturally valued plants (Dumroese et al. 2009). For example, Blackfeet Community College has a tribal nursery greenhouse project in which horticultural trials with traditionally used native plants species were conducted. More than 50 native plants were propagated for restoration and cultural education activities, especially for activities related to history and language associated with native plants (Luna 2000). Some of this restoration work is designed to create systems that include agroforestry practices.

Box 5.1. Winnebago Reservation in Nebraska

Members of the Winnebago Reservation in Nebraska started a project to integrate forestry and agricultural management to meet local tribal food, land restoration, and soil conservation needs. They implemented a multicropping system by converting some commercial agricultural land into crops of traditional food species integrated with cultivars (Szymanski and Colletti 1999). They planted clover, corn, and soybeans between black walnut trees in an alley cropping system. They reforested areas between fields creating windbreaks and riparian forest buffers along streams. These efforts also were intended to improve wildlife habitat (Szymanski et al. 1998). The goal of the multicropping system was to produce shorter rotation cover crops and annual food crops and to foster longer lived species that provide food and wildlife habitat. No published research on the outcomes of this project was located nor was a response received from the tribe when an effort was made to contact them.

Box 5.2. Mississippi Band of the Choctaw

A cooperative effort among the Mississippi Band of the Choctaw Tribe; the U.S. Department of Agriculture, Natural Resources Conservation Service; and others in Neshoba County, MS, sought to restore riparian and wetland systems to support cultural basketry traditions (Luna 2000). The tribal greenhouse was used for propagating plants that were of cultural and ecological importance. Focal plant species included Nutall oak (*Quercus texana*), mockernut hickory (*Carya tomentosa*), and switchcane (*Arundinaria gigantea*). Switchcane is one of the largest native grasses in North America, and the fiber is used in Choctaw basketry. The production of these baskets provides income for the tribe. Restored riparian and wetland areas with switchcane patches are harvested for use in traditional tribal basketry.

Box 5.3. Seminole Tribe of Florida

The Seminole Tribe of Florida is carrying out silvopasture and other agroforestry practices in several States of their ancestral territory on tribal reservation and other trust lands and also on purchased private lands. The Seminole historically raised cattle and integrated range management with traditional burning of forests and grasslands (Sievers et al. 1985). The tribal silvopasture program integrates cattle range improvement with prescribed fire and other agricultural and farming needs of the tribal community. The tribe is also leasing lands, implementing agroforestry and restoration practices, and generating revenue from land leasing for farming and hunting.

Box 5.4. Karuk, Yurok, and Hoopa Valley Tribes in California

In northern California, the Karuk, Yurok, and Hoopa Valley Tribes are integrating traditional forest management with agroforestry practices to reduce hazardous fuel loads, reintroduce fire, and enhance traditional foods (Rossier and Lake 2014). Tribes historically managed Douglas-fir-tanoak forests with fire to promote access for gathering different food resources. Fire reduces understory vegetation, improves tribal gatherer mobility, improves nutrient cycling, reduces nut and other insect pests, and enhances food quantity and quality (Anderson 1994). The benefits of agroforestry practices on valued tribal food and basketry plants are being studied in collaboration with Federal agencies, watershed and fire safe councils, and academic researchers. This work has the potential for application on National Forest System lands.

Projected Impacts of Climate Change on Tribally Valued Resources and Tribal Agroforestry Practices

Ecological disturbances, such as flooding, drought, fire, and extreme weather events (e.g. temperatures) affect agroforestry practices and resources used for a range of tribal purposes (Cleveland et al. 1995, Mondou 1998, Voggesser et al. 2013). These disturbances directly and indirectly affect ecosystem goods and services and valued habitats and resources such as traditional and cultivated food crops; basketry materials/fiber resources; ranching, farming, and hunting practices; wildlife habitat quality that is of spiritual, cultural, and economic importance; public/tribal municipal water and air quality; and community recreational activities (Burger et al. 2008, Lynn et al. 2013). Downscale climate models and specific species climatic resilience studies have general application to tribes (Liverman and Merideth 2002, Vose et al. 2012).

The effects of climatic variability and climate change on American Indians and affiliated indigenous people and the Federal policies and authorities that are applicable are not well understood by resource managers and others working with tribes (Cordalis and Suagee 2008). A limited number of Federal policies and authorities pertain to tribal agroforestry and climate change. Currently, these polices address tribal agroforestry and climate change as separate issues, which may limit the use of indigenous agroforestry as an adaptive strategy for climate change. For instance, Section 105(a)(4) of AIARMA (1994) has implications for tribal agroforestry, but it lacks specific mention of climate change. Native Hawaiians and Pacific Islanders of U.S.-affiliated territories have other local authorities such as Act 234 (State of Hawaii 2007), which addresses climate change but does not specifically address Native Hawaiians or agroforestry.

Considerations for Tribal Agroforestry

Many indigenous and tribal communities desire land, resource management, and agroforestry management tools that provide access to and improve the quality of valued habitats necessary to perpetuate traditional customs and knowledge systems in their ancestral homelands (Jones 2000, Rossier and Lake 2014). The adoption of traditional stewardship methods and related tribal agroforestry practices by nonindigenous/nontribal entities may have benefits ecologically and for food and fiber production systems, but it can create other concerns or pose threats for indigenous/tribal communities (Altieri and Nicholls 2013, Dixon et al. 1994). The misappropriation of traditional knowledge and tribal agroforestry practices by nonindigenous resource managers or industry is a concern and sensitive issue (Williams and Hardison 2013). Many anthropologists documented historical tribal harvesting practices and uses of food, fiber, and medicinal plants (Moerman 1998), from which many commercial enterprises benefit without any direct compensation back to tribes as the original holders of that knowledge and practice (Tedder et al. 2002). Many agricultural systems benefit from cultivars that originate from tribal sources, yet no recognition of or compensation for this indigenous/tribal legacy is formalized (Thrupp 2000). Mondou (1998: 407–408) states—

> Many Native American Indian farmers are striving to bring [traditional] farming back as an integral part of their respective culture by using modern technologies, while at same time trying to protect the folk variety seeds from mass marketing. With the advent of sophisticated biotechnologies and markets that are

worldwide in scope, notwithstanding intellectual property rights of the particular tribe, folk variety seeds of the indigenous people are in demand.

In addition, the commercial production, management, and wild harvesting of berries originates from tribal stewardship (Moore 1994), but commercial harvesting interest has affected tribal gathering.

The formulation of Federal policies and authorities that protect traditional knowledge, stewardship methods, and agroforestry practices consequently are limited. The Cultural and Heritage Cooperation Authority authorized in the Food, Conservation, and Energy Act of 2008 (also known as the 2008 Farm Bill) provides specific authority to the USDA Forest Service to protect tribal information about resources, cultural items, uses, or activities that have a traditional and cultural purpose from release under the Freedom of Information Act (CHCA 2008). Desai (2007) provides international examples for protecting traditional knowledge. Furthermore, many indigenous and tribal governments and community members will want assurances that their knowledge, traditional customs, and agroforestry practices will not be co-opted by nontribal members without permission or will not be inappropriately applied, which could result in the further disenfranchisement, marginalization, or exclusion from resource management, food and fiber production, and scientific research (Williams and Hardison 2013). Research can examine and provide evaluation for understanding at which scale or landscape condition indigenous and tribal agroforestry practices would increase the resilience of agricultural, range, and forestry production systems against changing conditions.

U.S.-Affiliated Tropical Islands

The U.S.-affiliated tropical islands of the Pacific and Caribbean comprise hundreds of islands of varying sizes, elevations, climates, peoples, and histories. Agroforestry was, and on many islands is still, the predominant form of agriculture, using species and techniques introduced and developed before contact with European/Western culture. On various islands, these techniques include shoreline plantings and windbreaks, intensive mulching, shifting agriculture followed by forest fallow with varying degrees of enhancement, and multistory agroforestry (see the section on Hawaii and the U.S.-Affiliated Pacific Islands in appendix A). Colonization and subsequent cultural change have affected land tenure; shifted subsistence agroforestry toward cash economies and monocrop agriculture; and interrupted the transmission of traditional ecological knowledge, including agroforestry.

Climate change impacts on these islands, which vary depending on the region and local topography, include drought, increased storm intensity (wind and rainfall), sea level rise and coastal erosion, and salinization of groundwater. High sea levels have been especially pronounced in the western Pacific in recent years because of prevailing La Niña conditions, with coastal erosion and groundwater salinization being exacerbated on atolls by development impacts (Keener et al. 2012; Hawaii and the U.S.-Affiliated Pacific Islands in appendix A). Current-day island experiences of storms, inundation events, drought, and degradation of freshwater resources heighten public awareness and anticipation of climate change in the Pacific and Caribbean. These experiences seem to accelerate Pacific migration trends (already occurring because of aspirations for education, health care, and employment) from atolls to "high" (volcanic) islands and from remote islands to U.S. domestic areas (Hezel 2001). At the same time, communities and governments assert the desire for "future generations living productive lives on these islands" despite climate change, prioritizing the need for adaptation of agricultural policies and practices (RMI 2011).

Practitioners of agroforestry in the islands are diverse and include—

- Indigenous Pacific people who follow practices passed down to them by centuries of common tradition and by guarded family secrets, as in the case of prestige crops like yams in Pohnpei (Raynor and Fownes 1993). Their traditional ecological knowledge encompasses practices that effectively conserve soil and water and provide nutritious subsistence produce. A serious constraint to the continuation of these systems has been the interruption of passing traditional ecological knowledge to younger generations. With cultural change, family members who move away, focus on paid employment, or do not value the old ways, do not acquire the knowledge of their elders.
- Pacific Island residents practicing agroforestry with less benefit of traditional ecological knowledge. This group of practitioners includes younger generations; farmers affected by new pests or diseases that are unknown in traditional systems; inter-island migrants, who now practice on a different island (with different soils or climate); and migrants and contract laborers (primarily from Asia), who bring their own cultural practices and crop preferences.
- Small- and large-acreage landowners who grow coffee and other row or orchard crops with overstory shade (coffee and cacao) or windbreaks, particularly in the Caribbean, Hawaii, and Guam.
- Ranchers who incorporate agroforestry techniques (windbreaks, shade trees, living fences, alley cropping, and/or protein banks), particularly in the Caribbean, Hawaii, and Mariana Islands.
- Families of any description who have homegardens, including tree and nontree crops.

Learning Networks

Changes in hydrology, variable weather conditions, and climate change and the introduction of invasive plants, insects, pests, and diseases constrain the success of traditional agroforestry systems. The variety of island ecosystems, indigenous systems, and species provides an opportunity for one island with changing conditions to look to another island for potential solutions. Pacific Island forestry agencies (USDA Forest Service grantees) welcome USDA technical assistance, even for traditional systems, to cope with new and unfamiliar weather/climate conditions and pests, as long as the advice and advisor respect the local context and knowledge (Friday 2011). In the Caribbean, associations for shade coffee and agroecology actively promote and support agroforestry, in collaboration with the USDA Natural Resources Conservation Service, U.S. Fish and Wildlife Service, university agricultural extension services, local governmental agencies, and environmental organizations that seek benefits for biodiversity and watersheds.

Food Security, Ethnoagrobotany, and Cultural Pride

In the Pacific, a constraint to sustaining subsistence agroforestry and expanding it into the commercial realm has been the relative inconvenience of agroforestry products to consumers. They tend to be perishable, unfamiliar to new residents, and/or not marketed through commercial channels (Hollyer 2014). The counterbalancing opportunity is increasing awareness of the nutritional value of fresh, local island produce, especially starches with high fiber and vitamin content (e.g., breadfruit, taro, yam, sweet potato) relative to processed carbohydrates (white rice and flour), and of traditional or introduced species and cultivars with high vitamin content (e.g., the Karat banana) (Englberger and Lorens 2004). Campaigns for food security have tapped cultural pride, as with the Waianae Diet (Shintani et al. 1994) and documentation of ethnoagrobotanical heritage (Balick 2009). Initiatives have included policies favoring local food, promotional festivals, and projects in food processing and marketing improvements. Demand and markets for subsistence products vary by island and time period. The Caribbean likewise has a wealth of tropical fruits and special varieties (e.g., the West Indian avocado) through homegardens and local markets that can enrich diets.

Economic Valuation

Another constraint to the use of agroforestry on the islands has been a historic focus by governments on cash crops and "modern" systems. This constraint in part stems from insufficient awareness and appreciation of traditional agroforestry. Many tropical agroforestry systems are still partially or wholly for subsistence use and their products are seldom included in agricultural and economic statistics. Past colonial or government decisions have resulted in land-use conversions to pasture and monocrop plantations (notably sugar and pineapple) and in a lack of institutional and extension support to validate and expand agroforestry. Valuation of agroforestry products, in terms of cash value of products (including import substitution) and per-acre values of agroforestry as a land use, provides an opportunity to increase recognition of agroforestry, leading to more supportive policies (ADB 2005; Drew et al. 2004, 2005).

Economic Viability at Farm Level

Coffee grown under partial tree canopy shade (considered a multistory agroforestry practice) was once common in Puerto Rico until government subsidies and technical assistance promoted a transition to higher yielding, full-sun (nonagroforestry) systems. Coffee production then encountered labor constraints, low incomes, and catastrophic hurricanes, resulting in marked declines between 1982 and 2007. Problems of full-sun systems include shortened life span of coffee shrubs, high erosion rates, water-quality problems, and destruction of habitat for wildlife species. Growers' preference for shaded coffee systems provides an opportunity to return to agroforestry practices that afford more biodiversity and watershed environmental services, especially if incentives and support are provided for shade coffee as they were for sun coffee (Borkhataria et al. 2012). Likewise, some coffee farmers in Hawaii prefer shade coffee because of its more pleasant work environment and wildlife habitat (Elevitch et al. 2009). Many of the U.S.-affiliated islands have important tourism industries that provide opportunities for additional farm income through tourist experiences with coffee and other exotic agroforestry products.

Land-Use Planning and Land Tenure

Migration and land tenure sometimes affect agroforestry in the context of the whole-island landscape. In the Pacific, as people move from distant to central islands or from coasts to interiors (because of climate change impacts or for other reasons), they seek land for food production. Sometimes native primary forest is converted to agroforest (FSM 2010), and sometimes agroforestry is intensified by using fewer trees (ASCC 2010). Where the practice of agroforestry or the planting of certain species signifies a claim to the land, that tradition thus encourages clearing native forest for agroforest. Changes in historic land tenure systems have resulted in weaker community and familial regulation of resources, often leading to exploitation and overuse (Falanruw 1992). The opportunities, therefore, are for governments to encourage agroforestry development in the most appropriate locations available—for example, by considering slope and erodibility when regulating land distribution and allowable uses (FSM 2010, KIRMA 2003), siting road development to enable access to suitable lands (Ramsay et al. 2013), providing grassland or secondary vegetation areas to migrants or other residents for agroforest development

(FSM 2010), reviving traditional conservation authorities, and providing extension support to influence choices (Shed 2012). In the Caribbean, historical changes in land tenure, industrialization, and recent urbanization disrupted family farming. Now, former agricultural land reverting to secondary forest in Puerto Rico and the U.S. Virgin Islands (Brandeis and Turner 2013a, 2013b) may provide an opportunity to expand agroforestry land uses, although the fertility of much of that land is constrained by soil degradation (Lugo and Helmer 2004).

Conclusions

Farmers, ranchers, tribes, and other land managers are the gatekeepers to realizing agroforestry's potential for climate mitigation and adaptation. Because agroforestry is primarily conducted on private lands, human dimensions must be considered in the development of policies, programs, and outreach efforts. Potential agroforestry adopters are diverse—they differ in respect to their needs, types and conditions of their resources, social and cultural backgrounds, and the landscapes in which they operate. Agroforestry practices are also site specific, modified to suit the physical resources and ecology of the site. As a result, no one route will effectively encourage agroforestry adoption. Different strategies are needed to address the different challenges that land managers face in managing their operations and resources under climate change. Research on human dimensions in agriculture and resource management provides a beginning foundation on which to effectively advance agroforestry outreach and adoption. Increased educational opportunities, policy support, and partnerships may also encourage agroforestry implementation. Renewed interest in protecting, expanding, and reestablishing agroforestry systems modeled after local indigenous systems has emerged because of the resilience of those systems to climate change threats. The adoption of these traditional stewardship methods should be done with care to protect and respect the autonomy of tribal and indigenous sovereignty.

Key Findings

- Factors influencing agroforestry adoption are similar to the factors that influence other conservation practices and, as such, agroforestry programs can build off information generated through research in these other areas.
- The various demographic groups in agriculture (e.g., small farms, tribes, limited-resource producers) have diverse motives and characteristics that can contribute to the adoption of agroforestry. Targeting adoption strategies based on these motivations and characteristics may enhance adoption.
- Addressing extreme weather and climate change impacts is but one of many reasons that landowners may adopt agroforestry practices.
- Common barriers to agroforestry adoption include implementation costs, labor requirements, longer timeframe for return on investment, uncertain land tenure, lack of information, and increased complexity.
- Traditional agroforestry systems of the United States and the U.S.-affiliated islands are important to indigenous populations, particularly for food security and cultural resources under the uncertainty of climate change. These time-tested models can inform solutions for building modern-day resilient agroecosystems, but few Federal policies specifically support indigenous agroforestry systems.
- Support for agroforestry adoption exists through various policies, partnerships, educational and technical assistance opportunities, and incentives and other financial assistance programs.

Key Information Needs

- A greater understanding of land managers' perceptions of climatic variability and change and how it influences their decisionmaking, particularly concerning use of conservation practices (including agroforestry practices).
- More information regarding how agroforestry can fit into different types and scales of agricultural operations and marketing systems, including financial and labor requirements and economic values.
- The identification of the types of technical support and educational opportunities that are most effective at encouraging agroforestry adoption.
- A broader understanding of the additional support tribes and U.S.-affiliated island communities will require for adapting to current and anticipated climate change impacts.
- Better documentation of historical and current tribal and island agroforestry practices, with an emphasis on how these practices can be framed as or adapted for agroforestry land management.
- Evaluations on the resiliency of tribal and island agroforestry systems to disturbances, including assessments of threats and opportunities to enhance sustainability under climate change.

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