Chapter 3
Regenerative Agriculture as Biodiversity Islands

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Abstract When the amount of biological diversity in an agricultural system is significantly higher than the baseline biodiversity of the surrounding area, the agricultural system itself may be recognized as a biodiversity island. Regenerative agricultural systems, which build and maintain fertility through time, may increase and maintain biodiversity as an integrated component of food production. Increases in biodiversity within an agricultural system can span all biological taxonomic kingdoms and vast numbers of classes and species within each. As such, regenerative agricultural management techniques geared toward harmonizing agricultural productivity and biodiversity conservation can contribute to mitigating or reversing detrimental effects of human impacts on landscapes. Greater diversity through intercropping, companion planting, combinations of perennial and annuals crops, cover cropping, hedgerows and diverse edge plantings, reduced agrochemical use, silvopasture with rotational grazing, and selection of rare, heirloom, underutilized, or diverse genetics allows for biodiversity to harmonize with agricultural production. In landscapes lacking protected areas or intact ecosystems, habitat restoration and preservation within agricultural systems can enable both farm productivity and biodiversity to increase. An integration of restoration and agriculture through farmer managed natural regeneration, rewilding, and incorporation of traditional ecological knowledge as operational management approaches within a regenerative agricultural framework may also achieve such ends. Much of the origins of regenerative agriculture emerged from indigenous practice of food production and traditional ecological knowledge that maintains biodiversity. Examples of regenerative agriculture as biodiversity islands, where farm productivity and improved biodiversity are achieved, span a multitude of crops, regions, and cultures throughout the world.

Keywords Agroforestry · Cover cropping · Intercropping · Habitat restoration · Hedgerows · Reduced agrochemical use · Silvopasture · Traditional ecological knowledge

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3.1 Introduction

Historically, expansion of agriculture has contributed to biodiversity loss globally. Conversion of native ecosystems to less diverse agriculturally productive landscapes tends to follow trends in global human population (Crist et al. 2017). Generally, a positive feedback loop exists related to population growth and ecosystem loss; as human populations increase, more land is converted to agriculture, providing the calories necessary for further population growth and greater land conversion (Henderson and Loreau 2019, Gustafson et al. 2020). While the technological and operational achievements of modern industrial agriculture provide relatively inexpensive calories to significant populations on a daily basis, the negative social costs in pollution, farmworker exploitation and health, and biodiversity loss are extensive. Even with considerable advancements and gains in yield per hectare through genetic selection and operational improvements, global biodiversity loss trends continue in response to agricultural expansion (Newbold et al. 2016). An inverse relationship typically emerges between increased crop specialization with production to achieve economies of scale and decreased landscape biodiversity and ecological function (Klasen et al. 2016). From deforestation for cattle ranching in the Amazon to commodity crop expansion in sub-Saharan Africa and corn and soybean production throughout the Midwestern United States, the global trends of rising global population linked with agricultural expansion and biodiversity loss continue (Fearnside 2017).

With the increase of such landscape degradation, ecosystem loss, and loss of species diversity throughout the globe, an urgency of design and communication frameworks is needed to protect biodiversity within the agricultural matrix (Kidd et al. 2019). Biodiversity islands, which may be defined as areas of high biodiversity nested within ecologically degraded, human-dominated landscapes, are one such instrument (Montagnini et al. 2022). The number of species in a biodiversity island is greater than the biodiversity of the surrounding human managed landscape. As such, biodiversity islands can take many forms, such as parklands surrounded by urban sprawl, conserved forestland surrounded by degraded and overgrazed pasture, or riparian corridors in a monocropped agricultural matrix (Montagnini et al. 2022). These ecological refugia can provide social, economic, and environmental value through time. Agricultural systems which utilize the practices of regenerative agriculture may harmonize ecosystem and agricultural productivity with biodiversity conservation, thus operating as biodiversity islands within the landscape.

Regenerative agriculture is an emerging term with a variety of definitions stemming from a diversity of land use approaches, ecological and social contexts, and lineages of agricultural practice. Consensus regarding an exact scientific definition for regenerative agriculture poses a challenge and frameworks for socio-economic and social implementation are sparse within the academic literature (Schreefel et al. 2020). In recent years, the term regenerative agriculture has gained popularity, differentiating itself from organic, conventional, conservation, or sustainable agriculture. Explicit practice-based definitions of regenerative agriculture may by limiting, given the system's approach and broad range of contexts towards which regenerative agricultural principles may be applied (Soloviev and Landua 2016). Regenerative agriculture draws from centuries of indigenous and traditional agricultural practices and decades of scientific study and applied research on organic farming, soil health, agroecology, permaculture, holistic management, and agroforestry around the globe. Generally, regenerative agriculture is a system of farming principles and practices that increase biodiversity, enrich soils, improve watersheds, and enhance ecosystem services (White 2020). They aim to capture carbon in soil and aboveground biomass, reversing current global trends of atmospheric carbon dioxide accumulation while offering increased yields, resilience to climate instability, and higher health and vitality for farming and ranching communities (www.regenerativeagriculturedefinition.com). The social aspects of agricultural production are also addressed by regenerative agriculture, in which production supports just and reciprocal relationships amongst all stakeholders. While a sustainable system maintains itself through time, a regenerative system builds and enhances ecological and social functioning, recognizing whole systems rather than reductionist viewpoints (Gibbons 2020). The definition and practice of regenerative agriculture continues to evolve.

This chapter focuses on regenerative agricultural systems which support wildlife, biodiversity conservation, and a diversity of genetic resources harmonized with farm productivity. Such agricultural methods may take many forms, from land sparing and land sharing, through traditional cultivation methods, and various other working-lands, agroecological management, and operational techniques (Perfecto et al. 2009; Gliessman 2016; Altieri 2018; Wagner 2020). Through time, as agricultural practices enhance fertility, sequester carbon, improve soil structure and water holding capacity, and reduce agrochemical inputs, farm biodiversity may increase as well (Toensmeier 2016; Rhodes 2017; Meena et al. 2020). When such biodiverse agricultural areas are within ecologically degraded human dominated surroundings, they act as biodiversity islands within the landscape. While general practices are described in this chapter, frameworks for implementation must consider social, economic, environmental, and cultural circumstances of each location. The following techniques and considerations described are useful for farmers, policy makers, researchers, and decision makers in landscape management.

3.2 Regenerative Management Increasing Biodiversity

Regenerative agricultural systems may be designed and managed to increase the on-farm presence of cultivated and wild species from numerous taxonomic kingdoms. This can include systems for water catchment, roads and pathway placement, and crop selection as well as more specific practices such as intercropping, polycultures, agroforestry, insectary hedgerows, reduced agrochemical use, and habitat restoration. These practices may also be interwoven with cultural and social restoration and the use of traditional ecological knowledge to fully foster regeneratively managed agricultural systems as part of the development of biodiversity islands within a landscape.

3.2.1 System Design and Management Plans

System design and management plans for increasing biodiversity through regenerative agriculture are highly specific to the region, social context, diversity of crop selection, and particular biophysical attributes of the site, such as geology, soil, and hydrology (Cabeza and Moilanen 2001; Mendenhall et al. 2014). The degree of existing ecological degradation, surrounding patch dynamics, and associated population ecology as it relates to island biogeography are also important factors determining species migration and baseline site biodiversity (Tavares et al. 2019). In severely degraded sites or existing monoculture industrialized agricultural systems, significant changes in cultural and management practices may be necessary to increase on-farm biodiversity. Yield of singular specialized crops may need to decrease to achieve greater on-farm biodiversity, while greater diversified crop yields, species abundance, and provision of ecosystem services can result (Altieri 2015). In many indigenous, traditional, and agroecological agricultural systems, management and design integrate biodiversity into production. A key principle of such agroecological management is designing agricultural ecosystems to mimic the function of local ecosystems through productive and diverse native species or agronomic crop analogs (Gliessman 2016; Altieri 2018). Integrating such practice through improved agricultural methods promotes habitat for a broad range of microbial, animal, plant, and fungi communities (Altieri 1999; Benayas and Bullock 2012). Sustainable intensification of agriculture through the application of agroecological principles can also increase trophic complexity, niche formation, and the biodiversity potential of the agroecosystem (Liere et al. 2017; Atkinson and Watson 2019).

Accordingly, system design and associated management for improved soil health can greatly increase biodiversity potential (Wagg et al. 2014). Terrestrial ecosystem functioning and biodiversity are controlled largely by soil microbial dynamics and soil health, whereas soil health is the capacity of soil to function as an essential living system, within ecosystem and land-use boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and promote plant and animal life (Giller et al. 1997; Lehmann et al. 2020). Management practices that enhance soil health are key indicators of ecosystem productivity and associated biodiversity (Brussaard et al. 2007).

From the physical and biophysical perspective, proper system design is essential in developing biodiverse and productive agricultural systems. Well-designed systems can be more productive, pest resistant, and water efficient, and they conserve and cycle nutrients more effectively (Doré et al. 2011; Ching 2018). Darren Dougherty's Regrarian's Platform®, built upon P.A. Yeoman's Keyline Scale of Permanence, offers one framework for considering factors according to the amount of time and effort required for farm modification by humans (Yeomans 1958). The consideration of these factors, including climate, geography, water, access, forestry, buildings, fences, soil, economy, and energy, can lead to the lasting commercial and ecological viability of the agricultural system (Chabay et al. 2015, www.Regrarians.org).

Long-term improved biodiversity can also correlate directly with other farm system design considerations that utilize an ecosystem approach (Dominati et al. 2019). For example, effective context-specific water management is extremely important for landscape productivity and improved biodiversity potential. When culturally, ecologically, and financially appropriate, earthworks designed and implemented to optimize on-farm water retention can increase the capacity for onsite cultivation and associated biodiversity (Socci et al. 2019). Keyline design, developed by agricultural innovator P.A. Yeomans, involves processes such as bringing water from valleys to ridgelines, to capture, slow, spread, store, and integrate water on the farm (Yeomans 1958). Utilizing such water management approaches, rainwater can become a tool for soil building, increased biomass accumulation, and increased biodiversity, rather than an erosive and potentially polluting force.

Planting arrangement and species selection are also important design considerations. For example, several vegetation strata, including low-lying groundcovers, understory herbs, low to mid story shrubs, and trees, some of which may be nitrogen-fixing, reduce dependency on agricultural inputs, enhancing synergisms among both biological and biophysical system functioning (Nair 2017). As these strategically designed biodiverse agricultural systems develop, in-situ mulching, improved nutrient cycling, increased water retention, more buffered temperatures, reduced soil evaporative loss, and increased biological control may result (Schroth et al. 2001; Lichtfouse 2018). Use of plants and animal breeds adapted to local conditions can also reduce dependence on foreign inputs and further increase nutrient cycling, soil fertility, and add biodiversity to the system (Enri et al. 2017; Jose et al. 2019). Regenerative agriculture may harness such principles, design strategies, and management techniques to achieve improved biodiversity outcomes for the farm system. If located within a degraded landscape with low biodiversity, such practices may allow for a biodiversity island to emerge.

3.2.2 Intercropping and Polycultures

Polycultures and intercropping involve the cultivation of multiple plant species in mixtures, typically in two or more parallel rows, though they may be planted in complex assemblages. These practices increase biodiversity and are utilized throughout the world for several agricultural benefits including diversified yields, improved biological pest control, weed control, reduced wind erosion, and improved water infiltration (McLaughlin and Mineau 1995; Corrado et al. 2019). Compared to a monocrop system, an intercropped system is inherently more biodiverse, given the increased number of plant species and varieties in cultivation, either planted at the same time or successionally on the same land. Food web interactions and habitat complexity also increase (Moss et al. 2020). Synergistic relationships of vertebrate, invertebrate, and microbial communities support and harbor more complex, resilient, and biodiverse farm ecosystems (Jackson et al. 2007; Zhao et al. 2019). Intercropping can consist of annuals, perennials, or combinations of the two.

The selection of intercropped species requires knowledge of which species grow well together. The degree of biodiversity improvements will depend on the species selected and cultivation strategy. In some instances, weeds are left to grow as a trap crop for insect pests, increasing invertebrate diversity (Reddy 2017). In other instances, diversified polycultures are intentionally planted from nursery stock or seeded in situ. Studies indicate that intercropping increases invertebrate abundance compared to monocrop systems (Cárcamo and Spence 1994; Tilman 2020). Similarly, in terms of microbial biodiversity, intercropping of diverse landscapes and tree species results in greater soil microbiological diversity (Lacombe et al. 2009; Chen et al. 2020). Overall, through intercropping, biodiversity of plants, soil, and animal life can increase and contribute to the creation of biodiversity islands in otherwise degraded landscapes.

3.2.3 Agroforestry

Agroforestry systems (AFS), an intensive land management system that optimizes benefits from the biological interactions created when trees and/or shrubs are deliberately combined with crops and/or livestock, can increase farm productivity while supporting biodiversity and providing social and economic benefits for farmers (Leakey 1999; Jose 2009, 2012; Montagnini and Metzel 2017; Udawatta et al. 2019; Montagnini 2020, https://www.aftaweb.org/). AFS are heterogeneous in their design, management, and species composition, and therefore have diverse values in terms of restoration, productivity, and conservation.

Within AFS, the highest amounts of biodiversity are typically found within successional AFS, home gardens, forest gardens, and other complex multi-strata systems (Huang et al. 2002). Other simpler AFS with fewer species of plants or animals will typically foster less biodiversity, though they may still be considered a biodiversity island if the surrounding landscape is degraded. In most instances, the AFS will be the most biodiverse cultivated system of the human dominated landscape (Schroth et al. 2004; McNeely and Schroth 2006). Riparian corridors, living fences, windbreaks, and perimeter hedges may also provide connectivity in fragmented agricultural landscapes and help bring greater biodiversity to a farm (Jose 2012). Perennial crops under shade or silvopastoral systems (SPS) with scattered trees for shade can also provide greater biodiversity and ecological benefits than monocultures or degraded fallow lands, though providing less biodiversity than complex multistrata AFS (Leakey 1999). To favor biodiversity restoration and conservation, AFS should increase their structural complexity in terms of strata and number of species (Montagnini and del Fierro 2022). Management and regenerative agricultural practices that employ agroforestry systems can increase biodiversity and aid in the development of agricultural lands as biodiversity islands within the landscape.

Correspondingly, successional agroforestry systems established through enrichment planting can mimic natural regeneration to produce biodiverse and productive food systems (Young 2017). Successional agroforestry systems consist of multistrata multifunctional species assemblages that collectively appear to have a similar structure to native forests. They can include both introduced and native species. Native species may emerge from the existing seedbank where seeds are otherwise unavailable. Tree-growth and crop productivity are achieved by management that promotes functional characteristics of key natural successional stages of the native landscape. As stands mature, unique habitats emerge, creating the conditions for greater biodiversity and opportunities for the establishment of a greater variety of successional productive species.

Many native or imported species cannot be planted in open plantations because seedlings are shade tolerant and otherwise will not germinate. As such, enrichment plantings of food bearing species within degraded landscapes may produce highly diverse agroforestry systems (Montagnini et al. 1997). Such practices are not new. For centuries, numerous indigenous cultures recognized the resiliency and food bearing potential of biodiverse successional agroforestry systems as forest analogues (Bertsch 2017).

3.2.4 Cover Cropping

Cover cropping, an agricultural technique where pure or mixed stands of perennial or annual herbaceous plants are grown to cover soil and improve fertility, has also been shown to increase farm biodiversity. As a tool for regenerative agriculture, cover cropping legumes, cereals, and other plant mixtures can improve soil structure, soil fertility, pest management, and biodiversity. Moreover, cover cropping improves water holding capacity and infiltration, reduces soil erosion, adds organic matter to soil horizons, cycles nutrients, nourishes the soil food web, reduces weed competition, and aids in the regulation of soil temperatures (Altieri 2015).

Cover crop management practices vary significantly depending on regional climate, species selection, tillage and clipping frequency, and time of seeding (Finch and Sharp 1976). Rye (*Secale cereale* L.), clovers (*Trifolium* spp.), vetches (*Vicia* spp.), alfalfa (*Medicago sativa*), and leguminous *Pueraria, Stylosanthes*, and *Centrosema* are commonly planted as cover crops (Altieri 1995). One study indicated the planting of leguminous cover crops (*Mucuna pruriens var. utilis*) increases soil macrofauna and nematofauna in maize cultivation (Blanchart et al. 2006). In rubber plantations, Kuzdu, *Pueraria phaseoloides* is a nitrogen fixing legume commonly used as a cover crop. Wild peanuts (*Arachis pintoi*) are commonly used as cover crops for coffee and silvopastural systems in Central and South America (De La Cruz et al. 1994).

A practice used from tropical to temperate systems, cover crops also promote invertebrate diversity, increase populations of beneficial parasitoids, and can improve biological pest control (Altieri and Schmidt 1985). As a tool in regenerative agriculture, cover cropping provides multiple benefits and increases belowground and aboveground biodiversity of the farm system. As such, cover cropping can enhance the capacity of regenerative agricultural systems as biodiversity islands.

3.2.5 Insectary Hedgerows

Planting a broad range of flowering perennial and annual species in hedgerows throughout a farm can harbor a diverse and balanced insect ecology while greatly reducing pest pressure on crops and maintaining on-farm biodiversity in regenerative agricultural systems (Long et al. 1998; Landis et al. 2000). These insectary hedgerows include plants that attract both pests and associated beneficial predatory insects, providing a breeding ground for beneficial insect populations to increase and expand into cultivated spaces. Flowering species which bloom in succession throughout the growing season should be included to ensure that nectar is available to support beneficial insects throughout the growing season (Holland 2019).

Within insectary hedgerows, plants can perform different functions related to biological pest control and on-farm biodiversity. Plants that are more attractive to a pest than the crop plant may be monitored as indicators of pest populations and developing pest pressures. For example, pole beans are more attractive to spider mites than tomato, pepper, cucumber, or strawberry. As such, indication of spider mites on pole beans can allow farmers to control outbreaks before significant crop damage occurs. Similarly, trap crops are plants which are more attractive to pests than the commercial crop, taking most of the pest damage and sparing the desired crop (Parker et al. 2016). Used in conjunction with one another, a monitoring plant can also act as a trap plant.

When beneficial insects become established by feeding on the pests, these trap crops can become banker crops providing a food source for the increase of beneficial insect populations (Miller et al. 2017). Banker plants attract and host pests and are used as an insectary to grow more beneficial insects (Balzan 2017). For example, fast growing cereal grasses such as ryegrass can be used to attract aphids that become a food source for aphid predators and parasites. In each of these instances, the simple increase of plant and arthropod diversity in the system, through the planting of insectary hedgerows, promotes great biodiversity and establishment of the agricultural system as a biodiversity island in an otherwise degraded, human dominated landscape.

3.2.6 Reduced Agrochemical Use

Another important aspect of regenerative agriculture as it relates to biodiversity is the reduction of agrochemical use. Use of pesticides, herbicides, and conventional fertilization all may contribute towards decreases in biodiversity (Benton et al. 2003; Mandal et al. 2020). Agrochemical use may also negatively affect nutrient cycling, the soil food web, decomposition of soil organic matter, beneficial insects and natural predator populations. Excessive use of agrochemicals may also increase NO_2 and other greenhouse gas emissions, thus affecting air quality and farmworker health, which are antithetical to the outcomes and principles of regenerative agriculture (Kimbrell 2002).

Insect populations have significantly decreased in recent years, largely attributable to increased pesticide use (Sánchez-Bayo and Wyckhuys 2019). In many instances, the effects of these chemical applications go beyond their point of use and can be associated with decreased biodiversity in the broader ecosystem. Runoff of excess nitrogen and phosphorus in fertilizers enters waterways and reduces aquatic biodiversity (Ali et al. 2011).

Fortunately, as described in this section, biological practices for pest management, weed abatement, and fertility are feasible and can increase on farm biodiversity without agrochemical use (Jørgensen and Kudsk 2006). Such regenerative practices can also decrease the costs of inputs through time by improving in situ nutrient cycling (Coleman et al. 1983). Agrochemical applications contradict the biological practices of regenerative agriculture particularly related to biodiversity. Therefore, their use should be minimized in the establishment and maintenance of agricultural systems as biodiversity islands.

3.2.7 Habitat Restoration Within Regenerative Agriculture

Another method to increase on-farm biodiversity is through the restoration of habitat and ecosystems within low diversity farm systems. Establishing areas of natural vegetation on farms allows the landscape to fulfill greater ecological function and provides additional ecosystem services simultaneously with agricultural production. In degraded lands, restoration of habitat towards these ends directly relates to the ecological objectives and goals of regenerative agriculture. The co-benefits of on-farm habitat restoration include production of nonagricultural products, habitat for various life forms, prevention of soil erosion through runoff and wind, increased carbon sequestration, and increased water infiltration and watershed health (Benton et al. 2003). The intentional integration of habitat restoration within the landscape is therefore a strategy a farmer may choose to implement as part of a regenerative agricultural system. Examples of biodiversity enhancing on-farm habitat restoration include farmer managed natural regeneration, successional agroforestry systems which integrate native species, and rewilding of farmlands.

Farmer managed natural regeneration increases biodiversity and farm productivity by allowing the existing on-farm sources of regeneration to germinate, grow, and compete with other vegetation. Through observation and selection of which useful species emerge, one can manage, tend, and harvest from more diversified farm ecosystems. This can be achieved by allowing natural regeneration to take place in fields or on selected patches within the farm (Wintle et al. 2019) Valuable species are selected to persist, thus creating a low-cost and biodiverse foundation from which productive agricultural systems may emerge. For example, in the Sahel region of Niger, rather than weeding all species, farmers may select specific species to remain in the fields. By caring for these naturally regenerating drought tolerant species, greater diversity and yields result. These practices have been a contributing factor in a low-cost option for increased diversity and indigenous genetics of gardens and agriculture throughout the region (Reij and Garrity 2016).

Allowing succession to occur in a slightly more hands-off approach may be known as rewilding or natural regeneration. Allocating land for rewilding, some areas of crop cultivation may be lost, but the trade-off results in greater diversity, pollination, and other ecosystem services (Navarro and Pereira 2015). These areas may also be seeded with a diversity of desired annual and perennial species, with minimal continued management.

The beneficial outcomes of natural regeneration on sections of farmland are particularly clear in certain grazing systems. For example, The Knepp Wildland Project in the United Kingdom originally utilized a traditional pastureland. As cattle were removed from sections of the farm, those areas underwent rapid natural regeneration. In some areas, existing seed banks were able to emerge and other areas were seeded with desirable species. After tree establishment, cattle were reintroduced to sections of the farm, where they had access to increased forage and greater shade, functioning as a silvopastoral system (Tree 2019). This integration of rewilding and natural regeneration provided habitat for a vastly greater number of local species, while still providing farm yields. The farm was transformed into a biodiversity island within the landscape.

3.2.8 Silvopasture and Rotational Grazing

Silvopasture with rotational grazing is another management strategy which can improve agricultural biodiversity as part of a regenerative agricultural system (Jose et al. 2019). Silvopasture is a type of agroforestry system consisting of the intentional combination of trees, forage plants and livestock together as an integrated, intensively-managed production system (https://www.aftaweb.org/). Silvopasture can provide profitable opportunities for tree growers, forest landowners, and livestock producers through the integration of what are typically separate production of tree crops and livestock. The benefits of rotational grazing are site and context specific but can include improved forage production, soil health, fertility, soil carbon storage, drought resistance, weed control, human and animal relationships, animal welfare, an extended grazing season, reduced forage waste, and reduced parasite problems (Orefice and Carroll 2017; Jose et al. 2019). Combined with silvopasture, additional economic benefits of tree production may emerge such as reduced fertilizer requirements, improved yields, increased weight gain, and reduced fodder needs (Gabriel 2018). Compared to monoculture tree cultivation or continuous grazing, silvopasture with rotational grazing can greatly increase biodiversity (McDermott and Rodewald 2014). Silvopastoral systems can harbor a high diversity of cultivated species in addition to a wide range of arboreal wildlife habitat.

As for rotational grazing, the diversity, quality, and longevity of forage species can increase when adequate rest is given to the grazed area, when compared to a continuous grazing system. Such outcomes are dependent on stocking rate, paddock size, longevity of grazing, and regional climatic and biophysical factors of the farm (Gabriel 2018). If managed optimally for the appropriate context of the farm, rotational grazing provides opportunities for a greater variety of forage species to persist and for greater profitability (Orefice et al. 2019). Additionally, greater farm biodiversity may be present in rare, native, or unique livestock breeds as well as the incorporation of different species including goats, chickens, ducks, pigs, cattle, buffalo, and others (Gabriel 2018). With proper management, silvopasture and rotational grazing can allow for greater biodiversity to emerge (McAdam and McEvoy 2009).

With both silvopasture and rotational grazing, one should learn the benefits as well as the risks before adopting the practices. Integration of multi-species grazing schemes may increase parasite loads if not managed properly. In certain areas, legislation prevents grazing on lands used for the cultivation of food crops within a specified time period preceding harvest in order to prevent contamination risks. Transition of land into silvopasture or grazing areas without proper management can damage soil, cause erosion, and eliminate opportunities for natural regeneration when appropriate or desired (Orefice et al. 2019). The complexity and diversity of approaches for integrating silvopasture and rotational grazing depends on farm location and larger holistic framework of farm context (Savory and Butterfield 1998). If properly applied and managed, silvopasture with rotation grazing is an agricultural practice which may increase on-farm biodiversity and allow for a farm to become a biodiversity island within a degraded landscape.

3.2.9 The Use of Rare, Heirloom, and Underutilized Species and Cultivars

When unique, rare, and diverse species of plants and livestock are cultivated in regenerative agricultural systems, these farm systems can serve as biodiversity islands within a human dominated and degraded landscape. Greater crop diversity of cultivated species increases the overall biodiversity of the agricultural system and can allow for increased food security, decreased pest pressures, more resilience to climate change, and enhanced connection between cultures and locally produced foods (Smith et al. 2008; Chateil et al. 2013; Gaudin et al. 2015).

Rare, heirloom, regional and family cultivars of fruit and vegetable crops were once commonplace globally, though an inverse relationship tends to exist between industrialized agriculture expansion and landrace presence and diversity (Nazarea

2005). Fortunately, farms, organizations, and community groups are working to continue to keep such species alive while increasing genetic diversity through time (Abebe 2005). Regenerative agriculture systems such as urban community gardens and homegardens commonly cultivate genetically diverse and heirloom crops (Bardhan et al. 2012; Redondo-Brenes and Montagnini 2010). Conservation of on-farm crop diversity is extremely important to both biodiversity and the cultures from which these crops arose (Brush 2000). In situ and ex situ methods of conservation allow for genetic resources to be preserved through time while expanding crop diversity (Swanson and Goeschl 2000). More diverse crops have the potential to support greater soil life diversity and insect diversity, with differing phenologies, nutrient requirements, decomposition rates, and structure (Redlich et al. 2018). When in urban environments, these systems can be important refugia for biodiversity, as well as places where people can connect with nature (Toensmeier 2022). When rare, heirloom, or underutilized species are cultivated, seeds saved and passed on through time, greater genetic diversity can persist in the human dominated landscape.

Maintaining the diversity of plants in cultivation can take many forms. Rowen White, through her work as an indigenous seed breeder, cofounder of the Sierra Seeds Cooperative, and chair of the board of The Seed Savers Exchange, emphasizes the genetic, cultural, and historical importance of seed saving (White et al. 2018). The Felix Gillet Institute, founded by the late Amigo Bob Cantisano, explores neglected homesteads and agricultural sites seeking surviving heirloom varieties of fruit and nut trees throughout California (https://felixgillet.org/). Plant explorers such as David Fair-Child traveled the globe bringing diverse and underutilized species into cultivation (Fair-Child 1939). Plant breeders such as the famed Luther Burbank utilize innovative breeding techniques to greatly expand favorable characteristics and useful varieties and diversity of plants in cultivation (Burbank 1915). Through seed saving, recovery of heirloom varieties, exploration of underutilized species, and innovative breeding for new genetics, the diversity of cultivated plants can expand, even when challenged by economic forces spurring an opposite trend (Nazarea 2005). Regenerative agriculture can utilize the broad range of cultivar diversity to keep the genetics, stories, and species diversity alive. In doing so, regenerative agricultural sites can continue to develop as biodiversity islands within the landscape.

3.3 Social Dimensions of Regenerative Agriculture as Biodiversity Islands

In attaining greater biodiversity in regenerative agricultural systems, social and cultural factors should not be overlooked. Restorative action can go beyond practices of cultivation and ecological management to address restoration and regeneration of community and human relationships. Respect for the cultural origins of regenerative agriculture and the historical ecology of cultivated lands, farmworker health, empowerment, right-livelihoods, and the affordability and access to regeneratively cultivated foods by consumers must integrate with enhanced biodiversity for the agricultural system to be truly regenerative. The potential to address these social considerations is a key task for regenerative agriculture into the future.

3.3.1 Traditional Ecological Knowledge: The Roots of Regenerative Agriculture

Traditional Ecological Knowledge (TEK) or Ecological Indigenous Knowledge (EIK) and the historical ecology of cultivated lands may contribute significantly towards the development and continuation of food production systems which act as biodiversity islands within a landscape. Much of regenerative agriculture is built upon this knowledge. When not already in place, indigenous, knowledge-holding representatives should hold positions of authority and decision-making within agricultural organizations. Land return to indigenously managed lands is another approach towards empowerment and social restoration in regenerative agriculture. Many indigenous communities inhabit areas where the diversity of plant and animal species have been utilized for thousands of years (Rocha et al. 2017). This can be seen in many terraced landscapes throughout the globe (Fig. 3.1).

Most inhabited places of the earth have an associated historical ecology, although in many instances this knowledge has been deeply eroded due to various social and economic factors (Balée 1998). Where traditional cultures remain, often certain members of the indigenous culture still hold knowledge of traditions and practices related to cultivating, managing, processing, and consuming diverse, native species (Berkes et al. 1994). For example, there is extensive knowledge of Native American management and cultivation of California's pre-colonial landscape (Anderson 2013). In areas where such knowledge is nearly lost from collective memory or culture, there is significant opportunity in the rediscovery and re-empowerment of such traditional knowledge as a fundamental component of productive and biodiverse regenerative agricultural systems of the future.

Technical and scientific knowledge of such traditional ecological knowledge may provide medicinal, nutritional, and otherwise valuable products. Among many others, guayusa, yerba mate, and cacao have well-documented examples of indigenous knowledge being integrated with scientific techniques to develop modern cultivation practices. In instances where local knowledge is used to gain insights into cultivation, harvesting, and processing, and bringing new products to market, one must be cautious to avoid exploitation and acknowledge the social responsibility within regenerative agriculture. For example, Yoco (*Paullinia yoco*), a vine that is wild-harvested for its caffeinated bark by the Secoya people, has had populations greatly reduced in recent years. A Yale researcher began working to restore populations of Yoco by designing systems with the community to enrich the forests

Fig. 3.1 A village outside Muktinath, Nepal. Irrigated terrace agriculture with incorporation of various annual grains and tree crops, adding to the biodiversity of the landscape. Techniques of traditional and regenerative agriculture allow for subsistence farming, organic nutrient cycling, and efficient use of water to transform otherwise inhospitable terrain into a biodiverse landscape. (Photo: Brett Levin)

with more yoco while monitoring key environmental outcomes of these systems. (Fig. 3.2) The project looks very carefully under which ecological conditions the yoco can be established, such as light, soils, and species assemblages. This connection between traditional, technical, and community empowerment is an example of how regenerative agriculture can enhance biodiversity through the incorporation of traditional ecological knowledge. These productive sites emerge as biodiversity islands within landscapes that are rapidly being cleared due to logging and conversion of forest to pasture.

Correspondingly, ethnobiology and ethnophenology address the human and cultural component of how species and genetics are selected through time (Nabhan 2016). Ethnobiology explores the complex interactions among cultures, their languages and resource management practices with genes, foods, medicines, habitats, and landscapes for addressing critical links between culture, cultivation, and ecological diversity. Ethnophenology refers to the cultural perception of the timing of recurrent natural history events and environmental conditions in the selection and managing of specific species. For example, records from the early 1900s provide anecdotal evidence that for the Hidatsa people of the Missouri River, the sunflower seed was always the first seed planted in the spring based on observations of the melting of ice along the banks of the Missouri River around April. This was followed by planting of corn in May based on the observation of the emergence of leaves of

Fig. 3.2 Expanding the traditional Secoya people cultivation through forest enrichment with Yoco in a multilayered, biodiverse forest system in the Amazon of Ecuador. (Photo: Luke Weiss)

the wild gooseberry bushes. These strong observations of environmental cues are learned by cultures with longstanding connections to land.

Through the incorporation of greater biodiversity into farm systems, regenerative agriculture can learn and build upon these traditions to provide a more perceptive, inclusive, and harmonious approach to cultivation, rather than mandate by strict agronomic management procedures (Nabhan 2014; Albuquerque and de Sousa 2016). Regenerative agriculture farms may become locations of applied practice towards cultural restoration and biodiversity enhancement in addition to agronomic cultivation.

3.3.2 Farmworker Health, Empowerment, and Right-Livelihood

Farmworker health, empowerment, and right-livelihood are other important social matters that must be considered as part of biodiversity-enhancing regenerative agricultural systems. Is an agricultural system that enhances biodiversity but harms and exploits its workers truly regenerative? Farmworker health issues caused by exposure to toxic agrochemicals is rampant in industrialized agriculture (Salzman

2018; Saxton 2021). By implementing biodiversity-enhancing agricultural systems, farmworker health can improve (Afshari et al. 2021). Opportunities in farmworker training and empowerment may also be integrated into biodiversity-friendly agricultural systems (Braun and Duveskog 2011). One such opportunity may be the training of farmworkers to recognize, monitor, and collect data on soil health and pest pressures, which can allow for more targeted biological approaches towards cultivation and pest management. A survey of Farmer Field School (FFS) programs, which employ local knowledge sharing and training in pest management, not only reduced pesticide use and improved associated farmworker health, but proved economically advantageous (Rejesus and Jones 2020).

Additionally, workers should be paid a living wage for their time and energy if the agricultural system is to be recognized as regenerative. Worker-ownership and cooperative business structures can provide long-term equity, wealth building and authority to all levels of the organization while biodiversity practices are implemented (Alkon and Guthman 2017). Such approaches are utilized in coffee plantations throughout El Salvador and farmworker cooperatives of the United States (Bacon et al. 2008; Gray 2013). Sylvanaqua farms is a unique example in the Washington DC area focused on both the social and ecological components of regenerative agriculture (https://www.sylvanaqua.com/). Overall, for a farm system that enhances biodiversity to be recognized as regenerative, it must also consider the health and wellbeing of the farmers who work the land.

3.3.3 Affordability and Access to Regenerative Agriculture

The lack of affordability and access of regeneratively grown crops and associated products is another often overlooked social dimension of regenerative agriculture. If only the wealthy can afford regenerative agriculture, is it truly regenerative? When on-farm biodiversity improvements cause prices to increase, low-income consumers become excluded from the market. Similarly, when the negative social costs of degradative agriculture are not factored into pricing, prices remain artificially low (Pascual and Perrings 2007).

Such issues can be addressed through numerous progressive and grassroots strategies. Removal of existing governmental subsidies that support degradative practices is essential. Support of new subsidies for regenerative practices advance affordability. Negative social costs such as biodiversity loss, soil loss, greenhouse gas emissions, water quality degradation, and effects of industrial agriculture on human health must be factored into pricing (Mouysset et al. 2015). Payments for ecosystem services can also reduce prices of food and products to consumers that are grown regeneratively (Lankoski 2016). Additionally, with grassroots efforts to develop local regenerative agricultural systems and community supported agriculture projects as biodiversity islands, low-income access and affordability can improve. Examples are numerous and worldwide, spanning urban to rural areas lacking access to regeneratively grown produce (Adam 2006; Duchemin et al. 2008; Lovell 2010).

Overall, a transition from degenerative agricultural practices to regenerative practices requires a cultural shift to one that sees natural systems as essential, valuable, and inherently interconnected. Regenerative agricultural practices that increase biodiversity should also improve social and human wellbeing. Much of the origins of regenerative agriculture emerged from indigenous practices of food production and traditional ecological knowledge that maintains biodiversity. Recognizing, appreciating, and empowering this history is an essential component of the story of regenerative agriculture that is commonly appropriated, dismissed, or ignored. For agriculture to be truly regenerative, it must use a systems approach and consider impacts to the interrelated human systems that make cultivation, distribution, and food access possible.

3.4 Regenerative Agriculture in the Modern Age

As regenerative agriculture continues to expand, it is important to highlight some of the key organizations currently shaping the conversation. Future considerations regarding funding, monitoring of environmental outcomes, and education are essential for the continued widespread adoption of regenerative agriculture which may act as biodiversity islands.

3.4.1 Organizations Supporting Regenerative Agriculture for Biodiversity Conservation

The promotion and adoption of regenerative agriculture continues to expand in various sectors. Organizations and projects supporting the advancement of biodiverse regenerative agriculture are diverse and worldwide. Investment entities, farms, service organizations, consumer packaged goods manufacturers, and nonprofit organizations are rapidly expanding their language and practices surrounding regenerative agriculture (http://www.ethansoloviev.com/regenerative-agriculture-industry-map/). The International Federation of Organic Agriculture Movements (IFOAM), the National Center for Appropriate Technology (NCAT) and their ATTRA program, Ecological Farming Association (Ecofarm), The Tropical Agricultural Research and Higher Education Center (CATIE), The Society of Ethnobiology, and countless other organizations support research and communication of these ideas. Some additional examples are reviewed in greater detail below to highlight the diversity of geography and scope of work from which supporting organizations exist.

SOCLA (Sociedad Cientifica de Agricultura Latino Americana de Agroecologia, Latin America Scientific Society of Agroecology) is a network of researchers, professors, extensionists, and other professionals which promotes agroecological and regenerative practices to confront the crisis of industrial agriculture. SOCLA promotes agroecology as a scientifically justifiable and sustainable rural development strategy in Latin America. To accomplish its objectives SOCLA organizes scientific congresses, holds short training courses in various countries, produces publications on key issues, and maintains working groups that provide information, analysis and technical advice to numerous civil and farmers organizations involved in agroecology in the region. Recently, the North American SOCLA chapter was launched. This work promotes the integration of greater biodiversity within regenerative agricultural systems (https://www.socla.co/).

Rodale Institute has been a leader in organic and regenerative agriculture since its founding in 1947 in Kutztown, Pennsylvania. As a pioneer in this field, they support new farmers, contribute valuable research, and educate consumers regarding the benefits of organic products. A key component of their work encourages biodiversity through regenerative agriculture. Rodale recognizes that a rich mix of microorganisms, plants, and animals on the farm creates healthy soil, strong crops, and resilient natural systems that don't require chemical intervention to manage pests and diseases. This knowledge is shared broadly through their public, outreach and education, in addition to being applied on their own agricultural land. In 2018, Rodale Institute helped spearhead a new, holistic, high-bar standard for agriculture certification. Regenerative Organic Certification, or ROC, is overseen by the Regenerative Organic Alliance, a non-profit made up of experts in farming, ranching, soil health, animal welfare, as well as farmer and worker fairness (https://rodaleinstitute.org/). The certification consists of three pillars: soil health, animal welfare, and social fairness. Attaining certification supports approaches to land management and associated processes that contribute to the health of ecosystems and human communities.

The Land Institute, founded by Wes Jackson in the 1970s, has been working to develop perennial grain crops and support biodiverse polycultures. Located in Salinas, Kansas, they have recently had success with the development of a new species of perennial grain called Kernza, which has the potential to transform much of the world's grain production into perennial agriculture, thereby contributing to soil protection and the preservation of waterways. The Land Institute is also developing a crop protection program that relies on biological control using natural enemies (https://landinstitute.org/our-work/ecological-intensification/).

The Al Bahaya project in Saudi Arabia is transforming a barren desert into productive savanna grasslands and agroforestry systems using regenerative agriculture techniques and extensive stone terracing to capture water. Choosing the appropriate species has been essential. When the system was first established, irrigation was utilized and later it was cut off. For 31 months there was no precipitation. After it finally rained, the species were able to recover and begin a biological cascade towards rejuvenation. (https://www.youtube.com/watch?v=T39QHprz-x8). Here, once the system was established, regenerative agricultural processes utilize the resources available, no matter how scarce, to build biodiversity and productive agricultural systems. Such considerations are the basis of the future of regenerative agriculture as biodiversity islands within degraded landscapes.

The Savanna Institute, a nonprofit organization located in Wisconsin, is a leader in temperate agroforestry research, laying the groundwork for widespread agroforestry in the Midwest US. Working in collaboration with farmers and scientists, the Savanna Institute is developing perennial food and fodder crops within multifunctional polyculture systems, grounded in ecology, and inspired by the savanna biome, with an emphasis on tree crops. Chestnuts and hazelnuts tend to be the backbone of The Savanna Institute's diverse agroforestry systems and they strategically enact their mission via research, education, and outreach (http://savannainstitute.org/).

Numerous family farms with goals of integrating biodiversity and food production also continue to emerge. New Forest Farm is a diverse restoration agriculture research site in southwestern Wisconsin, USA. Located on a former cornfield, through the efforts of Mark Shephard, the land has been transformed into a biodiverse perennial agriculture ecosystem. Utilizing innovative water management techniques, various trees, shrubs, vines, canes, grasses, forbs and fungi have been planted, organized to optimize yield and efficiency in harvesting and management. Woody crops include hazelnuts, chestnuts, walnuts, and apples (Shepard 2013). The diverse plantings and biology present within New Forest Farm make it a biodiversity island within the surrounding vast expanse of monoculture corn and soy production. Polyface farm is another example of a biodiverse regenerative agriculture family farm. Spearheaded by the Salatin family, the operation produces pastured poultry and a broad range of crops focusing on soil health, community health, and the continued improvement of the land base. Through time, measured improvements in biodiversity have resulted (Salatin 2010). Such operations as biodiversity islands within the landscape integrate old farm knowledge with new innovations, paving the future of a new, regenerative, and biodiverse agricultural paradigm.

The Savory Institute and Holistic Management International both promote, advocate, and teach about regenerative agriculture through holistic rangeland management and holistic decision making (https://holisticmanagement.org/, https://savory.global/). Holistic management was born from the work of Allan Savory, a Zimbabwean ecologist. Properly managed livestock are the ecological foundation of the holistic context. The general objectives are to help ranchers and land stewards strengthen local economies, improve local food quality, heal the environment, improve wildlife habitats, and enhance community. The teachings train farmers to recognize their goals, plan appropriately based on specific contexts, and manage livestock to mimic natural ecological patterning of mob grazing while improving soil carbon sequestration and overall rangeland biodiversity as compared to conventional grazing and cattle raising operations.

These organizations are a small sampling of many more groups focused on advancing biodiversity through regenerative agriculture. It is also important to recognize the millions of smallholders practicing similar techniques and sharing traditional knowledge throughout the world. As awareness and interest continues to grow for increasing biodiversity in degraded landscapes while producing food, one can expect the influence of these bodies to continue to expand and new organizations to continue to emerge.

3.4.2 Considering the Future: Funding, Monitoring, and Education

Alongside private sector approaches, governments can continue to support and grow programs for agricultural practices that encourage farmers to increase farm biodiversity. Governments can work towards goals of increased agricultural biodiversity in the same way successful widespread adoption of organic programs in Europe took place. This was achieved through increased funding of training programs, offsetting certification costs, and improving the quality of government advisory services, all of which have proven highly effective (Mills et al. 2020). In the United States, the Department of Agriculture and the Natural Resources Conservation Service currently have several financial incentives for farmers to adopt practices such as riparian corridors, windbreaks, and hedgerows (Duru et al. 2015). The Environmental Quality Incentives Program (EQIP) aids agricultural producers through technical and financial support through public funding to address natural resource degradation and to improve the environment through increased water and air quality, conserved ground and surface water, increased soil health, reduced soil erosion, improved or created wildlife habitat, and mitigation against increasing weather volatility through public funding. Of these conservation practices, many contribute to the development of agricultural biodiversity islands within a landscape (https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/). Though well-funded with a budget of $1.75 billion in fiscal years 2019 and 2020, $1.8 billion in fiscal year 2021, $1.85 billion in fiscal year 2022 and $2.025 billion in fiscal year 2023, there remains opportunity for greater financing of biodiversity enhancing conservation practices (https://www.fb.org/market-intel/eqip-and-csp-conservation-programs-in-the-2018-farm-bill). This type of financial assistance can be greatly expanded upon, and include all the previously mentioned practices, which can increase farm resilience, yields, and on-farm biodiversity. Within the United States, this can be addressed through a revision of funding priorities federally in the Farm Bill, and locally through state action and cooperative extensions.

Additionally, as private funding and markets for payments for ecosystem services and carbon sequestration in agriculture continue to advance, it is important to consider the potential to integrate biodiversity within such projects. Many carbon offset projects focus solely on biomass production and carbon sequestration. Focusing on the maximum biomass growth possible to obtain as many carbon credits as possible may place higher value on fast growing species than native, bio-regionally appropriate food-bearing species. In these instances, where projects focus on biomass generation for either carbon or bioenergy, biodiversity can decrease through time rather than improve (Abreu et al. 2017). By incorporating some of the practices mentioned above, these projects can have mutually beneficial outcomes of biomass production, sequestration, and improved biodiversity outcomes.

Advancements in monitoring of biodiversity coupled with carbon sequestration and other ecosystem services may provide another significant increase in the adoption of regenerative agriculture. When the benefits and positive impacts of these practices are measurable with greater certainty, value can be associated with such practices, and the positive social benefits can be attributed to individual farms and farmers. The externalities of any farm, positive or negative, influence the rest of the landscape. When such externalities are properly monitored and valued, society is more able to perceive those benefits, which in turn makes regenerative agriculture more attractive. This opens further opportunity for community engagement, investment, funding, and more widespread adoption of biodiverse regenerative farming, sparking the development of biodiversity islands throughout degraded landscapes (https://www.regen.network/, https://www.ecosystemmarketplace.com/).

Online educational opportunities for learning regenerative agricultural practices that enhance biodiversity outcomes have grown significantly. Reports, podcasts, webinars, workshops, conferences, virtual university extension programs which are now widely available for free, provide information that is both conceptual and specific for bioregional applied practice. Many examples of such media can be found on websites and platforms such as, https://attra.ncat.org/multimedia/, https://ecoagriculture.org/, https://imfn.net/, https://satoyama-initiative.org/, https://www.nature.org/en-us/, https://www.conservation.org/, https://www.worldwildlife.org/, https://onehealthinitiative.com/, and others mentioned in Chap. 1 Sect. 1.5 of this volume.

Additionally, there are a growing number of technical and scientific publications accessible to a broad audience, such as *Working with Nature: Resource Management for Sustainability* (Jordan 1998), *Tomorrow's Biodiversity* (Shiva 2000), *Call of the Reed Warbler* (Massy 2017), *Growing a Revolution* (Montgomery 2018), and *Reclaiming the Commons* (Shiva 2020). Such resources and writings are inspiring a new generation of educators, policy makers, and farmers to engage in the work of developing biodiverse regenerative agricultural systems which may act as biodiversity islands within the landscape.

Regenerative agriculture emerged from traditional knowledge and ecological observations through time. While conducted mostly by indigenous people and smallholders throughout the world, over the past century, writers and practitioners worldwide have continued to advance the science and practice of regenerative agriculture in the western paradigm. Such notable proponents include Amigo Bob Cantisano, Bill Mollison, Christine Jones, Cyril G Hopkins, Darren Dougherty, David Montgomery, Edward Faulkner, Eric Toesnmeier, Ethan Soloviev, Eve Balfour, Everette "Deke" Dietrick, F.H. King, Gabe Brown, J. Russell Smith, J.I. Rodale, Joel Salatin, John Jeavons, John Kempf, John Lundgren, Judith Schwartz, Miguel Altieri, Leah Penniman, Mark Shepard, Masanobu Fukuoka, Newman Turner, P.A. Yeomans, Reginaldo Haslett-Marroquin, Richard Perkins, Rudolph Steiner, Sir Albert Howard, Thomas Barrett, Vandana Shiva, William Albrecht, Wendell Berry, and many others. Through an ever-growing application of scientific, philosophical, ethical, and on-the-ground practice, the role and impact of biodiverse regenerative agriculture continues to expand, increasing the development of biodiversity islands in degraded lands.

3.5 Conclusions

Biodiversity enhancing regenerative agricultural practices can be applied wherever agriculture is practiced. Throughout the twentieth century, a shift in agricultural production to large scale, industrial, monoculture production with the use of agrochemicals became commonplace. While providing cheap calories, this agriculture has a myriad of negative consequences for both humans and the environment. This chapter has described successful examples and techniques for the advancement of a different approach towards agriculture, where agrochemical use is limited or eliminated, diverse genetics are utilized, and design and agricultural techniques are examined to enhance biodiversity within agricultural systems.

Much of regenerative agriculture emerged from indigenous land use systems. Building from this knowledge as science, diverse agroecosystems can continue to spread throughout the globe with great success. A diversity of organizations and case studies were presented to highlight the scope, scale, and diversity of regenerative agriculture as it contributes to biodiversity islands in a landscape. If managed following the approaches described throughout this chapter, farms can become biodiversity islands within the matrix of degraded landscapes.

Financial, cultural, and ecological opportunities abound in the transition of degraded lands into agriculturally based biodiversity islands. As adoption of biodiversity into agricultural lands becomes more commonplace and more farms throughout the landscape harbor greater levels of biodiversity, one can envision an agricultural future in which biodiversity islands are the norm. As such, speciation and species preservation may continue to increase through time in harmony with human habitation and agricultural production, and the biodiversity island which is planet earth may flourish towards a greater bounty and beauty that is evident in the diversity of life.

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