A Model of Food Forestry and its Monitoring Framework in the Context of Ecological Restoration

by

Hyeone Park
B.A., Pusan National University, 2009

A Thesis Submitted in Partial Fulfillment of the
Requirements for the Degree of

MASTER OF ARTS

in the School of Environmental Studies

Supervisory Committee

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Abstract

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Food forestry has grown in its popularity in Canada, the United States and the United Kingdom, which it has not been traditionally practiced before, for its potential to produce healthy food, to create habitat for wildlife species, to reconnect people with nature and to provide various ecosystem services such as carbon storage. Diverse food forest projects are conceived from urban food initiatives to integrated conservation and restoration planning. Currently, the Galiano Conservancy Association is creating two food forests in the heart of a mature Coastal Douglas-fir landscape on Galiano Island, British Columbia, which is protected under a conservation covenant, in pursuit of sustainable food production, education and contribution to ecological restoration and conservation efforts. To investigate the relationships between emerging food forestry and ecological restoration and to identify key indicators to measure best practices of food forestry in the context of ecological restoration, I conducted 16 semi-structured interviews with food forestry and ecological restoration experts. In addition, I conducted a workshop with the Conservancy stakeholders to develop a comprehensive and systematic monitoring framework for their food forest projects. My studies suggest that restoration principles and resilience thinking can provide guidelines for restorative food forestry. Food forestry may serve as an innovative restoration tool to restore urban landscapes where lack significant opportunities for conventional restoration. A generic monitoring framework for food forestry could be adapted by other projects, yet this will require the process of defining goals and objectives of a given project and assessing landscape contexts and the organization's capacity to monitor.

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Acknowledgements

This thesis was only possible because of thoughts, passions and support generously given by a web of wonderful people. I sincerely thank my committee supervisor Eric Higgs and advisor Nancy Turner for their encouragement and guidance that brought me academic success as well as the meaningful and unforgettable time in my new home Canada.

I am deeply grateful to my interview participants and representatives from the Galiano Conservancy Association, the Cottonwood Community Garden and the Beacon Food Forest for generously giving their support and sharing their insight, experience and knowledge.

I thank Social Sciences and Humanities Research Council, University of Victoria and Sara Spencer Foundation for their financial support.

Countless thanks to my loving family in Korea, friends and mentors.

Chapter 1: Introduction

1.1 Ecological Restoration: Challenges and Opportunities

Ecological restoration is “the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed” (SER 2004). Although restoration of native species community characteristics is currently the primary and most common restoration goal (Hallett et al. 2013), classical restoration — “returning an ecosystem to a historic trajectory” (SER 2004) and focusing on species composition — is facing formidable challenges (Higgs et al. 2014). Among many, restoration practitioners are facing two compelling challenges: the emergence of an “increasingly human-dominated Earth system” (Alberti et al. 2003) and rapid and significant environmental, ecological and social changes (Hobbs et al. 2013). As a result, a growing body of ecological restoration literature asks: how can we restore for future sustainability and resilience while restoring past biodiversity and improving the quality of human life and ecosystem services? (Hobbs et al. 2014; Suding et al. 2015).

Worldwide, more than 2 billion hectares of degraded forestlands have the potential for ecological restoration. Of these, an estimated 1.5 billion hectares during and following restoration would still integrate with other land uses such as agroforestry, agriculture and/or grazing (Minnemeyer et al. 2011). In fact, a multifunctional landscape that improves the capacity of such human practices for enhancing ecosystem services and biodiversity is increasingly common for community conservation and restoration (Hobbs et al. 2014). Agroforestry has been used as a tool for restoring a landscape (Lefroy et al. 1999; Montagnini et al. 2011; Xu et al. 2012), and therefore, combining ecological restoration with agroforestry—food forestry—provides multiple opportunities for improving forest ecosystems and sustaining food production, while enhancing biodiversity.

1.2 Food Forestry

Food forests, also known as forest gardens (Belcher et al. (2005), homegardens (Jose & Shanmugaratnam (1993), successional agroforests (Vieira et al. (2009) or multistrata systems (Crawford 2010), are edible polyculture systems that replicate forest structures and functions such as closed-loop nutrient cycling. They refer to a "carefully designed and maintained ecosystem" (Crawford 2010) that houses diverse perennial and annual plants with different physiognomy, height and root characteristics for production of food, medicine, art, building material and/or fodder. The plants are organized spatially, temporally and numerically "in such a way that they will benefit ecologically from each other" (Hills 1988).

Food forestry, a type of agroforestry, has long developed as a traditional means for people to adapt and transform lands largely in tropical, rural regions in response to changing environmental and socioeconomic conditions, including economic circumstances and migration, while contributing to the conservation of biodiversity and cultural traditions (Hills 1988). For example, the origin of the Javanese homegardens is associated with fishing villages existing from 13,000 to 9,000 B.C. (Kumar & Nair 2006), and homegardening in Kerala, India is thought to be over 4,000 years old (Kumar & Nair 2004). Some tropical food forests are very similar to natural forests in structure and functions with high species richness and ecological complexity (Jose & Shanmugaratnam 1993).

Inspired by tropical food forests, food forests are burgeoning in the Global North, particularly in temperate-to-cold regions of Canada, the United States (U.S.) and the United Kingdom (U.K.). Robert Hart introduced and popularized the concept of food forestry in the U.K. approximately 40 years ago (Hart 1996; Crawford 2010). Food forests (or forest gardens) in temperate regions are in general "modelled on the structure of young natural woodland, utilizing plant of direct and indirect benefit to people—often edible plants" (Crawford 2010) and, in some cases poultry and livestock (Scherr & McNeely 2008). Jack and Toensmeier (2005), who contextualized food forests in North America, describe a food forest as "perennial polyculture of multipurpose plants…in other words, edible ecosystem, a consciously designed community of mutual beneficial plants and animals intended for food production…forest gardens mimic forest ecosystems."

Emerging food forestry crosses over contemporary sciences and environmental movements (e.g. permaculture) to address emerging social and environmental issues (e.g. flood control, food security) (Mollison 1988; Clark & Nicholas 2013). Food and Agriculture Organization (FAO) of the United Nations (2016) stresses policy and regulatory support on the development of urban food forestry and incorporation of food forests into municipal plans for public parks, schoolyards and streets as a means to improve food security in urban and peri-urban environments. Potential benefits of food forestry are not limited to food production but also include: habitat for wildlife species, place for people to (re)connect to nature and learn, and various ecosystem services (e.g. flood control, carbon storage, nutrient cycling, income generation) (Jacke & Toensmeier 2005; Scherr & MaNeely 2008; Crawford 2010; Clark & Nicholas 2013). The Beacon Food Forest in Seattle in the U.S. (Fig. 1.1) was created with "permaculture principles of integrated agro-forestry woodland food systems" so as to "provide a local and resilient food source; enhance ecosystem services such as soil enrichment, carbon storage, run-off management; and empower community connections" (McLain et al. 2012). This project is community-driven movement toward creating a multifunctional, edible landscape in urban environments (FAO 2016).

Figure 1.1 Beacon Food Forest in Seattle, U.S. (April 2016)

1.3 Permaculture and Agroforestry

The term “food forestry” is predominantly used among permaculture practitioners in North America. Permaculture is a word coined from **perma**nent and agri**culture** by an Australian ecologist Bill Mollison and his student David Holmgren in the late 1970s. It is “the conscious design and maintenance of agriculturally productive ecosystems which have the diversity, stability and resilience of natural ecosystems” (Mollison 1988). The use of tree crops and traditional agroforestry practices is prevalent in permaculture. Permaculture design intends to integrate people into a landscape in a sustainable way for providing food, shelter, energy and other needs (including emotional satisfaction or sense of connection with nature and people) and to ultimately benefit all life forms (Mollison 1988). Today, permaculture practices go beyond food production and expand to personal lifestyle and belief, ethical investment, socio-economic system, and community culture (Jacke & Toensmeier 2005).

Agroforestry has increasingly drawn scientific interests on its effects on soil and biodiversity conservation in cultural landscapes (Montagnini et al. 2011). In tropical and dry climates, agroforestry knowledge is already used for forest restoration, especially through community engagement and education (Durigan et al.2013). Yet, studies on temperate agroforestry at a home scale are relatively younger (Jacke & Toensmeier 2005).

1.4 Local Case: Galiano Conservancy Association

The Galiano Conservancy Association (GCA) is one of the first community-based land trusts in British Columbia (BC), Canada (GCA 2013) and, in 2015, planted the Galiano Community Food Forest (GCFF) with primarily non-native species in the mature Coastal Douglas-fir forest landscape under protection on Galiano Island on the west coast of BC. The food forest is intended primarily to feed participants in educational programs, to provide educational opportunities and to promote local food security and sustainability while regenerating a degraded piece of the landscape and contributing to ecological integrity of the conservation land. The GCA has plans underway to create the Restoration Forage Forest (RFF) with native plant species.

The food forests are not typical agriculture projects because activities within them are intended to contribute to overall ecological restoration and conservation efforts of the GCA and comply with their integrated conservation planning (GCA 2013, available from http://galianoconservancy.ca/). At the same time, they are not a common restoration project since their primary goal is food production and their secondary goal is to contribute to maintaining or enhancing ecological integrity of the forested landscape. The GCA had to decide at which end of a continuum between food production and restoration their food forest projects would be positioned (Fig. 1.2). The GCA stressed that monitoring would be essential for assessing how effectively the projects are meeting their goals and thus informing adaptive management of the projects, and asked me to help to develop monitoring indicators they could apply (Erickson, Galiano Conservancy Association, personal communication, 2015).

Figure 1.2 The continuum between ecological integrity and food production food forestry may sit (originally developed by Higgs and Kathrens)

1.5 Conceptual Foundation and Organization of the Thesis

Overall, I investigated the relationships of emerging food forestry and ecological restoration and explored a potential application of food forestry in ecological restoration, which led to two separate studies. The first study sheds light on emerging food forestry and similarities and differences between food forestry and ecological restoration, and suggests key elements that must be in place for a food forest to contribute in any significant way to restoration efforts. The second study introduces a Criteria & Indicators (C&I) monitoring framework to guide a holistic and systematic assessment of a food forest project in the context of ecological restoration. This generic C&I framework was adapted and tailored by the GCA for developing their monitoring program.

The two studies adopt four principles for guiding comprehensive ecological restoration—ecological integrity, informed by past and future, social benefits and engagement, and long-term sustainability—as conceptual underpinnings of ecological restoration (Suding et al. 2015). These principles were developed in an attempt to guide planning and policy-making of large-scale forest restoration as a response to the New York Declaration on Forests of the 2014 UN Climate Summit targets restoration of 350 million hectares of degraded lands to forest by 2030 (Suding et al. 2015). The principles as a whole underscore the collaboration of ecological and social sciences and purposeful, delicate balance between ecological and human benefits while providing a "necessary foundation to achieve sustainability and resilience into the future" (Suding et al. 2015). The four principles guided my overall thinking around food forestry and human interactions with a social-ecological system in a multifunctional landscape. These principles were compared against goals and attributes of food forestry in the first study and conceptualized the C&I monitoring framework for food forestry.

The first study (Chapter 2) has resulted in a research article submitted to Restoration Ecology. An article from the second study (Chapter 3) will be submitted to Biodiversity and Conservation. As a result, the main body of my thesis includes two separate articles each having its own abstract, introduction, methods, results, discussion, references, supporting documents and citation styles. The articles indicate "we" as researchers instead of "I," even though I (Hyeone Park) conceptualized the entire work under the mentorship of supervisor, Eric Higgs, and committee member, Nancy Turner, and conducted the research and analysed the results, and drafted all components.

Chapter 2: Exploring the potential of food forestry to assist in ecological restoration

2.1 Abstract

A food forest—an edible, perennial, polyculture system—is of growing interest in North America and the United Kingdom across project types from urban food initiatives to integrated conservation and restoration planning. To examine emerging food forestry against the backdrop of ecological restoration, we conducted semi-structured interviews with eight experts each from the fields of food forestry and ecological restoration in conjunction with observations of food forests in Canada, the United States and the United Kingdom. Using content analysis, our study builds a food forestry model that encompasses the underlying goals of food forestry—forest function, diversity of yields, education & culture sharing, healthy habitat for people and other species and sustainability. We argue that food forestry has potential as an urban restoration tool in terms of enhancing the multifunctionality of heterogeneous landscapes undergoing significant change and building resilience for complex social-ecological systems. This will require meaningful consideration of resilience thinking, multiple values of ecosystems and comprehensive restoration principles, in particular ecological integrity and landscape contexts and integration of historical knowledge. Systematic, long-term monitoring of different types of food forests will be essential to effectively apply food forestry in ecological restoration. This research provides one of the first in-depth analyses of how emerging food forestry might contribute to restoration in the time of the Anthropocene, incorporating perspectives of both ecological restoration and food forestry.

2.2 Conceptual Implications

- Both food forestry and ecological restoration aim to restore sustainable systems, optimizing ecological processes, that benefit people and other species.
- General differences between food forestry and ecological restoration include: different priorities on social benefits and native species; management intensity; and wildlife species that a food forest can support as a habitat. These differences are context-specific and can be diffuse.

- Urban food forestry may serve as an innovative restoration model to restore forest functions and improve biodiversity, the quality of human life, and human-nature connections in urban landscapes that are undergoing significant change. Comprehensive restoration principles (Suding et al. 2015) and resilience thinking can provide conceptual guideline for restorative food forestry.
- This discussion will require further examination of relationship among food forests, urban resilience, and urban landscapes, followed by a thorough assessment and long-term monitoring of food forests.

2.3 Introduction

Ecological restoration is facing two compelling challenges: the emergence of an "increasingly human-dominated Earth system" (Alberti et al. 2003) and rapid and significant environmental, ecological and social changes (Hobbs et al. 2013). A growing body of ecological restoration literature asks: how can we build sustainability and resilience of ecosystems that are dynamic and complex while restoring biodiversity and improving the quality of human life and ecosystem services? (Hobbs et al. 2014; Suding et al. 2015). In the midst of such challenges, more than 2 billion hectares of degraded forestlands worldwide have the potential for restoration. Of these, an estimated 1.5 billion hectares would integrate with other land uses such as agroforestry, agriculture and/or grazing during and following restoration (Minnemeyer et al. 2011).

There is growing interest in food forests in North America and the United Kingdom (Clark & Nicholas 2013; Crawford 2010) across diverse project types from urban food initiatives (e.g. Beacon Food Forest, Seattle) to integrated conservation and restoration planning (e.g. Galiano Community Food Forest, British Columbia). A wide range of values and needs motivate such projects, including food production, biodiversity conservation, and provision of ecosystem services (e.g. carbon sequestration, flood control), education, wildlife habitat and places for (re)connecting with nature (McLain et al. 2012; Clark & Nicholas 2013).

A food forest is an edible, perennial, polyculture system that is designed and managed to mimic multi-storey forest structures and to function like a natural, self-sustaining forest (Jacke & Toensmeier 2005; Walker 2015). Design, techniques and goals vary depending on ecological, environmental and socio-economic conditions. Yet, food forests are generally planted with high diversity of canopy and small tree, shrubs and herbaceous, root and/or vine species in a way that maximizes beneficial plant interactions. The plants have direct uses such as food, medicine, building, and art as well as indirect roles such as nitrogen-fixing and pollination (Hills 1988).

There are no universally-accepted boundaries about what is and is not a food forest (Kumar & Nair 2004; Crawford 2010), and implementation covers a wide continuum of human intention and intervention (Table S2.4 in the Supporting Information). This article refers to food forests that are prescribed, intensive systems and that differ from forage forests, where people marginally modify certain elements of an existing forest and simply collect mushrooms, firewood, berries or herbs (Crawford 2010). Also, food forests are intended as permanent systems, which differ from shifting cultivation systems (Belcher et al. 2005).

Food forestry has long developed as a traditional means for people to adapt and transform lands in response to changing environmental and socioeconomic conditions, including economic circumstances and migration, while contributing to the conservation of biodiversity and cultural traditions (Hills 1988). It encompasses myriad forms of ancient knowledge and skills from traditional homegardens, forest gardens and multi-storey tree gardens largely in tropical, rural regions. For example, homegardening in Kerala, India is thought to be over 4,000 years old (Kumar & Nair 2004), and the origin of the Javanese homegardens is associated with fishing villages existing from 13,000 to 9,000 B.C. (Kumar & Nair 2006). At the same time, food forestry crosses over contemporary science and environmental movements (e.g. permaculture) to address emerging social and environmental issues (Mollison 1988; Clark & Nicholas 2013).

Agroforestry has been used as a restoration tool to enhance multifunctionality of landscapes and to provide a balanced compromise among diverse values (Belcher et al. 2005; Montagnini et al. 2011). However, most scientific studies have focused on traditional food forests in South Asia, Africa and Central America and in rural settings (e.g. Jose & Shanmugaratnam 1993; McNeely & Schroth 2006), aside from limited English literature that indicates possible traditional food forest systems in temperate regions in China (Wenhua 2001). Emerging food forestry, inspired by these tropical food forest systems, is being increasingly adapted to areas that have not traditionally practiced this method of food production before, such as temperate-to-cold regions in Canada, the United States and the United Kingdom (Crawford 2010; Clark & Nicholas 2013). Therefore, in such places, little research has attempted to examine emerging food forestry (Clark & Nicholas 2013) in relation to ecological restoration.

Choi et al. (2008) propose that "future-aimed restoration" should: consider changing and uncertain future environments; use historical information as a guideline; set multiple, realistic goals and trajectories; and explore various restoration techniques. In this context, we present a food forestry model to help understand the relationships between emerging food forestry and ecological restoration, and argue for key elements that must be in place for a food forest to contribute in any significant way to restoration efforts. Yet, our goal is not so much to conclusively demonstrate propositions around food forestry but rather to make suggestions, based on empirical knowledge and experiences in the fields, which we hope other researchers and practitioners will draw on for further research and practice.

2.4 Methods

This study involved the creation of a food forestry model based on comparative assessments of literature, semi-structured interviews with restoration and food forestry specialists, conventional content analysis of transcribed interviews, and participation/observation at food forest projects in Canada, the United States and the United Kingdom. Qualitative research is best used for analysing "the potential antecedents and facts about which little has been known and explored" (Khan 2014). Limited research and theory on emerging food forestry in relation to ecological restoration led us to conventional content analysis, which is an inductive, iterative, and systematic process of coding and identifying themes or patterns grounded in the qualitative data (Hsieh & Shannon 2005). This approach enables researchers to "immerse themselves in the data to allow new insights to emerge" (Hsieh & Shannon 2005) and to develop a rich understanding of the phenomenon. The conventional content analysis is also used for comparing the findings against a relevant model, building a model (Hsieh & Shannon 2005) or even developing theory (Zhang & Wildemuth 2009) in conjunction a constant comparative method for data analysis (Glaser & Strauss 1967).

2.4.1 Semi-structured Interviews

16 experts from the fields of food forestry (FF; n=8) and ecological restoration (ER; n=8) participated in the semi-structured interviews (Table 2.1). We recruited participants through a

purposive, snowball sampling method (Cohen & Arieli 2011). The experts are practitioners, researchers, or both, and they have professional experience of between 6 years and over 40 years in their field (averaging 27.5 years in ecological restoration and 24.5 years in food forestry). Among them, seven participants have experiences in both food forestry and restoration.

Table 2.1 16 interviewees from the fields of food forestry (FF; n=8) and ecological restoration (ER; n=8)

	Food forestry (FF; n=8)	**Ecological restoration (ER; n=8)**
Geographic location	Five in North America and three in the United Kingdom	Eight in North America
Related experience	Permaculture Agroforestry Organic farming Restoration	Traditional ecological knowledge Forest restoration Urban restoration Conservation
Most participants have engaged in local and international projects; nevertheless, their experience and knowledge can be geographically, culturally context-specific and do not represent global perspectives		

The interviews took place in the period from August 2015 to August 2016 through in-person, phone, or online video chat and were followed up by email and/or phone. We tested the interview process and questions with one of the participants, and refined them. We asked food forestry and restoration experts the following open-ended questions: 1) what are the goals of food forests?; 2) what differences and similarities characterise food forestry and restoration?; and 3) what are the potential benefits and challenges of incorporating food forestry in restoration? Consequently, we explored the potential best applications. During the interview(s), new questions emerged, and participants were free to explore them. The interviews ranged from a minimum of 40 minutes up to 120 minutes (averaging 75 minutes) and were audio-recorded and transcribed in full.

We provided a food forestry diagram (Fig. 2.1) as a response instrument used in the subsequent interviews, which allowed the participants to have common understanding of key elements of food forestry. The participants reported it as a “very good baseline model” or “good foundation of thinking about food forestry.” The interviews with sixteen participants were small but in-depth, systematic, and equipped with prescribed, tested open-ended questions and the response instrument, which allowed us to uncover a range of attributes of complex food forest systems and facilitate comprehensive comparison between food forestry and ecological restoration. After the interview process, this diagram evolved into a more complex model that encapsulates a wide range of goals of the participants’ food forests. As a final step in this development, the diagram was reviewed by the participants. The interview process followed the Ethics Protocol (15-233) approved by the University of Victoria (consistent with Canada’s Tri-Council Policy Statement on Ethical Conduct for Research Involving Humans).

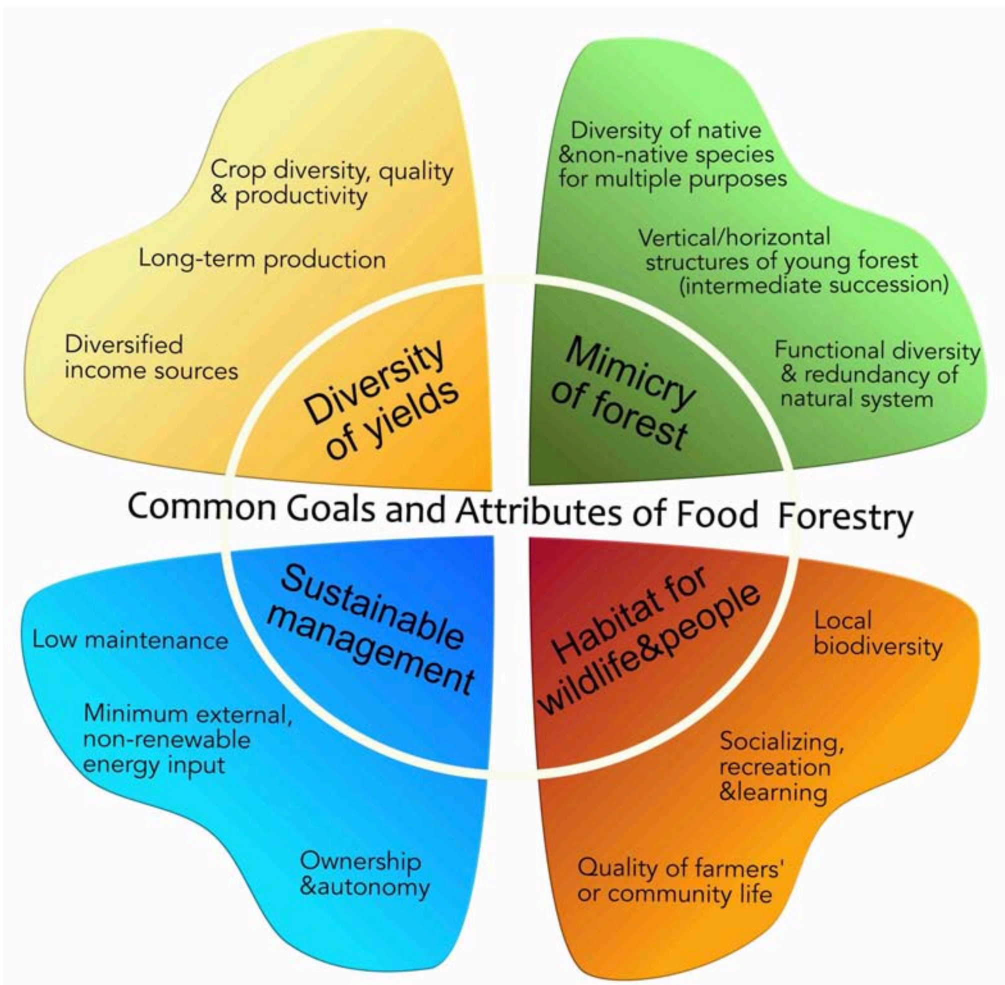

Figure 2.1 The Common Goals and Attributes of Food Forestry: key elements of food forestry described in Wiersum 2004 & 2006; Belcher et al. 2005; Jacke & Toensmeier 2005; Vieira et al. 2009; and Crawford 2010 were compared, using conventional content analysis (Hsieh &

Shannon 2005), to show common goals and attributes across the five literature resources. This diagram was used as a response instrument for semi-structured interviews.

2.4.2 Content Analysis

We conducted conventional content analysis of each interview transcript (Hsieh & Shannon 2005), using Atlas.ti, qualitative data analysis software. First, we carried out transcribing, close reading (four times each), note-taking and initial-coding of the interview transcripts concurrently with the interview process. This enabled us to subsequently ask about emerging theory, themes or questions drawn from the initial analysis of the previous interviews. After the interview process and close-reading were complete, second, we thoroughly read, merged and fragmented the initial codes based on their properties and dimensions while defining relationships (e.g. opposite, similar) among the codes until no new definite themes or properties were detected. Third, we grouped these codes into question code groups (e.g. goals of food forestry) and thematic code groups (e.g. succession; best applications of food forestry; sustainability; and native VS non-native) to capture key themes that naturally emerged from the participants during the interviews. Then, by using a visualisation tool "network analysis" (in Atlas.ti), we thematically grouped the codes to compare different responses and to analyze the codes and their association with other codes. Last, we cross-checked and compared the interview data with scientific literature and our site observations for discussion.

2.4.3 Observation and Participation

One of us (Park) observed over twelve food forests including ones of our interview participants in the period from August 2015 to August 2016 in Canada, the United States and the United Kingdom. These food forests were household, education-oriented, commercial and public ones in urban, suburban and rural settings. They ranged in maturity from one recently initiated to a 25 year old project. In addition, we participated in site assessment, planting and/or a public design charrette of a food forest project developed by the Galiano Conservancy Association, which took place in their conservation land on Galiano Island, British Columbia, on the west coast of Canada.

Figure 2.2 Cottonwood Community Garden in Vancouver, Canada (June 2016)

Figure 2.3 Means of Production Garden in Vancouver, Canada (June 2016)

Figure 2.4 Forest Garden Project of the Agroforestry Research Trust in Dartington, England (August 2015)

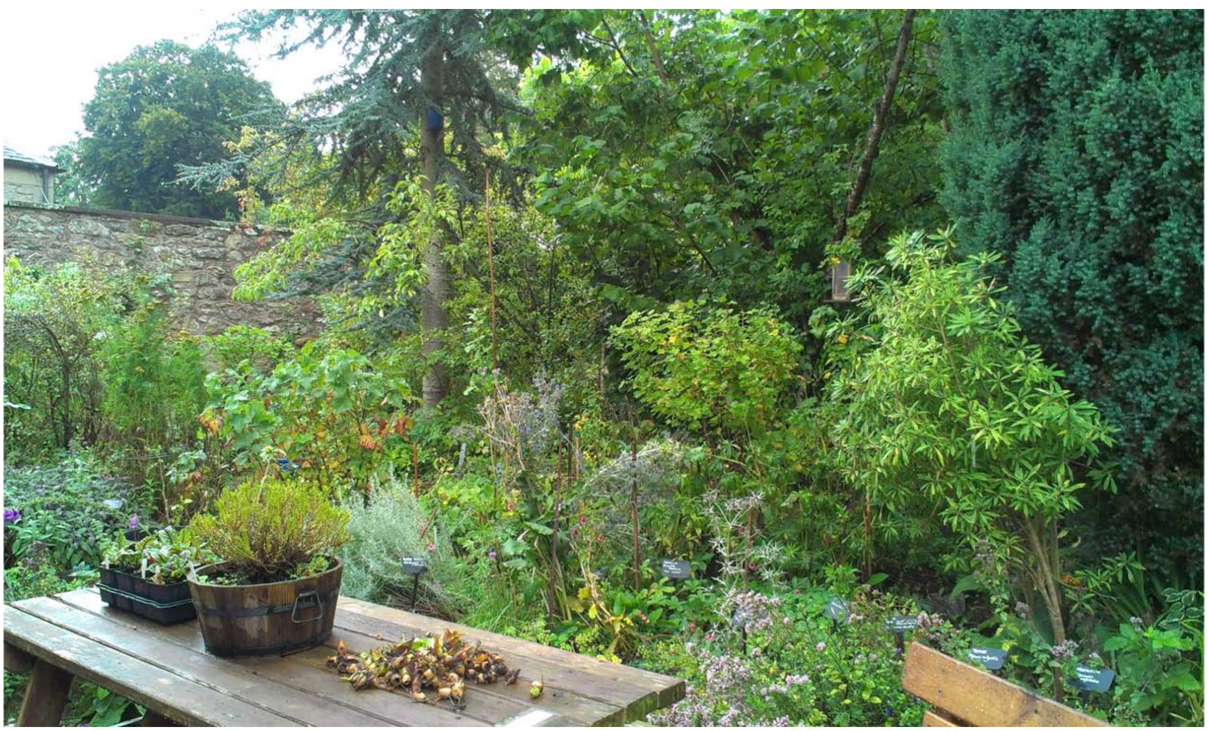

Figure 2.5 Garden Cottage in Coldstream, Scotland (September 2015)

2.5 Results

2.5.1 Goals and Attributes of Food Forests

The food foresters identified a total of 5 goals and 19 essential attributes of their food forests (Table S2.5), which manifest multi-functionality and underlying interwoven relationships between people and nature anchored at the heart of food forestry.

Forest Functions

A food forest is a "multistorey, perennial polyculture" system (FF-5), which is designed and managed to function like a self-sustaining natural forest, including closed nutrient cycling, accumulation of soil organic matter, microclimate control, water retention and pollination. A high diversity of native and/or non-native plants and structural diversity were key ecological components of the food forests. In particular, all food foresters placed emphasis on building healthy soil and promoting diversity of soil biota. One food forest (of FF-6) initially showed 2.4 % of soil organic matter, and after 12 years, this increased to 9.0 %. A food forester believes that healthy soil is "a legacy that can be left for future generations. It's a major goal here … to leave in a much-improved condition for the next citizens to work with" (FF-7).

Diversity of Yields

Food forestry aims for diverse and high quality yields (e.g. food, medicinal plants, art, building materials) produced over the longest season possible, over an extended time, while generating supplementary income from diverse sources (e.g. herbal products, nursery, vacation home, tours, and workshops). Yet, the food foresters have had different experiences with productivity depending on management intensity, the amount of input and a purpose of their food forest.

Education and Culture Sharing

The participants underscored the value of their food forests for learning, teaching, culture-sharing and/or demonstrating of different designs (e.g. a native food forest; integrated housing and community design; and ecocultural edge). All of the food foresters engage in different forms of education, in particular experimental and social learning. The food foresters plant diverse species that are adapted to multiple possible trajectories of the current climate conditions, testing how these plants respond and interact (FF-1), and/or facilitating exchange of genetic materials from the globe (FF-7). Social learning was identified as strength of public food forestry by both expert groups, as "It [food forestry] brings people together with common goals of looking after the places and learning together about how to do that the best way possible" (ER-8). Social learning includes not only ecological and botanical knowledge, but also management and social skills and capacities to share skills and responsibilities, which are essential for the long-term success of food forestry (FF-6).

Healthy Habitat

One of the underlying values of the food forests is to create a healthy habitat for both people and other species and to strengthen communities and human-nature connection within. One interviewee (FF-1) emphasized, "Food forestry is not only about feeding us. All living things are people. Birds, earthworms are people. They are just different people from us. So, how can we use this food forest in a way that allows everyone to live?"

In addition, a food forest provides an urban community with green, functional space for growing food, who otherwise have no or little of their own (FF-4). The Cottonwood Community Garden was transformed from an illegal waste dump site into one of the first public food forests of Canada in a lowest-income, industrial neighbourhood in East Vancouver in order to address environmental and social justice. In addition, the food forest invites people to be more active, integral part of the landscape and to (re)connect to landscapes where they live, which distinguishes itself from passive recreation such as jogging or walking in a park. This creates a "social-ecological connection" (FF-4).

Sustainability

One of the most important goals is to maximize "ecological processes to support a sustainable system" which becomes "self-regulating, self-propagating and self-fertilizing" (FF-7). Over time, food forests should sustain with lower maintenance and external input than other food production systems and withstand stresses such as extreme weather events, outbreaks of pest and disease, and temporary absence of maintenance. Yet, the more input goes into a food forest, the more yields the system will produce (FF-5). Both restoration and food forestry experts emphasize continuity in ownership, collective governance and/or stewardship as essential factors for sustainability.

The food forestry model (Fig. 2.6) encompasses the goals and attributes of food forestry identified by the food forestry experts. Each goal and attribute is cross-linked to others; and some experts found it hard to prioritize one from another. Also, only some goals and attributes, if not all, may be relevant to individual food forests, depending on size, landscape context (e.g. urban, protected areas), type of entitlement (private, commercial, public), personal values and temporal scales (e.g. Fig 2.7). Also, as a food forest evolves, the goals and their importance in each case will change over time (FF-4).

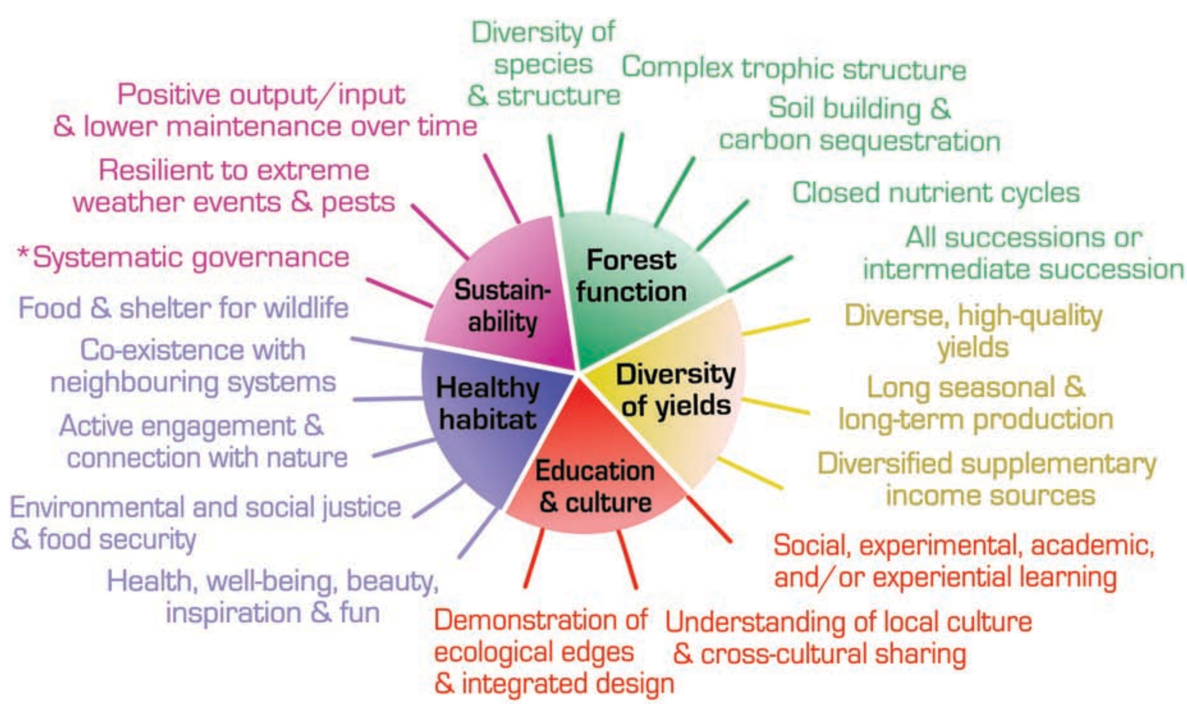

Figure 2.6 Food forestry Model: key 5 goals and 19 essential attributes of food forestry identified by the food foresters in Canada, the United States and the United Kingdom.

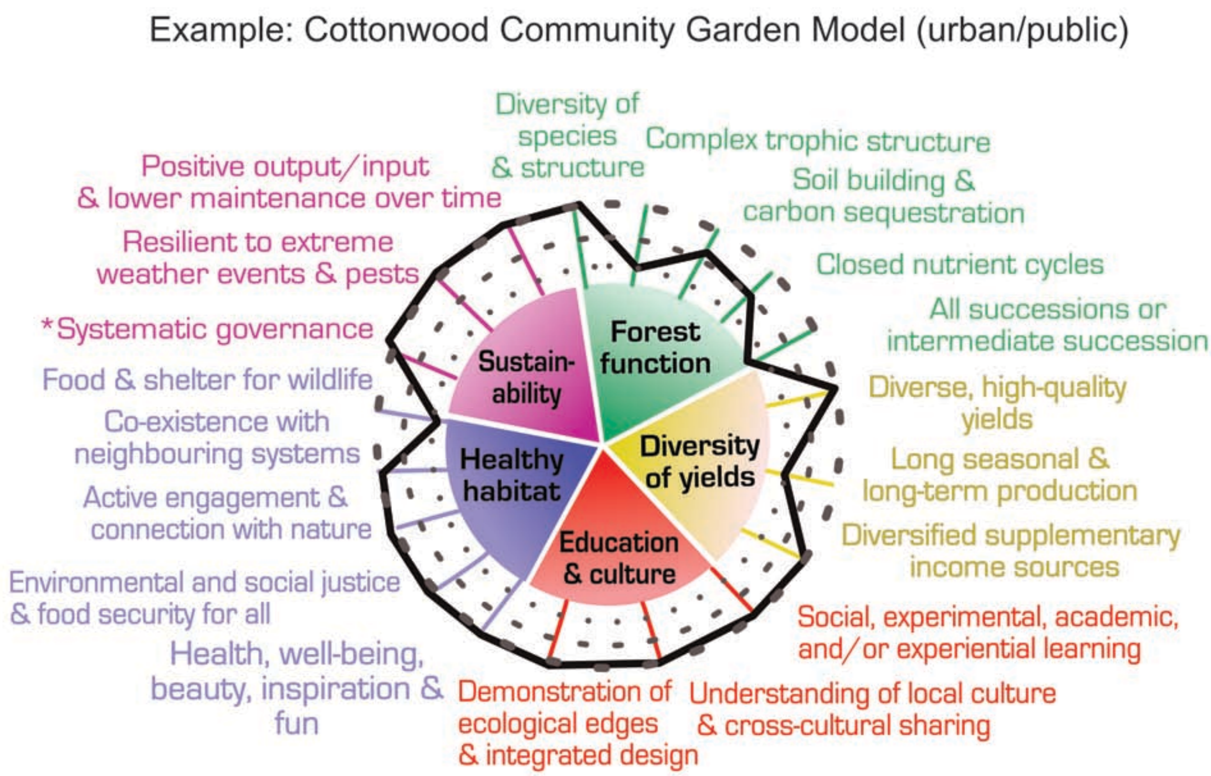

Figure 2.7 Cottonwood Community Garden Model. This is a snapshot of what the Cottonwood Community Garden (urban/public) is currently intended to achieve, and the outer line implies the highest priority of the garden. The goals and their priority will change over time as the food forest evolves.

2.5.2 Comparing Food Forestry and Ecological Restoration

The participants identified similarities and differences between food forestry and ecological restoration (Table 2.2). In general, food forestry promotes a diversity of composition, structure, and function and aims to create a food system that is as close to a self-sustaining forest as possible (FF-7). One interviewee (ER-8) suggested, “Both food forestry and restoration are premised on restoring sustainable systems, using natural processes, that benefit people and other species. And, both are very complementary.”

Table 2.2 Similarities and Differences between Food Forestry and Ecological Restoration

Restoration element	Similarities	Differences	
		Food forestry	**Ecological restoration**
Succession	Accelerating and managing succession, primarily by controlling invasive species or grass (ER-3; FF-7)	Culturally managed system (ER-8)	Forest restoration encourages the system to be self-sustaining, to find its own path and to reach its full succession on its own (ER-2) Depending on a type of ecosystem to restore (e.g. Garry oak meadow requires ongoing maintenance to prevent the encroachment of shrubs and trees) (ER-7)
		Maintains a desired successional stage(s) for productivity. Typically, young-to-intermediate succession in temperate climate to maintain optimal net primary productivity of the system but this depends on goals, size, etc. (FF-2; FF-7)	
		A food forest can exhibit at all successional stages with clearing, regenerating areas, and areas of mature trees (FF-1)	
		Introduces all species including “climax trees” which may be different from ones in a neighbouring natural forest (FF-1)	Forest restoration puts pieces in place, which would lead to more diversity (EF-7)
Historical fidelity	May be embedded in traditional management systems and knowledge (ER-8)	Accepts novel ecosystems and non-native species (FF-6; ER-8) In some parts of the world, food forestry is a traditional way of managing the land and producing yields (FF-6; FF-8)	Primarily aims to reinstate native biodiversity. But, restoring historical fidelity is becoming more challenged (ER-5)
Nature by design (Higgs 2003)	Intentional intervention and nature by design which changes over time	Emphasis on human needs and consideration of potential sources of conflict among stakeholders with different goals (FF-4)	Employing similar practices with gardening but for different goals (e.g. ecological integrity and historical fidelity)

	(ER-8)	(e.g. "human forest"/FF-1)	(ER-4)
	Common design elements (e.g. soil, water sources, site history, succession) (ER-3; ER-7)		
Continuous Management	Intended for a "self-sustaining" system by intervening as little as possible, but it often requires high initial intervention, ongoing management, observation, and adaptation (FF-4; FF-7)	Highly regulated system (ER-4)	Aims for as little intervention as possible and then tails off over time (ER-2)
		High emphasis on ongoing, active interaction with nature and engagement in landscapes (e.g. planting, harvesting) (FF-4)	
		The more input goes into the food forest, the more yields the system will produce (FF-5)	Given rapid changes, intervention intensity in long-term is unknown (ER-3)
Livelihoods and economic benefits	Influenced by utilitarian values (ER-6; ER-8)	More emphasis on livelihood and economic benefits (ER-2; ER-4)	More about balance in ecosystem functions (ER-1)
Wildlife	Improving habitat quality (FF-1; FF-3; FF-6)	Optimal habitat for species that are more dependent on a mosaic of successional stages (FF-4)	Primarily aims to reinstate native biodiversity (ER-1)

Succession

Both practices (Food Forestry and Ecological Restoration) manage succession. A restoration expert (ER-3) stated, "People who are restorationists are successionists because we are all changing something and setting it on a new path. Invasive species moving in is a disturbance event, and you are removing it and you are influencing succession." A food forester (FF-7) manages succession by mulching, irrigation and removal of weeds and grass from young plants. He said, "[Food foresters] We're trying to bypass all—a lot of things that nature takes a lot of time to do. [But] we have no long-range or long-term model to go by in this [temperate-to-cooler] climate. We do see food forests done in a warmer zone that are long-lived and have been around for thousands years." The restoration experts identified differences in management goals, ideal state, introduction of successional species and climax species.

Historical Fidelity

Restoration primarily aims to reinstate native biodiversity. "In North America," an interviewee (EF-6) commented, "we often talk about historical baselines and … this idea that we can come back to baselines and that we should be restoring baselines." Another expert said, "historical fidelity will separate out restoration from food forestry" (ER-4). Depending on a context, this might be different: "Not all restoration is historically reflective, especially in urban areas, and the choice of restoring historical fidelity becomes site-dependent." (ER-5). Although food forestry may not necessarily restore a forest back to what it was before and more readily accepts novel ecosystems and non-native species, historical fidelity might be an important part of food forestry if it is embedded in traditional management systems and knowledge (ER-8).

Nature by Design

Both practices are "intentional and nature by design" (ER-8). The food foresters underline "thoughtful design" (FF-4) and "purposeful design" (FF-8), using nature as a model or "replicating principles of a forest"(FF-7). Food forestry and restoration share common design elements such as soil, water sources, sun aspect, site history, slope, plants and succession. Further, the food foresters highlighted the importance of considering, in design, different values and potential sources of conflict among people who live in the land.

Continuous Management

Both practices generally require higher intervention at an initial stage, observation and often adaptation in management while aiming to create a self-sustaining system. One food forester (FF-7) experienced that 90 % of his labour and resources over 30 years were invested in the first 5 years. Nevertheless, emerging food forestry underscores the value of reconnecting people to landscapes through continuous, active interaction with the system. For example, a food forester (FF-4) described the Cottonwood Community Garden as an "open source landscape": "The idea of a landscape that people actively design, redesign, and constantly adapt to their needs. I would restore it as a process. Soon, other people will come, participate and ultimately change it to what they want. It became a living thing. This landscape never stayed the same."

Livelihoods and Economic Benefits

Most ecological restoration interviewees responded that producing yields or providing income is still considered less relevant to restoration. Instead, ecological restoration is about the balance of all ecosystem functions. Native species will be planted for wildlife but not necessarily for people's use (ER-1). Yet, a different view was expressed: "Food forestry perhaps has more utilitarian slant to it than ecological restoration, but … ecological restoration has utilitarian slant to it as well. It might be a different kind of utility. It is looking at the utilitarian value of ecosystems, I suppose, and original ecosystems and combinations. A food forest is not all about food production. It embodies values of biodiversity, cultural diversity, local productivity and bioregionalism—all of these things are part of it" (ER-8).

Wildlife

Both successful systems can support wildlife, but possibly different species and associations. An invertebrate survey (West 2006) found that a food forest (of FF-2) had higher invertebrate taxa richness and more even distribution of the individuals across the taxa than a restored woodland at Dartington, in south Devon, UK. Yet, the maximum similarity of compositions was less than 50%, which indicates two systems supported different invertebrate communities. Similar results were found by a limited study on wildlife biodiversity of tropical homegardens in India by a student of a restoration interviewee (ER-6). These observations might support: "All of these [human/nature exchange at the ecological edges] create a optimal habitat for species that are more dependent on a mosaic of successional vegetative stages and conditions that are harder to find in a climax, closed canopy woodland" (FF-4).

A restoration interviewee (ER-6) suggests food forestry be an “interesting restoration model” to explore for places where restoring to a historical baseline is no longer possible. She asked: “What is the niche in the middle between recreating something having solid human benefits and restoring function and bringing back some biodiversity and … between that middle of that gradient of wild on one hand and very managed on the other hand?”

2.6 Discussion

Suding et al. (2015) propose four core principles for guiding and planning ecological restoration as a response to the New York Declaration on Forests at the 2014 United Nations Climate Summit manifesting global, concerted ambition to restore 350 million hectares of degraded lands by 2030:

1. Restoration increases ecological integrity;
2. Restoration is informed by the past and future;
3. Restoration benefits and engages society; and
4. Restoration is sustainable in the long term.

With careful consideration of emerging challenges that restoration is facing, the core principles are intended to amplify diverse benefits and opportunities of up-scaling of restoration without ecological net loss. These extend earlier work on guidelines, including those issued by the World Commission on Protected Areas (Keenleyside et al. 2012), and the Society for Ecological Restoration Primer (2004).

Good ecological restoration should address “ecological, cultural and socio-economic values of natural-human systems,” and therefore restoration should be guided by all four principles (Suding et al. 2015). Projects specializing on a single principle (e.g. carbon farming with a monoculture of fast-growing species), even though they are valuable themselves, will not be considered as good restoration and may compromise biodiversity and/or lead to commodification of ecosystems (Suding et al. 2015). On the other hand, restoration failing to address a broad range of human needs may experience lack of long-term, public support, which is often key for long-term success of restoration (Hallett et al. 2013). We used the four principles to help to further examine the relationships of food forestry to restoration and discuss key elements that must be in place for a food forest to contribute to restoration efforts (Fig. 2.8).

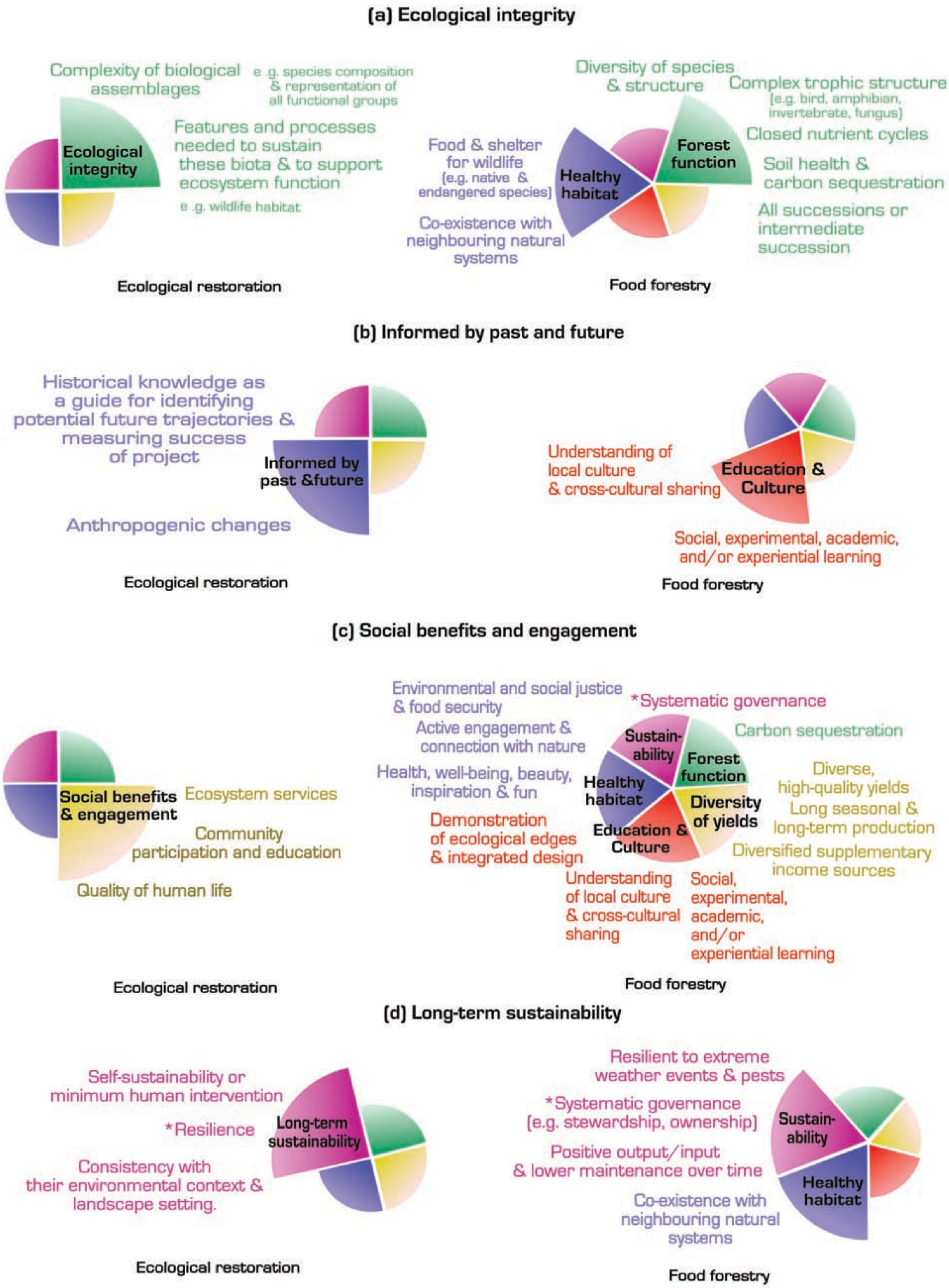
(a) Ecological integrity
Complexity of biological assemblages
e.g. species composition & representation of all functional groups
Features and processes needed to sustain these biota & to support ecosystem function
e.g. wildlife habitat
Ecological integrity
Ecological restoration
Diversity of species & structure
Complex trophic structure (e.g. bird, amphibian, invertebrate, fungus)
Closed nutrient cycles
Soil health & carbon sequestration
All successions or intermediate succession
Food & shelter for wildlife (e.g. native & endangered species)
Co-existence with neighbouring natural systems
Forest function
Healthy habitat
Food forestry
(b) Informed by past and future
Historical knowledge as a guide for identifying potential future trajectories & measuring success of project
Anthropogenic changes
Informed by past &future
Ecological restoration
Understanding of local culture & cross-cultural sharing
Education & Culture
Social, experimental, academic, and/or experiential learning
Food forestry
(c) Social benefits and engagement
Social benefits & engagement
Ecosystem services
Community participation and education
Quality of human life
Ecological restoration
Environmental and social justice & food security
Active engagement & connection with nature
Health, well-being, beauty, inspiration & fun
Demonstration of ecological edges & integrated design
*Systematic governance
Carbon sequestration
Sustain-ability
Forest function
Healthy habitat
Diversity of yields
Education & Culture
Diverse, high-quality yields
Long seasonal & long-term production
Diversified supplementary income sources
Understanding of local culture & cross-cultural sharing
Social, experimental, academic, and/or experiential learning
Food forestry
(d) Long-term sustainability
Self-sustainability or minimum human intervention
*Resilience
Consistency with their environmental context & landscape setting.
Long-term sustainability
Ecological restoration
Resilient to extreme weather events & pests
*Systematic governance (e.g. stewardship, ownership)
Positive output/input & lower maintenance over time
Co-existence with neighbouring natural systems
Sustain-ability
Healthy habitat
Food forestry

Figure 2.8 Comparisons between the food forestry model and an ecological restoration model based on the four restoration principles (adapted from Suding et al. 2015): a) ecological integrity; b) informed by the past and anticipated future; c) social benefits and engagement; and d) long-term sustainability. Suding et al. (2015) stress that all four principles are essential foundations to "achieve sustainability and resilience into the future." As a result, the long-term sustainability diagram (d) can be expanded and include three principles and associated goals and attributes of food forestry.

2.6.1 Ecological Integrity

Suding et al. (2015) underscores the recovery of "complexity of biological assemblages, including species composition and representation of all functional groups, as well as the features and processes needed to sustain these biota and to support ecosystem function." Therefore, restoring only a physical structure of a stream or host tree species does not suffice as good restoration. Similarly, food forestry emphasizes on maximizing both essential ecological processes and diversity of species and structure in addition to providing habitat for wildlife. Nevertheless, a food forest, as a "human ecosystem" (Jose & Shanmugaratnam 1993) or "designed ecosystem" for production (Higgs 2016), may not necessarily restore the same habitat quality and other values of native forests (Sarr & Puettmann 2008) and the same species composition (Crawford 2010).

In ecological restoration, what constitutes ecological integrity differs across social, environmental and ecological contexts. Consequently, many definitions exist, encompassing ecosystem health, biodiversity, ecological processes, native species, stressors, resilience and self-maintenance. These elements are weighted differently in each restoration project (Andreasen et al. 2001; Suding et al. 2015). Protected areas would prioritize native, "wild" or "pristine" components of ecosystems (e.g. Parks Canada Agency 2005), which sometimes requires exclusion of human activities including use of natural resources and allows only "minor consideration of human dynamics and needs" or (cultural) activities that assist natural processes (Sarr & Puettmann 2008; Suding et al. 2015). Urban forest restoration generally focuses on improving ecological processes to support ecosystem services while trying to retain some native species diversity (Ordóñez & Duinker 2012). Similarly, a food forest can be planted in diverse environments from an urban backyard and park, to rural agricultural land, to an edge of a protected area. Depending on where a food forest is planted, specific components of ecological integrity (e.g. native biodiversity, function, productivity) and their relative importance will differ.

Yet, a definition of ecological integrity will help to guide and assess contribution of food forestry to improving ecological integrity. To open discussion on what definitions would be applicable for food forestry, we suggest the WWF/IUCN (2000) definition used in the context of forest conservation: "maintaining the diversity and quality of ecosystems, and enhancing their capacity to adapt to change and provide for the needs of future generations." This definition encourages consideration of multiple facets of ecological integrity, from functions, to resilience, to human needs. It is future-oriented and comprehensive, addressing interdependent relationships between human and nature embedded in food forestry (Hills 1998). Given this definition, ecological integrity can serve as a foundational principle that supports other goals of a food forest.

2.6.2 Informed by Past and Future

Historical knowledge can shed light on how ecosystems functioned in the past and how they might operate to changing conditions; so it serves as a guide to identify potential future trajectories and indicate the functional and compositional success of projects (Higgs et al. 2014). In addition, it helps to attend to indigenous species, restore cultural significance and conserve native systems. Food forests can be used for reinstating native diversity to varying degrees. Use of native species in food forests, which are already adaptive to local conditions, can be encouraged to enhance habitat quality for native species and to facilitate continuity of local traditions (Jake & Toensmeier 2003; Harris et al. 2006; Shackelford et al. 2013). Traditional ecological knowledge will be invaluable in selecting local species of varying functions and of different conditions. For example, the Galiano Conservancy Association plan to use traditional land management techniques and local species in one of their food forests. Yet, in rapidly changing environments, flexibility will be needed regarding the degree of historical fidelity (Suding et al. 2015).

In addition to ecological fidelity, food forestry might contribute to building cultural fidelity. Cultural fidelity includes restoration of a particular traditional activity as well as development of "ways of matching functional characteristics of former practices" from community participation, cultural livelihoods, sense of place, health, traditional knowledge, and local economies, to social justice (Higgs 2003). Throughout the Pacific Northwest has been traditionally managed for food production in a way that promotes ecological and cultural diversity through social interaction and exchange of products (e.g. roots, berries, pacific salmon), knowledge, skills and beliefs (Turner, Davidson-Hunt & O'Flaherty 2003; Apostol et al. 2006). For example, the Cottonwood Community Garden produces a variety of edible plants from different cultural traditions and regions. Community members of this garden share recipes and try each other's cuisines, which creates "this wonderful enhancement of the cross-cultural understanding" (FF-6). In-depth understanding and monitoring of the Cottonwood Community Garden will help to test if, and how much, food forestry contributes to restoring or enhancing a myriad of functional characteristics of cultures in a fast-changing, multi-cultural urban environment.

Information on anticipated future conditions is valuable in food forestry design (Crawford 2010; Walker 2015). Food forests can be used for exploring a wide range of species, especially in urban environments, that are adaptive to different climate trajectories (Gobster 2012). Yet, a thorough assessment of ecological (including biodiversity, function and resilience), cultural and economic impacts of new species should be made before and after introduction.

2.6.3 Social Benefits and Engagement

Globally, many ecological restoration projects attempt to incorporate food crops and economic benefits into restoration (Hallett et al. 2013). Both restoration and food forestry deliver a wide range of ecosystem services (e.g. carbon sequestration, food, income) to enhance the quality of human life. Apart from economic benefits, Hallett et al. (2013) identified other attributes of the social goals of restoration projects: community engagement, cultural values, education and governance, which are also essential attributes of food forestry.

Ethical concerns arise regarding projects that focus on such economic benefits or ecosystem services due to possibility of adverse commodification of nature and compromise of biodiversity and ecological integrity (Suding et al. 2015). Suding et al. (2015) emphasize the importance of fostering greater understanding of ecosystems and their values through community engagement and education, which reinforces a stronger relationship between people and nature (Higgs 2003). Similarly, public food forestry aims to cultivate social learning, hands-on experience, stewardship and connection between people with their landscapes and with one another (Jacke & Toensmeier 2005), in particular in urban landscapes (Clark & Nicholas 2013).

2.6.4 Long-term Sustainability

Both food forestry and ecological restoration aim for a self-sustainable system and intend to minimize intervention over time (SER 2004; Walker 2015). Yet, Hallett et al. (2013) argue that self-sustainability can be an unrealistic goal and has rarely been stated as a goal for restoration projects. Instead, public support and long-term stewardship are often critical attributes of successful restoration projects. In food forestry, ongoing human interaction in many different forms—for example, (re)designing, pruning, harvesting and directed succession—is viewed as an essential process for the development of the systems (Kumar & Nair 2006).

Both systems will be continually altered by people living in/near the landscape and interacting with them (Hills 1998; Kumar & Nair 2006; Hallett et al. 2013; Boivin et al. 2016). In resilience literature, growing emphasis is being placed on human actions as an integral part of dynamic and resilient ecosystems, in particular urban landscapes (Gobster 2012; Davidson et al. 2016). As the Earth systems undergo transformation "outside its Holocene stability domain," the capacity of the systems to adapt or transform to a desired state has became an crucial aspect of "resilience thinking," along with the capacity to persist (Folke et al. 2010). Yet, social and ecological contexts of landscape will affect the degree and types of ongoing interventions considered appropriate and required. A food forest should not compromise sustainability and resilience of natural and other valued systems in the landscape (Kumar & Nair 2006).

Suding et al. (2015) stress that the four restoration principles are "a necessary foundation to achieve sustainability and resilience." This approach requires consideration of environmental and ecological attributes (e.g. genetic diversity, high species interaction, tolerance of ecological communities to extreme events) and societal attributes (e.g. social learning, collective capacity, governance) of resilience (Keenleyside et al. 2012; Davidson et al. 2016). Therefore, long-term sustainability can be translated more comprehensively by embracing most, if not all, the attributes of all restoration principles and of the goals of food forestry.

Our study suggests that food forestry may have the biggest ecological restoration impact in urban landscapes that prevalently comprise hybrid and novel ecosystems and lack significant opportunities for conventional restoration. Urban food forestry provides a unique opportunity to explore how to restore unproductive or undesired ecosystems. It can also contribute to improving biodiversity, social justice, local food security, providing important ecosystem services and promoting appreciation of multiple values of ecosystems and human-nature connection. Clark and Nicholas (2013) introduce urban food forestry as "an emerging multifunctional and interdisciplinary approach to increase urban sustainability and resilience" as far as food security is concerned. Yet, this opportunity comes with many challenges such as potential of dispersal of invasive species, land-use competition and ethical concerns (Table 2.3). Therefore, a critical assessment of urban food forests through long-term, systematic monitoring will be crucial to test and strengthen urban food forestry.

Table 2.3 Urban Food Forestry: Potential Benefits and Challenges. Challenges are applicable to food forestry in different landscape contexts.

	Benefits	**Challenges**
Ecological integrity	Promoting biodiversity and habitat for urban wildlife in cities Restoring ecological processes, which enhances ecosystem services such as carbon sequestration, erosion control, pollination Reduction of impacts on other parts of the world by growing food and materials in cities (McLain et al. 2012; Clark & Nicholas 2013) Serving as an ecological edge: suppressing the dispersal of invasive species into a natural forest if it mimics the forest structure, creates shades and improves soil conditions (Mesquita et al. 1999)	Balancing and defining different components of ecological integrity Dispersal of invasive species and land-use competition which compromises native ecosystems and biodiversity, already under ongoing pressure (ER-3)

Long-term sustainability	Promoting sustainable development and resilience of urban communities (Kumar & Nair 2006)	Continuity of community support and stewardship (ER-4)
Informed by past and future	Testing ground for exploring new ecological communities and assisted migration with future adapted species (Gobster 2012)	Slippery slope in our commitment to restoring native systems (Hobbs et al. 2014) by incorporating introduced species and not necessarily embracing historic fidelity Respecting native systems and local cultures (ER-3)
Social benefits and engagement	Education: interesting place where people can interact with and learn nature, especially for children Human-nature connections: feeling connected to the landscape in more active and participatory ways than simply walking in an urban park (Starr & Puettmann 2008; Clark & Nicholas 2013) Stewardship and social connection: great for inspiration, socializing, sharing of cultures and skills, and building of relationships to the land, society and people. Beauty is "very important part of our experience and makes everyone cooperative in a beautiful environment" (FF-7) Social justice and food security: in particular for marginalized groups (e.g. migrants, refugees, low-income, homeless) by providing space for growing food and other subsistence plants (Kumar & Nair 2006; McLain et al. 2012; Clark & Nicholas 2013) Multifunctionality: diverse ecosystem services including flood control, air quality, carbon sequestration, production of other subsistence and microenterprise opportunities (Clark & Nicholas 2013)	Identifying neighbours, engaging with the community and balancing conflicting needs (FF-4) Mindful design and ongoing maintenance for creating a safe social space (FF-4) Changing regulation toward planting nut and fruit trees in public space, streets or a park (FF-4) Public attitude toward responsively harvesting and sharing food from a public space (FF-4)

2.7 Acknowledgements

We deeply thank all interview participants and representatives from the Galiano Conservancy Association, the Cottonwood Community Garden, and the Beacon Food Forest for their guidance, insights and support. We also thank the School of Environmental Studies at the University of Victoria, the Sara Spencer Foundation, and the Social Sciences and Humanities Research Council for their financial support. We have no conflicts of interest to disclose.

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2.8 Supporting Information

Table S2.4 10 literature sources describe food forest systems with different scales, characteristics, and purposes. There are many terms that refer to food forest systems; the most common terms are food forest, forest garden, and homegarden.

Authors (quoted from)	**Jose & Shanmugaratnam (1993)**	**Hills (1988)**	**Wiersum (2006)**	**Belcher et al. (2005)**	**Vieira et al. (2009)**
Term used	Traditional homegarden	Food forest	Homegarden, mixed garden & forest garden	Forest garden system or anthropogenic forest (with permanent forest culture)	Successional agroforestry system
Location	Kerala, India	Central America	East Kalimantan of Indonesia	Sumatran and Kalimantan Indonesia	Colombia and Northeastern Brazil
Description	Sustainable human ecosystem Ensemble of deliberately chosen species of plants of human utility combined so as to mimic a natural climax system	Agronomic, economic and social device, whose character varies according to existing physical, biological, economic and social conditions	Multi-strata cropping system that mimics the structure of natural forests or nature-analogous agroforestry system Categorized based on the proximity to home; yet, distinction is diffuse	One of forest garden systems with emphasis on diversified economic and productive functions over long time	Vertically stratified agricultural system that mimics natural succession for progressively through time-increasing income, biodiversity, and ecosystem structure and function
Composition	Economically valuable trees and understorey crops of high diversity	A variety of crops, perennials and/or annuals of different	Homegarden: largely cultivated fruit and other trees, vegetable herbs	High canopy trees for timber and fruit, understory trees (e.g. cinnamon	Mix of annual and perennial crops and several tree species with

		heights, physiognomy and root characteristics	and annual crops Forest garden: cash crop trees (e.g. cacao) with higher percentage of native trees	trees) and undergrowth herbs	high functional diversity
Structure	Climax ecosystem of which ecological succession is consciously manipulated	Spatially, temporally and numerically organized in such a way that they will benefit ecologically from each other. Partial imitation of the tropical rain forest, especially in regard to species diversity, the multi-storied configuration and extent of the vegetation cover	Multistorey canopy Structure changes Forest garden: resembling either primary forests or (more close to) secondary forests	Close to those of late successional or old-growth forests	Vertically stratified
Function	Ecological processes (e.g. regeneration and conservation of soil, nutrient cycling, water cycling)	Symbiotic; closed nutrient cycle; protection against damage by disease, pests and wind			Improving microclimate and soil fertility; increasing animal seed dispersal; and shading out grasses and forbs

Authors (quoted from)	Hart (1996)	Jacke & Toensmeier (2005)	Crawford (2010)	McLain et al. (2012)	Walker (2015)
Term used	Forest garden	Forest garden	Forest garden	Food forest	Food forest & forest garden
Location	United Kingdom	United States	United Kingdom	United Sates	Canada
Description	Largely self-regulating like the natural forest Requiring minimal maintenance Way to utilize vast resources in sustainable ways to satisfy essential needs	Edible ecosystem, a consciously designed community of mutually beneficial and animals intended for food production for other benefits (e.g. fuel, fibre, fun)	Carefully designed and maintained ecosystem of useful plants (and perhaps animals). Same as home garden, and multi-strata system	Integrated agroforestry woodland food systems, based on permaculture principles	Planted garden that aims to mimic the 'closed-loop, self-sustaining biological system of a natural forest with the added benefit of growing food and medicine
Composition	Mainly perennial plants—fruit, nut trees and bushes with perennial vegetable and herbs	Perennial polyculture of multipurpose plants of trees, shrubs, herbs, vines	Large trees, small trees, shrubs, herbaceous perennials, herbs, annual, root crops and climbers with direct and indirect benefit to people (mostly edible) Planted in a way as to maximise positive interactions and minimise negative interactions		Trees, shrubs, herbaceous plants, root crops, vines
Structure	Canopy; low-tree;	Intermediate	Young natural		Multiple (e.g.

	shrub; herbaceous; vertical, groundcover; rhizosphere	succession or pre-closed canopy forest stage	woodland		seven) vertical layers
Function	Self-regenerating; self-fertilizing; self-watering; self-mulching and weed-suppressing; self-pollinating; self-healing	Self-renewing, self-fertilizing, and self-maintenance Forest mimics but a true forest	Largely self-regulating; and self-fertilizing (closed nutrient cycling)	Food production; ecosystem services (e.g. soil enrichment, control of runoff & air quality; carbon storage); community connections	Self-sustaining; Carbon storage; water retention; food production; beauty; enjoyment; well-bing of human and other fellow planetary citizens

Table S2.5 Goals and Attributes of Participants' Food Forest(s)

Goal	Attribute	Description	Example
Forest functions	Species and structural diversity (Plant diversity)	A food forest is a "multi-storey, perennial, polyculture" system (FF-5), which is designed and managed to function like a self-sustaining, healthy forest	550 species including 80 tree and 100 shrub species; 50% tree canopy cover (FF-2)
	Complex ecological web		Recording invertebrates, fungi, plants, birds, earthworms (FF-1)
	Soil building & carbon sequestration		Soil organic matter increased from 2.4 % to 9 % over 12 years. Calculated to sequestrate 7.5 tons of carbon over 10 years (FF-6)
	Closed nutrient and water cycling		Maximising species interaction, "chop and drop" technique, mulching (FF-7)
	All succession or intermediate succession		Modelling on a young woodland (FF-7) Encouraging all succession (FF-1)
Diversity of yields	Diverse & high quality yields	Important to sustainably produce food while contributing to addressing issues around the growing population, food security, poverty, refugee, peak oil, deforestation, environmental destruction, and climate change	300 plant species, mostly edible in a food forest (approximately 800 m^2) in Coldstream, Scotland (FF-1). 1.3 metric tons of food in 2014 and 1.25 metric tons in 2015 by working with average 2 days per week (FF-1) Producing 80% of food consumed (FF-7)
	Long seasonal & long-term production		Producing fruit from late May to early December in Massachusetts, U.S. (FF-6)
	Diversified supplementary income sources		Herbal products (FF-7); plants, seeds (FF-1; FF-2); eggs (FF-6); vacation home (FF-8); tours (FF-2; FF-3); fieldwork (EF-2), workshops (FF-1; FF-2; ER-2); arts and crafts (e.g. Means of Production Garden, Canada)
Education &	Social, academic,	All participants	Workparty (e.g.Galiano Conservancy

culture share	experimental and/or experiential learning	practice and consider education essential part of food forestry	Association); invertebrate and bird survey with a graduate student (FF-2); planting diverse species that are adapted to multiple possible trajectories of the current climate conditions (FF-1); facilitating exchange of genetic materials from the globe (FF-7)
	Understanding of local culture & cross-cultural exchange		Planting a variety of culturally important species and sharing food e.g. Cottonwood Community Garden
	Demonstration of ecological edge and integrated design		Homestead farm and education (FF-8) Food forestry using native species (FF-3;FF-6) Integrated housing and community design (FF-7) Ecocultural edge (FF-4) Alternative way of living (FF-1)
Healthy habitat	Food & shelter for wildlife (ecological justice)	All species live in harmony People become integral, active part of ecosystems Social, emotional, and cultural benefits beyond just food production	37 bird species nesting in the food forest (FF-1) Recording a list of bird species & abundance every year from initially city birds like sparrow, starling now to migratory birds whose typical habitats are a forest (FF-6)
	Co-existence with neighbouring natural ecosystems		Galiano Community Food Forest in a conservation forested land to be monitored (FF-7; ER-2)
	Environmental and social justice for the marginalised groups (low-income, homeless, migrants, refugees, etc.) who are deprived of healthy food and access to their traditions		Providing a space for growing food for the community (e.g, Cottonwood Community Garden)

	Health, well-being, beauty, inspiration & fun		Creating many aspects of beauty for inspiration, socialization, collaboration (FF-2; FF-3; FF-7)
	Active engagement and connection with nature		Means of Production Garden: local artists sustainably use resources and steward the garden (FF-4) Providing a space for a community to engage with nature and landscapes (e.g, Cottonwood Community Garden)
Sustainability	Resilient to extreme weather events & pests	How a food forest is managed	No crop failure of pear and apple for the 20 years, withstanding severe frosts and weather patterns in a cold climate, Canada (FF-7)
	Positive output/input or lower input & maintenance over time		90% of the overall investment and time in the first 5 years (FF-7)
	Systematic governance Including stewardship, ownership		Means of Production Garden: local artists sustainably use resources and steward the garden (FF-4)

Chapter 3: A Criteria and Indicators Monitoring Framework for Food Forestry embedded in the Principles of Ecological Restoration

3.1 Abstract

Food forests are of growing interest in North America, representing a strong multifunctional approach that combines agriculture, forestry and ecological restoration. The Galiano Conservancy Association (GCA), a community conservation organization on Galiano Island, British Columbia in Canada, recently created a food forest with primarily non-native species and is planning a second food forest (2017) comprising native species on one of their protected forested lands. These projects, aimed at food production, education, and promotion of local food security and sustainability, are also intended to contribute to the overall ecological integrity of the landscape. Monitoring of the food forests allows for a systematic assessment of the projects' progress, which informs adaptive management. Yet, presently there are no comprehensive monitoring frameworks for food forestry available. To fill this need, we developed a generic Criteria and Indicators (C&I) monitoring framework for food forestry, embedded in four restoration principles by employing content analysis of 63 literature resources, semi-structured interviews with 16 experts in the fields of food forestry and ecological restoration. As a case study, we conducted a workshop with the GCA stakeholders to develop their own monitoring framework, using the generic C&I framework. The generic C&I framework comprises 14 criteria, 39 indicators, and 109 measures. Our generic C&I framework, embedded in comprehensive ecological restoration principles, has potential for a broader application; yet, decisions on specific C&I to be used in each case must be made through a thorough assessment of multiple variables: goals, objectives and scale of a project, landscape context, anticipated changes and capacity for monitoring.

Keywords: ecosystem services; food forest; Galiano Conservancy Association; sustainable forest management

3.2 Introduction

Forest restoration and food security are pressing concerns, especially in the face of directional climate change (Acevedo 2011; Chandon et al. 2016). The New York Declaration on Forests of the 2014 UN Climate Summit targets restoration of 350 million hectares of degraded lands to forest by 2030. The importance of forest restoration and sustainable management was reiterated at the 2015 UN Climate Change Conference in Paris. Globally, more than 2 billion hectares of degraded forested lands have the potential for different types of restoration (Minnemeyer et al. 2011). Meanwhile, one in every nine people in the world has suffered from hunger in the last three year (FAO 2015), and food production is increasingly challenging due to climate change (Acevedo 2011).

Growing attention is directed towards developing an integrated approach in "managing forests at the landscape level, which requires balancing multiple types of ecosystems with the needs of multiple sets of actors who use them" (Chazdon et al. 2016). Of the 2 billion hectares of degraded forest lands that have the potential for ecological restoration, an estimated 1.5 billion hectares would be suitable for integrating with other land uses such as agroforestry and/or agriculture (Minnemeyer et al. 2011). An integrated approach invites ecological restoration to be more comprehensive and flexible, which may blur the perceptual boundaries of conservation, forestry and agriculture that we often draw.

Numerous studies have examined the potential of multifunctional agroforestry systems, along with examples of their development, as a tool for ecological restoration and landscape management (Jose 2012; Lander and Boshier 2014; McNeely and Schroth 2006; Montagnini et al. 2011; Xu et al. 2012). Food forests, known also as homegardens, successional agroforests or forest gardens, are perennial, polyculture systems that mimic forest structures and functions (Crawford 2010; Jacke and Toenmeier 2005). They are generally planted with high diversity of trees, shrubs, and herbaceous species, including root crops and/or vines, in a way that maximizes favourable plant interactions for direct uses (e.g. food, medicine, fodders, building, art), as well as for ecological benefits (e.g. nitrogen-fixing, pollination, water conservation) (Hills 1988). Food forests have for many centuries enabled people to adapt to changing environmental and socioeconomic conditions, largely in tropical regions (Kumar and Nair 2004, 2006). For example, homegardening in Kerala, India is thought to be over 4,000 years old (Kumar & Nair

2004), and the origin of the Javanese homegardens is associated with fishing villages existing from 13,000 to 9,000 B.C. (Kumar & Nair 2006).

Inspired by the tropical food forests, food forestry has recently grown in popularity in the Global North, particularly in temperate-to-cold regions of Canada, the United States and the United Kingdom, where it appears to have not traditionally been practiced as a major means for food production (Clark and Nicholas 2013; Crawford 2010). Emerging food forestry is being promoted for its potential to provide locally-produced diverse food and education, to reconnect people with nature, to create habitat for wildlife species, and enhance various ecosystem services such as carbon sequestration, flood control and microenterprise opportunities (Clark and Nicholas 2013; Jacke and Toensmeier 2005). Many projects are conceived in backyards, city parks and degraded pieces of land in urban/suburban landscapes (e.g. Beacon Food Forest, Seattle).

In 2015, the Galiano Conservancy Association (GCA), one of the first community-based land trusts in British Columbia (BC), Canada, planted the Galiano Community Food Forest (GCFF), using primarily non-native species, at the heart of their conservation forested land on Galiano Island (the Millard Learning Centre) on the southwest coast of BC (Fig. 3.1). The food forest is primarily intended to feed participants in educational programs, to provide educational opportunities for visitors and locals and to promote local food security and sustainability while regenerating a degraded piece of the land and contributing to the overall ecological integrity of the conservation land. The GCA plans to create the Restoration Forage Forest (RFF), mainly with native plant species, in 2017, with similar goals to those of the GCFF, but also with the goals of supporting revitalization of traditional culture and plant uses. The GCA recognized that monitoring would be essential for assessing how effectively the projects are meeting their goals and thus informing adaptive management of the projects, and asked us to help to develop monitoring indicators (Erickson, Galiano Conservancy Association, personal communication, 2015).

Figure 3.1 Location of Galiano Island and the Millard Learning Center (formerly, Galiano Conservancy Learning Centre) ©Daniel Brendle-Moczuk

Tensions among different human values make food forestry ecologically and socially complex. The two emerging food forests of the GCA are not a typical agriculture or agroforestry project because activities in the food forests are intended to contribute to overall restoration and conservation efforts in their conservation land and need to comply with their integrated conservation planning (GCA 2013, available from http://galianoconservancy.ca/). At the same time, neither are typical restoration projects, since their primary goal is food production; the commitment to the forested landscape's ecological integrity stands as a secondary principle. These tensions emphasize the salience of an integrated, holistic approach that embraces a wide range of values, and of the delicate balance among these.

As a case study, the food forest projects of the GCA provide a unique learning opportunity, and one of the first living experiments to explore how community-based conservation groups might use food forestry in assisting in restoration and conservation in North America and other temperate climate regions. For this reason, long-term monitoring and assessment will be essential to identify what benefits and risks might be involved in integrating food forestry to restoring and managing a multifunctional landscape. This requires the development of a monitoring framework that is contextualized in a comprehensive and integrated restoration principles and that meaningfully reflects distinctive aspects of food forestry.

Food forest monitoring is drawing international attention. The Permaculture Association developed methods to measure soils, plant diversity, and yields of a polyculture food system (https://www.permaculture.org.uk/). Individual food foresters measure yields, soil organic carbon, or wildlife species such as birds and amphibians, depending on their personal or academic interests (Toensmeier 2013; West 2006). At the International Permaculture Conference 2015 in London, UK, food forestry practitioners and researchers collectively expressed the need for monitoring frameworks that encompass multiple aspects of a food forest system, which allow systematic assessments and production of scientific data.

As a modest attempt to contribute to the international and local movements, we developed a Criteria and Indicators (C&I) monitoring framework for food forestry. The C&I framework is primarily intended to guide a comprehensive and systematic assessment of a given food forest project in the context of ecological restoration. It was adapted by the GCA with the intention of taking an initial step toward developing a comprehensive, tailored monitoring program, which will inform adaptive management of their permaculture and ecological restoration activities (Erickson, Galiano Conservancy Association, personal communication, 2016). Our generic C&I framework shows the potential to be applied to food forestry in general, and we hope that it will be tested, adapted, and improved by other researchers, practitioners, and environmental groups.

3.3 Site Description and Research Context

3.3.1 Site Description

Galiano Island, one of the southern Gulf Islands, is located on the west side of the Strait of Georgia, between Vancouver Island and the west coast mainland of Canada (Ewonus et al. 2011). The Island is situated within the Coastal Douglas-fir biogeoclimatic zone (CDF), which is found only in BC and adjacent Washington State, characterized by a Mediterranean climate of warm, dry summers and mild, wet winters. Due to intensive land conversion and logging, the coastal Douglas-fir (*Pseudotsuga menziesii*) forest is one of the rarest ecosystem types listed in BC, and its primary plant association is of global and provincial conservation concern (Austin et al. 2008; Forest Practices Board 2010).

In 2012, the GCA purchased a 76-hectare parcel on the central west coast of Galiano Island and established it as the Millard Learning Centre. The acquisition protected approximately 20 hectares of old growth and mature forest along 2 km of shoreline, two small stream systems with accompanying wetland and riparian habitats, as well as areas where forestry and agricultural activities had taken place in the past. This coastal Douglas-fir forested property is part of the Mid-Galiano Island Protection Network for conservation, which protects the island's ecological diversity and functions as a critical ecological corridor for island plants and animals, under the integrated conservation planning program (GCA 2013). In the heart of the coastal Douglas-fir forested landscape of the Centre, approximately 13.06 hectares of Agricultural Land Reserve (ALR) is designated under the Agricultural Land Commission Act, which houses the two food forests of the GCA.

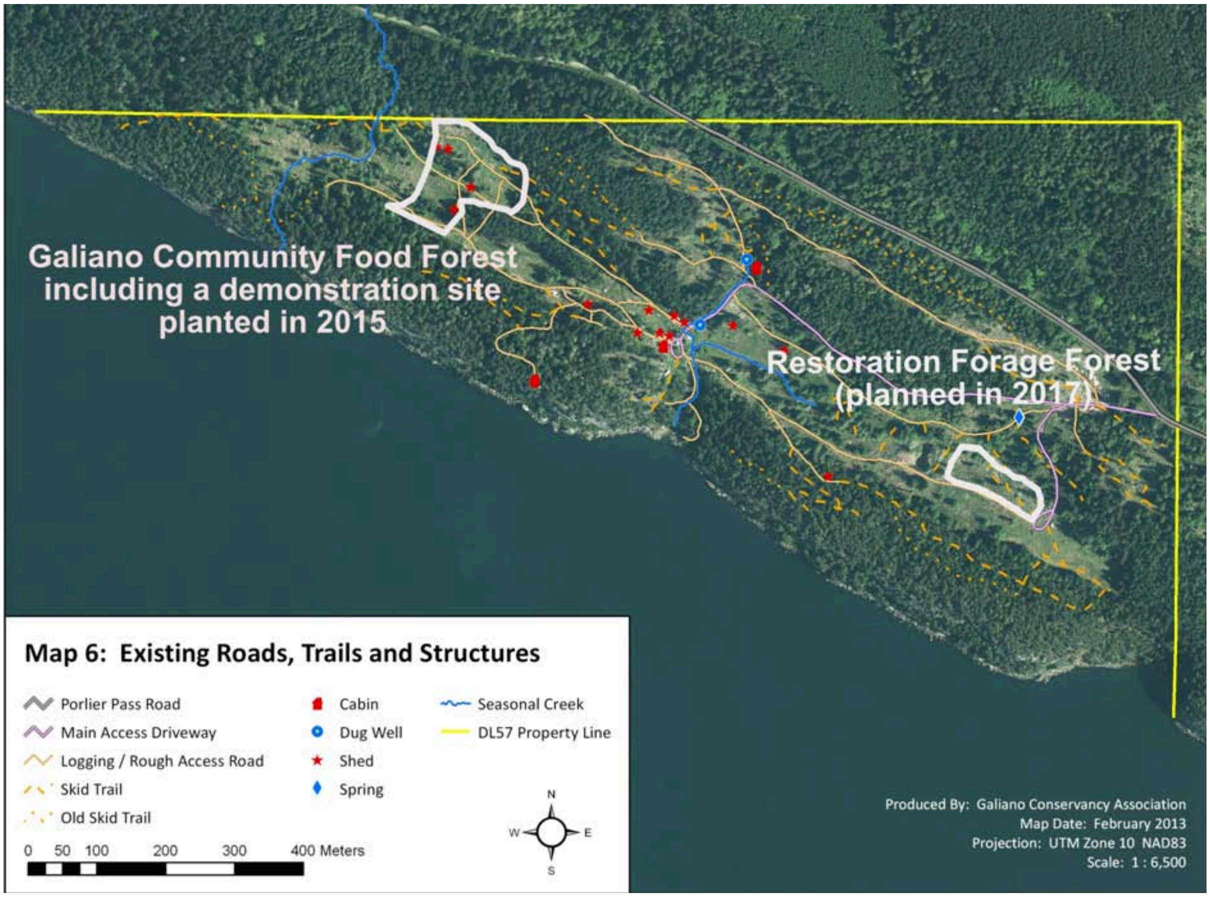

Figure 3.2 Galiano Community Food Forest and planned Restoration Forage Forest sites (Map modified from GCA 2013)

Galiano Community Food Forest (GCFF)

The GCFF was planted in a primary agriculture zoning area (1.64 ha) within the ALR, which is designated for food production and horticulture (Fig. 3.2). The area had been repeatedly clear-cut and grazed until the time the GCA purchased the land. It is currently an open, dry graminoid-dominated land with very little regeneration occurring. Dominant species include bent grass (*Agrostis capillaris*), common velvet-grass (*Holcus lanatus*), and thistle (*Cirsium* sp.). Soil compaction is severe, which implies the possibility of having been used historically as a log staging area as part of past logging activities on the site (Galiano Learning Centre Management Committee 2013).

In 2015, the GCA created the GCFF of 750m^2 as a demonstration site by building woody debris mounds and contour trenches in this area (Fig. 3.3). They then planted over 50 plant species on the mounds, including: 5 tree species [e.g. Chinese chestnut (*Castanea mollissima*), persimmon (*Diospyros kaki*), jujube (*Ziziphus jujuba*)]; 8 shrub species [e.g. black currant (*Ribes nigrum*), goumi (*Elaeagnus multiflora*)]; 28 herbaceous perennials [e.g. Jerusalem artichoke (*Helianthus tuberosus*), Russian sage (*Perovskia atriplicifolia*)]; 4 vines [e.g. grape (*Vitis* spp.), arguta kiwi (*Actinidia arguta*)]; 11 self-sowing annuals [e.g. amaranth (*Amaranthus cruentus*), radish (*Raphanus sativus*)]; and different varieties of garlic (*Allium sativum*) as a cash crop to help with initial operational costs.

The GCA aim to create a sustainable, resilient food production system that will feed participants in their educational programs taking place at the Centre, to provide educational opportunities, and to sell and donate food to the local community. A nursery and an outdoor classroom/auditorium are being currently constructed on the site and will be complete by the end of 2016. The food forest project adopts a social enterprise approach and is intended to generate base revenue for project operation while supporting further conservation and restoration on the property. If the project is deemed ecologically and socioeconomically successful, the demonstration site will be expanded in the future.

Figure 3.3 The Galiano Community Food Forest demonstration site (July 2015) before site preparation and planting (left) and after planting (August 2016) (right)

Restoration Forage Forest (RFF)

The RFF will be planted in a parcel of approximately 1 ha in size within the integrated management zoning area (Fig. 3.4) primarily designated for integrated agriculture, agroforestry and forest use within the ALR (Galiano Learning Centre Management Committee 2013). In this area more emphasis is placed on restoration of ecological processes and conservation of native species than the agricultural zoning area where the GCFF is planted. It is currently graminoid-dominated, with introduced grasses (e.g. *Holcus lanatis, Agrostis capillaris*, *Anthoxanthum odoratum*) and invasive species (e.g. *Cirsium* spp.). It exhibits slow regeneration of native plants including coastal Douglas-fir (*Pseudotsuga menziesii*), salal (G*aultheria shallon*), and sword fern (*Polystichum munitum*) (Galiano Learning Centre Management Committee 2013).

Figure 3.4 Restoration Forage Forest site with the "grandmother" western redcedar (*Thuja plicata*) (April 2015)

This area was originally planned for the GCFF. However, at the site is, an old-growth western redcedar (*Thuja plicata*), known locally as the "grandmother" tree, which was almost felled but saved at the last minute when the land was acquired by the GCA. This special tree became the centre of heated debate during a public design charrette (in April 2015) for the GCFF: the Conservancy had to decide whether to remove the tree (including some of the native plants surrounding it) for maximum food productivity, or to compromise productivity by keeping them and honouring the ecological and cultural legacy of the site. As a result, the GCA changed the location of the GCFF to the primary agriculturally zoned area and decided to create the RFF surrounding the grandmother tree, which will be planted with native plant species.

The debate illustrates the tension that might arise when food forestry is practiced on land intended for biodiversity conservation. At which end of a continuum between food production and restoration would a food forest be positioned? The GCA will manage the two sites under the same conservation planning and use the same indicators in monitoring. However, the primary agriculture area will focus more on food productivity and place less emphasis on improving ecological integrity in comparison to the RFF in the integrated management area (Galiano Learning Centre Management Committee 2013).

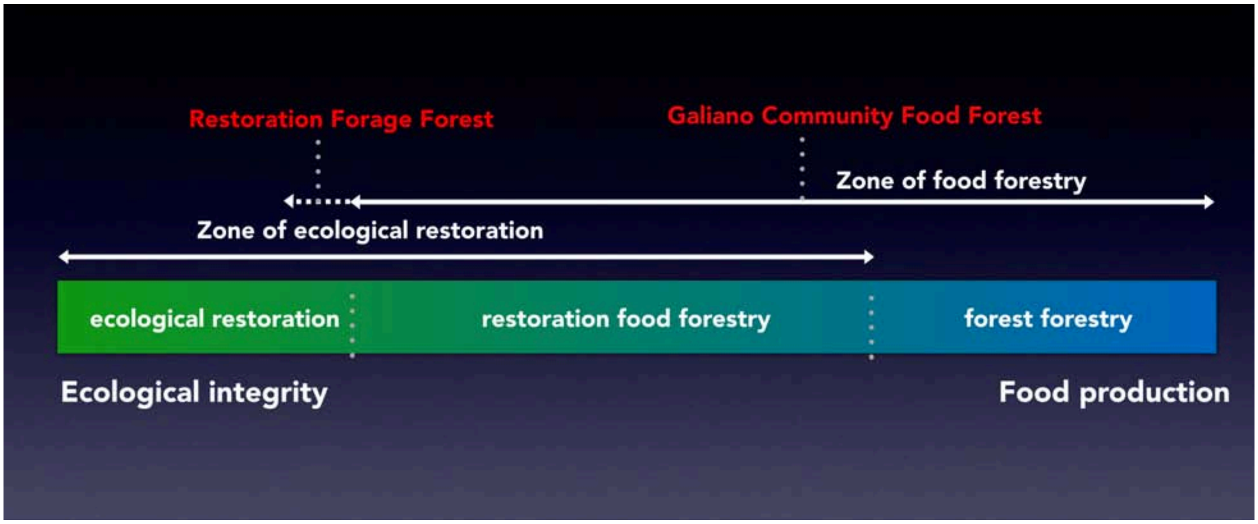

Figure 3.5 A diagram showing at which end of the continuum the GCA's food forests may position hypothetically

3.3.2 Research Context

Hierarchical Structure of a Criteria and Indicators (C&I) Framework

A C&I framework is a "hierarchical framework to help to design sets of indicators for sustainability monitoring programs" (Wright et al. 2002) and is a powerful organizational tool for identifying parameters of sustainability and assessing progress. We adapted the hierarchical structure of the Forest Service Local Unit Criteria and Indicators Development (LUCID) C&I (Wright et al. 2002), which was developed by six interdisciplinary forest teams in order to systematically monitor social, economic and ecological aspects of local forest management in the United States. The LUCID C&I lays out the ontology of sustainable forest management, and transparent relationships among hierarchical parameters. Originally, the framework had a six-level hierarchical structure (Wright et al. 2002). For the purposes of the present research, we simplified the structure to a four-level hierarchy: principle, criterion, indicator and measure (Table 3.1). Other two subsequent, detailed levels—data element (i.e. specific method) and reference value—may be determined by the Conservancy (or other organizations) as appropriate.

These levels require more time to assess resources available presently and in the future, and to identify appropriate reference ecosystems and/or values.

Table 3.1 Components, Definitions and Examples of the LUCID C&I Monitoring Framework (adapted from Wright et al. 2002)

Component	Definition	Example
Principle	A fundamental law or rule serving as a basis for reasoning and action. An explicit element of the sustainability goal	Ecological integrity is maintained
Criterion	A component of the structure or function of the ecological, social or economic systems, which should be in place as result of adherence to a principle. Criteria form the conceptual architecture of the systems under investigation	Landscape structure/composition
Indicator	A quantitative or qualitative parameter that can be assessed in relation to a criterion	Landscape patterns
Measure	The methodology and source of information for the indicator. The form, scale, timing and units of data that are gathered are specified	Density and distribution of human developed features by use class (e.g. number of road crossings)

Prahbu et al. (1996) used "top-down" and "bottom-up" processes in the development of a C&I assessment framework for forest management. The authors emphasized that the "assessment system must be first conceptualized from the "top-down" principles and criteria so as to ensure the selection of assessment parameters is "conceptually and scientifically" integrated with the principles. Then, in reverse, individual parameters for assessing sustainable management were collected from existing assessment systems in order to generate "bottom-up" criteria and indicators (bottom-up process). "Bottom-up" criteria and indicators were compared with the top-down criteria. We adopted their approach for building the C&I monitoring framework for food forestry.

Conceptual Foundation of a C&I Framework

We determined that the C&I monitoring framework for food forestry should be conceptually founded on principles that encompass diverse social and ecological values of food forestry and ecological restoration. Suding et al. (2015) underscored that good restoration addresses the "ecological, cultural, and socio-economic values of complex natural-human systems" and proposed four principles for guiding ecological restoration that is pragmatic, scientifically-sound, and comprehensive, in pursuit of creating sustainable and resilient systems (Table 3.2). These principles are extended from existing ecological restoration guidelines, including those issued by the World Commission on Protected Areas (Keenleyside et al. 2012) and provided in the Society for Ecological Restoration Primer (2004). These four restoration principles are comprehensive enough to be applicable for the two projects of the GCA, which embody diverse human values and have different levels of emphasis on historical fidelity and employ different management approaches yet are governed by the integrated conservation planning of the GCA and aim for sustainability and resilience. Therefore, we adopted the four principles to guide the generation of common monitoring criteria and indicators. The key attributes for each principle identified by Suding et al. (2015) were used as "top-down" criteria, which was subsequently complemented by "bottom-up" criteria resulted from an extensive literature review.

Table 3.2 Principles and Key Attributes for Guiding Comprehensive Ecological Restoration (adapted from Suding et al. 2015)

Principles	Description and attributes
P1 Restoration increases ecological integrity	Recovery of biological assemblages including species composition, functional groups and ecological processes to sustain the these biota and ecosystem function
P2 Restoration is informed by the past and future	Consideration of both historical knowledge and likely ecosystem/landscape trajectories, especially under conditions of rapid change
P3 Restoration benefits and engages society	Enhancement of ecosystem services; quality of human life and communities; participation; and understanding of ecosystems and their benefits
P4 Restoration is sustainable in the long-term	Establishment of self-sustaining and resilient system with minimum human intervention over time with the consideration of landscape contexts

3.4 Methods

3.4.1 Literature Review

In order to develop a C&I monitoring framework for food forestry in general and the Conservancy's food forest projects, we first generated a preliminary C&I framework (Online Resource 3.6). Due to lack of existing monitoring frameworks and indicators for food forestry, we conducted an extensive review of a total of 63 literature resources on standards, principles, and assessment and monitoring approaches drawn from five related fields: ecological restoration, agriculture/agroecology, agroforestry, sustainable forest management and permaculture (Table 3.3). Using conventional content analysis (Hsieh and Shannon 2005) and Atlas.ti (qualitative data analysis software), we inductively coded a total of 988 parameters until no new themes or properties emerged and categorized them to criterion, indicator and measure according to the guidelines of LUCID C&I (Wright et al. 2002). We iteratively compared and segmented codes and lumped redundant codes until redundancy in all codes was eliminated. Key themes that emerged across three different fields or more were selected as bottom-up criteria, which complemented the top-down criteria drawn from Suding et al. (2015). The preliminary C&I framework was used as a response instrument for subsequent semi-structured interviews.

Table 3.3 A total of 63 literature resources include: peer review articles; books; proceedings; and International/national reports

	Field (number of literature resources)				
Nature of literature resources	Restoration (25)	Agriculture/ Agroecology (13)	Agroforestry (11)	Sustainable forest management (10)	Permaculture (4)
Guidelines;	Burton 2014	CGSB 2008	Atangana et al. 2014		Jacke and Toensmeier 2005
Standards;	DeLuca et al. 2010	Cassman and Wood 2005	Araujo et al. 2012		
Review of practices	Díaz et al. 2007	OECD 2001a	Callo-Concha and Denich 2011		

(24)					
	Hallett et al. 2013	Webster 1999	Day et al. 2011		
	Keenleyside et al. 2012		Hart 1996		
	Ordóñez et al. 2012		Hills 1988		
	SER 2004		Jose 2012		
	Shackelford et al. 2013		Szymanski and Colletti 1998		
	Suding et al. 2015		Terrones Rincon et al. 2011		
	Woodley 2010				
Monitoring and assessment (39)	Egan and Estrada 2011	Bockstaller et al. 1997	Casanova et al. 2012	Balana et al. 2010	Louvain 2015
	Environment Canada 2003	Hayati et al. 2010	CIFOR 2013	CCFM 2003	Remiarz 2014
	Faber-Landgenden et al. 2006	McRae et al. 2000		Kirby et al. 2005	Warburton-brown and Kemeny 2015
	Feld et al. 2009	OECD 2001b		MCPFE 2003	
	Garry Oak Ecosystems Recovery Team 2011	Rigby et al. 2001		Montréal Process Working Group 2009	
	Gomontean et al. 2008	Sands and Podmore 2000		Mrosek et al. 2006	
	Herrick et al. 2006	Tellarini and Caporali 2000		Pei et al. 2009	
	LaPaix et al. 2009	Van Cauwenbergh et al. 2007		Prabhe et al. 1996	
	Lee and Rudd 2003	Zhen and Routray		Williamson and Edwards	

		2003	2014
	Mason et al. 2005 Noss 1990 Parks Quebec Network 2014 Ruiz-Jaen and Aide 2005 Spellerberg 2005 Tierney et al. 2009		Wright et al. 2002

3.4.2 Semi-structured Interviews

Sixteen experts from the fields of food forestry (FF; n=8) and ecological restoration (ER; n=8) participated in semi-structured interviews and identified key monitoring indicators and measures for food forestry. The participants were recruited through a purposive, snowball sampling method (Cohen and Arieli 2011) and are practitioners, researchers, or both, and they have professional experience in their field ranging between six years and over forty years (averaging 27.5 years in restoration and 24.5 years in food forestry) in Canada, the United States and the United Kingdom. Seven participants have experiences in both fields. The interviews took place in the period from September 2015 to June 2016 via phone, online video chat, or in person, and were audio-recorded. The interview process followed the Ethics Protocol (15-233) approved by the University of Victoria (consistent with Canada's Tri-Council Policy Statement on Ethical Conduct for Research Involving Humans).

Using the preliminary C&I framework as a response instrument, we discussed monitoring indicators and measures with the participants based on:

a) what they use (e.g. "we do soil test, looking at soil organic matter, 2.4 % initially to 9% now over the course of 12 years … [and] we have looked at how much we need to spray organic sprays" (FF-6));

b) what they wish to use if given more resources (e.g. “I would like to measure the amount of fungal life in soil, particularly mycorrhizae and measure aboveground biomass … It will be useful to be able to monitor nutrient cycling” (FF-2)); and
c) what they think might be useful for the Conservancy (e.g. “I will monitor what birds, insects, and food production are in the garden. Time for maintenance, watering. Inputs and outputs” (FF-3), or “As a social enterprise, you might want to check who you are benefiting, who are users” (FF-1)).

We conducted content analysis (Hsieh and Shannon 2005) of interview transcripts. While reading individual transcripts thoroughly, four times each, we identified and coded monitoring parameters that were recommended by the participants and compared against the preliminary framework, using Atlas.ti. The semi-structured interviews generated a generic C&I monitoring framework, which was adapted by the GCA for the development of their own C&I monitoring framework.

3.4.3 Workshop

A key for developing a local C&I framework is to undertake active stakeholder consultation and to focus on a small number of principal indicators relevant to management and monitoring goals of a project (Hickey and Innes 2008). We conducted a three-hour workshop with five staff and one board member of the GCA on Galiano Island in February 2016. We first discussed the generic C&I framework and key monitoring considerations drawn from the previous interviews analysis. Then, the GCA stakeholders and we qualitatively examined the indicators and measures, based on: 1) importance/relevance to their food forest goals, 2) resources available (e.g. staff hours) and 3) ease of the use (e.g. level of expertise needed). Based on the analysis of the discussion and our note, we refined the generic framework. Then, the GCA reviewed it and finalized their monitoring framework (Galiano C&I framework).

3.4.4 Participation and Observation

This study and the GCFF project started almost at the same time. From April 2015 to August 2016, one of us (HP) participated in site assessment, design workshop, vegetation survey and planting. Such first-hand participation and engagement with stakeholders gave a good understanding of the local ecological, social and cultural aspects of the two projects in the context of restoration and conservation. At the same time, the GCA members and staff contributed their knowledge and experience to the development of the monitoring framework as well as internal documents relevant to the food forest projects.

3.5 Results

The preliminary C&I framework consists of 4 principles, 13 criteria, 46 indicators and 161 measures (Appendix C). It was then refined by the food forestry and restoration experts and distilled to the generic C&I framework of 14 criteria, 39 indicators, and 109 measures (Online Resource 1). Ecological integrity has the highest number of parameters, followed by social benefits and engagement. The interviewees greatly contributed to operationalizing socio-economic aspects of long-term sustainability at a project level.

Table 3.4 Generic C&I Monitoring Framework for Food Forestry (excluding measures)

Principle 1 Ecological integrity	
Criterion (6)	Indicator (18)
Integrity of the biotic community	Plant diversity (species and structure)
	Trophic structure (food web/chain) from decomposer, invertebrates to birds
	Regeneration and reproduction
Habitat quality	Habitat structural diversity
	Landscape connectivity
Ecological processes	Productivity
	Carbon sequestration
	Succession
	Nutrient cycling
Soil	Physical characteristics
	Biological characteristics
	Chemical characteristics

	Soil erosion
Hydrology	Water storage and flow
	Water quality
Disturbance	Diseases and pests
	Environmental factors including fire, windstorms
	Herbivory

Principle 2 Informed by past and future

Criterion (2)	Indicator (3)
Historical knowledge	Historical biological community or processes
	Traditional and/or local knowledge of the forest
Anthropogenic changes	Weather patterns

Principle 3 Social benefits an engagement

Criterion (3)	Indicator (10)
Cultural values and social equity	Food security (high quality, reliable, affordable food for a community)
	Local community access to forest-related livelihood opportunities
	Cultural identity and spiritual values
	Life quality of a farmer and a family
Economic benefits	Yield
	Employment
	Local business
	Contribution to the community
Outreach, education and training	Acquisition of knowledge and skills
	Research and science

Principle 4 Long-term sustainability

Criterion (3)	Indicator (8)
Resilience & stability	Prepared and resilient to extreme weather
	Self-regulating (in the absence of maintenance)

	Functional diversity
Economic	True yield (output–input)
self-sufficiency	Product energy/input energy ratio (EROI)
Governance	Collaborative participation
	Continuity in management
	Stewardship

3.5.1 Ecological Integrity

Biodiversity, soil, ecological process (or function) and disturbance were identified as key ecological criteria across all five fields of the literature resources reviewed, and landscape and hydrology across the four fields. Among these criteria, the interviewees highlighted plant diversity, complex trophic structure, ecological process and soil as essential ecological aspects for monitoring (Table 3.4).

A criterion of biotic integrity captures the experts' emphasis on plant diversity (composition and structure) as well as a complex trophic structure of a food forest system. Monitoring species richness and abundance of each forest structural layer is seen as fundamental for understanding plant diversity of a food forest system. If it is not feasible to observe all species, dominant and representative species of each layer, or only tree and shrub species, can be selectively monitored. A food forest of 2 acres in Devon, England accommodates 550 plant species including 80 tree and 100 shrub species with 50% tree canopy cover (FF-2). Non-plant species such as birds, amphibians, invertebrates and/or fungi can be observed as a measure of a trophic structure of a food forest. Bird monitoring was common among the food foresters we interviewed. One food forester (FF-1) had recorded 21 bird species nesting in his food forest and 25 bird species visiting (occasionally and frequently) over five years, in addition to over a total of 100 pollinator, spider, snail, beetle and earthworm species (available from http://grahambell.org).

For ecological processes, productivity, carbon sequestration, nutrient cycling, and succession drew strong interest. Productivity is associated with tree growth, which can be measured by DBH (ER-6) or the amount of yield (FF-1). Repeat photography and video-recording of successional changes were recommended for the GCA's food forests (FF-1).

Additionally, the percentage and patterns of successional communities can be used to indicate habitat quality (ER-3).

Both expert groups underscored monitoring soil quality, in particular soil microbiology and soil organic matter, for its association with productivity, nutrient cycling, water conservation and resilience to extreme weather events. A restoration interviewee (ER-7) recommended mushrooms as an indicator for soil health, decomposition, and symbiosis of plant-fungus species. Also, having no bare soil was proposed as a proxy for soil erosion prevention (ER-7), which also helps to moderate changes in soil temperature, which primarily influence soil microbial activity (FF-1). Nutrient availability in soils (e.g. nitrogen, phosphorous) can vary seasonally and may serve as a secondary monitoring indicator (FF-2). On the other hand, a food forest should not leach nutrients into a creek or other systems or cause undesirable changes in hydrology of a landscape (ER-1; ER-3). Indicator species (e.g. *Lysichiton Americanus*) could be used to infer soil moisture and nutrient (ER-7).

3.5.2 Informed by Past and Future

Historical knowledge in any form can indicate how the systems have functioned (Boivin et al. 2016; Suding et al. 2015; Wright et al. 2002). A restoration expert (ER-4) underscored that an assessment of ecosystem and landscape legacies may help the operators to understand historic conditions and to discuss desired trajectories of the systems. For example, pollen cores provide information on long-term plant community dynamics (Wright et al. 2002); but such measurements can be too expensive or time-consuming for some organizations. Alternatively, traditional ecological knowledge, which accumulates throughout generations and is directly associated with local plants and environments, may be more accessible and practical for understanding the site history.

Incorporation of traditional ecological knowledge by engaging a local community can indicate the degree of community participation and cultural identity integrated in a practice (Pei et al. 2009). Participation and cultural identity are related to two other principles: long-term sustainability and social benefits and engagement respectively (CCFM 2014; Suding et al; 2015; Wright et al. 2002). Yet, a distinction was made between traditional ecological knowledge and local ecological knowledge depending on a local history of settlement and immigration (ER-7;

FF-1). As a result, traditional knowledge could be differently interpreted between the UK and Canada (FF-1). Microscopically, for the GCA, the GCFF and the RFF would give different emphasis in the application of traditional ecological knowledge (ER-4).

In conjunction with historical knowledge, information on weather patterns and climate variables, such as length of a growing season (CCFM 2014) and blooming times over time, can be used to guide adaptive management in the wake of climate change (Hallett et al. 2013).

3.5.3 Social Benefits and Engagement

All food forestry interviewees highlighted the educational value of food forests, and they provide education in various forms (e.g. workshop, tour, research). The numbers of educational events, readers of their publication, and/or site visitors are recorded as well as feedbacks of visitors (FF-3; FF-6). Further, how and what people contribute to a community after acquiring knowledge and skills from a food forest project could serve as a measure of the educational impacts of the project (ER-5). Stewardship is critical for building sustainability of a public or community-run project, and at the same time it reflects the level of community engagement in the project (ER-6).

Economic benefits of a food forest project can be measured in two ways: economic return to the project itself, and a broader spin-off to local businesses and community. A food forester (FF-1) measures the weight of each food crop and total weight of all crops. His food forest of $800m^2$ in size produced a total of 1.3 metric tons of crops in 2014. Or, the total (potential) sales income from all crops could be measured. Incomes from other activities such as nursery, workshops and tours are included in measuring economic benefits (FF-1). For the broader economic spin-off to the community, recommended measures include: the number of bed nights of people staying in local accommodations because of the food forest project (FF-1); and number of local businesses created due to a food forest (ER-5; ER-6). Local food security can be measured by the amount of or the monetary value of yields donated to the community, or local consumption/purchase of the products (ER-7).

3.5.4 Long-term Sustainability

Resilience and self-sustainability are key elements for long-term sustainability of ecological restoration (Suding et al. 2015). A resilient system tolerates extreme events and is resistant to soil erosion and spread of invasive species (Keenleyside et al. 2012). Resilience indicators include genetic diversity, species interaction, functional redundancy and response diversity (Keenleyside et al. 2012). Yet, these are complex and often hard to measure, and it is difficult to understand to what degree resilience of terrestrial systems is affected by these factors (Bestelmeyer et al. 2011). In food forestry, as indicators, practitioners observed signs of pests and disease, mortality and survival rate of plants, and crop productivity, in particular after extreme weather events or the absence of or decrease in maintenance (FF-2; FF-7).

In the meantime, sustainability is also about socioeconomic management (CCFM 2014; Wright et al. 2002). The generic C&I framework includes economic self-sufficiency and systematic governance as sustainability criteria. As regards economic self-sufficiency, a project should be financially viable and/or able to operate without relying on external funds over time (ER-6). All costs for maintaining a food forest (e.g. irrigation, labour, and electricity) and all incomes from the project (e.g. product sales and workshop fees) will be considered (FF-4). In terms of systematic governance, a community project should have the capacity to sustain or adapt in the midst of changes. Does a project rely on one champion, a few people who dedicate their whole time, or a larger pool of dependable volunteers? Can a project be sustained in the absence a champion or clear leadership? (ER-6; ER-7) The interviewees stressed collaborative participation, continuity in management, and stewardship as critical attributes of a project that is socially resilient and sustainable (ER-4; ER-6; ER-7; FF-4). This socio-economic aspect of long-term sustainability will be important for a community food forest project like the GCFF that requires continuous maintenance and monetary sources.

3.5.5 Case Study: Galiano C&I Framework

The GCA selected a total of 13 criteria, 31 indicators and 19 associated core measures and 28 optional measures based on relevance to the projects and their capacity (e.g. expertise, finance, time) to employ the measure (Table 3.5). Core measures are the ones that the GCA currently has the capacity to monitor on either an annual basis (e.g. repeat photography) or every three to five years (e.g. species richness and % cover by layer), as appropriate. Optional measures are pertinent to the projects and may be employed when additional expertise and/or time commitment is available. Further, specific time frames and methods need to be determined.

Similar to the interview results, the GCA stakeholders were interested in monitoring plant diversity, trophic structure, ecological processes (e.g. carbon sequestration, succession and nutrient cycling), soil organic matter and soil biological conditions. In addition, observation of disease and pests was important for both food production and the ecological integrity of the landscape. Native species diversity was related to cultural values and use of historical knowledge. Overall, social indicators selected manifest the goals of the GCA's projects: local food security and economy, cultural revitalization, education and active research collaboration. All of long-term sustainability criteria—resilience & stability; economic self-sufficiency; and governance—were all considered critical, and one or more core measures were chosen from each criterion.

Table 3.5 The Galiano C&I monitoring framework consists of 4 principles, 13 criteria, 31 indicators, 19 core measures and 28 optional measures. The core measures are the ones that the GCA has the capacity to monitor over time on either an annual basis or every three to five years as appropriate. Optional measures are pertinent to the projects and may be employed when additional expertise and/or time commitment available. Measures in italics are those used more than once.

Principle 1 Ecological integrity			
Criterion	Indicator	Core measure	Optional measure
Integrity of the biotic community	Plant diversity (species and structure)	Species richness and its cover (%) in each structural layer (including invasive species) *Native species richness and its cover* Tree (10m+) density (number of stems per unit area)	
	Trophic structure (food web/chain) from		Insect species diversity (especially, pollinators,

	decomposers, invertebrates to birds		*Scarabaeinae, Carabidae*) Amphibian diversity (e.g. frogs, salamanders) and behaviour (e.g. reproduction, migration, health) Bird diversity and behaviour (e.g. nesting)
	Regeneration and reproduction		Percentage & number of seedlings (DBH<5 cm) and saplings (5-10 cm)
Habitat quality	Habitat structural diversity	Volume of coarse woody debris, small woody debris and snags	
	Landscape connectivity	Area (% of site) of roads and footpath	
Ecological processes	Productivity		*Biomass (allometric equations: dbh and species)*
	Carbon sequestration		*Biomass (allometric equations: dbh and species)* Soil organic carbon
	Succession	Repeat photography or video recording	
	Nutrient cycling		Presence of mycorrhizal mushrooms *Soil microbial biomass* Soil organic matter
Soil	Biological characteristics		Ratio of bacteria & fungi Signs of arbuscular mycorrhizae colonization *Soil microbial biomass*
	Chemical characteristics		Soil pH Nutrient availability (e.g. nitrogen, phosphorous, calcium)
	Soil erosion	None or less than 5 % exposed soil including	

		roads/paths (or more than 95 % vegetation cover)	
Disturbance	Disease and pest		Use of organic spray for pest control *Areas disturbed by pest and disease (e.g. leaf damage, plant mortality) within a food forest* Areas disturbed by pest and disease (e.g. leaf damage, plant mortality) in neighbouring areas

Principle 2 Informed by past and future			
Criterion	Indicator	Core measure	Optional measure
Historical knowledge	Historical biological community or processes	*Native species richness and its cover*	
Anthropogenic changes	Weather patterns		Temperature Precipitation Wind Solar radiation

Principle 3 Social benefits and engagement			
Criterion	Indicator	Core measure	Optional measure
Cultural values and social equity	Food security (high quality, reliable, affordable food for a community)	Destination of products and food produced (local or non-local)	
	Cultural identity and spiritual values	Aboriginal participation	Culturally important species used
	Life quality of a farmer and a family		Wage, income rates Satisfaction/enjoyment from work
Economic benefits	Yield	*Income from yield (e.g. food, value-added products) and other activities (e.g. workshop)*	Total annual quantity (e.g. weight or volume of each crop)
	Employment	Number of jobs created	Number of staff and wages Number of community

			residents employed by the project
	Local business		Local businesses created by the project (e.g. herbalists/honey production/mushrooms)
Outreach, education and training	Acquisition of knowledge and skills	Number of education and outreach events Number and demographics of visitors: age (*youth & senior), locality, ethnic, level of knowledge, interest	Number of hours invested in education, training, project implementation, monitoring for youth and locals
	Research and science	Number of research/ Education and individuals studying the system (including nature of research)	

Principle 4 Long-term sustainability			
Criterion	Indicator	Core measure	Optional measure
Resilience & stability	Prepared and resilient to extreme weather	Crop failure after extreme weather events (e.g. drought)	
	Self-regulating (in the absence of maintenance)	Outbreaks of disease	*Areas disturbed by pests and disease (e.g. leaf damage, plant mortality) within a food forest*
	Functional diversity		Evenness of the distribution of abundance in nutrient-cycling microbes (fungi, nitrogen-fixing bacteria, ammonia-oxidizing bacteria)
Economic self-sufficiency	True yield (output-input)	Input and cost: labour hours and wage, volunteer hours, fertility input, seeds, imported plants, tools, fuel/oil, irrigation, any investment in infrastructure	

		Output: income from yield (e.g. food & value products) and other activities (e.g. workshop)	
	Product energy/input energy ratio (EROI)		Labour hours, machinery, fuel/oil, electricity, irrigation, fertilizer (compost)
Governance	Collaborative participation	Number of collaborators involved in the project	
	Stewardship	Number of volunteers and volunteer hours	

3.6 Discussion

Our experience with developing the monitoring framework with the Galiano Conservancy Association provided a tangible local approach but also conceptual and practical considerations as to how the generic C&I might be interpreted and adapted in other settings.

3.6.1 Conceptual Considerations

At the heart of the discussion of how food forests can be monitored in the context of ecological restoration, a critical question was raised: How can the concept of ecological integrity be interpreted in a food forest system, in particular one that has a totally different plant community from plant communities of its landscape or a native plant community? Implementation in forest restoration involves the process of defining forests, which “reveal the qualities and trajectories of forests in a spatially and temporally dynamic landscape matrix,” and definitions influence how the forests are monitored and assessed (Chandon et al. 2015). Therefore, one might need to firstly define what kind of a system a food forest is or *aims to be*, and subsequently decide what attributes of ecological integrity will be most appropriate for the given food forest.

Is a food forest a forest or a food production system? The food forestry and restoration experts answered this question differently. Chandon et al. (2016) suggest, “forests are viewed, defined, assessed and valued through different lenses.” The authors describe how a forest can be viewed as, for example: an ecosystem to conserve biological diversity (UN Convention on Biological Diversity); a home for indigenous people who wish to continue their way of living (UN Permanent Forum on Indigenous Issues); an agricultural/agroforestry system (World Agroforestry Centre); a socio-ecological system that is managed to be resilient (stakeholder groups); or part of a multifunctional landscape (Global Partnership on Forest Landscape Restoration). Different views will be reflected in the goals and objectives of a given project, and the goals and objectives will influence "the relative importance of different aspects of forest state, dynamics, and landscape context," and definitions "should not be used for purposes beyond those for which they were intended" (Chandon et al. 2016). Therefore, a practical approach will be to closely examine the goals and objectives of the project and accordingly to decide definition(s) of the food forest that are most appropriate ecologically and socially.

How, then, will ecological integrity be defined in food forestry? Ecological integrity encompasses a range of ecosystem attributes from ecosystem health, biodiversity, ecological processes, native species, stressors, and resilience, to self-maintenance. These attributes are weighted differently to different restoration projects; as a result, interpretation of ecological integrity varies across social, ecological and environmental contexts. For example, a restoration project in a national park may apply a different definition of ecological integrity from one in a city (Andreasen et al. 2001; Ordóñez and Duinker 2012; Suding et al. 2015). Similarly, it will be important to define ecological integrity in a way that is most applicable and practical for the objectives and the scope of the food forest project while considering social, ecological, and environmental contexts. A clear definition of ecological integrity for the project will help the managers to project what a given food forest could do or could not do and to identify potential positive and negative impacts on ecological integrity of its landscape.

3.6.2 Practical Considerations

The usefullness of the generic C&I monitoring framework will vary across projects. Further refining, modification and clarification will be needed so as to meaningfully reflect the specific goals and objectives of a project and monitoring. First, the principle of social benefits and engagement may be too broad for a small-scale project that is only accessed by and only benefits a small number of people. Second, the principle of being informed by the past may be irrelevant or beyond the scope of some projects, although it was seen as important to the GCA due to the RFF project and their commitment to conservation and restoration. Third, the categorization of monitoring parameters can be changed according to their relevance to the principles. For example, stewardship is one of the criteria for monitoring long-term sustainability in the generic C&I framework; at the same time it is associated with the principle of enhancing social benefits and engagement. Last, as a food forest evolves, the goals and objectives of the food forest project may change over time as well as appropriate monitoring indicators (FF-4). Therefore, a monitoring framework should not be static; rather it can be refined, complemented or reorganized to reflect changes over time.

A project scale and landscape contexts affect the selection of appropriate landscape indicators. Many agroforestry projects are highly valued as buffers or ecological corridors that facilitate landscape connectivity and diversity (Atagana et al. 2014; Ricketts et al. 2004). Yet, if a food forest occupies a small pocket of a large forested landscape, one should decide how critical it is for the food forest system to facilitate the movement of species and genetic interchange and/or link various habitats. Further, if a food forest hosts a great abundance of non-native species, as with the GCFF, how beneficial it is to encourage the dispersal of species (ER-3)?

Wildlife indicator species can be useful for inferring biotic conditions of a system (ER-6). Selecting wildlife species indicators requires considerations of project's scale and landscape contexts and available resources for monitoring. Mobile species such as birds should be carefully chosen as indicators for a small-scale food forest project like the GCFF as monitoring results can be significantly influenced by co-variables of surrounding landscapes and forests (ER-6). Alternately, less mobile species could be used (ER-7). For example, forest-dependent indicator species (e.g. *Scarabaeinae* communities) were used for comparing biodiversity among monoculture, agroforestry and primary forest systems (Jose 2012; McNeely and Schroth 2006). Yet, such monitoring requires high levels of identification skills and equipment or may need a specialist.

3.6.3 Reference Systems for Food Forestry Monitoring

In ecological restoration, reference ecosystems are essential for setting goals and assessing the success of a project (Ruiz-Jaen and Aide 2013). Also, sustainable forest management compares reference values to evaluate and adapt actions in managing forest sustainability (Wright et al. 2002). If one decides that having reference conditions may be valuable for assessing a food forest and informing adaptive management, what reference ecosystems can be used?

A historic reference could be valuable if a project is intended to recover historic biological communities and functions in a site that does not exhibit significant change. However, use of "historically-determined references" is increasingly challenging in the wake of climate change, in particular where the abiotic conditions (e.g. soils, hydrology) have significantly changed and the systems are practically impossible to return to past parameters (Higgs et al. 2014; Keenleyside et al. 2012). Alternatively, reference sites of similar ecosystems "in the same life zone, close so the project" and "exposed to similar natural disturbances" can be used for comparison (Society for Ecological Restoration 2004). In tropical climates, traditional agroforests are often compared to natural forests in the same area in terms of structure, functions and habitat quality (Jose and Shanmugaratnam 1993; Jose 2012).

It is unknown how similar or different a temperate food forest will be to a natural forest in the same area or in the same climatic zone over time (FF-7; Rolim and Chiarello 2004). The restoration experts hypothesized that the GCFF would exhibit different functions and habitat quality given different composition and structure of the neighbouring forests (ER-1; ER-6). At the management level, one will have to decide how essential it is for the project to have a food forest that is similar to late-successional forests, and how much of difference to natural mature systems is acceptable, considering that the food forest is providing valuable benefits that other systems do not provide (ER-6).

A mature, functioning food forest in the same area or in a similar climatic zone could serve as a reference ecosystem. In restoration, when the goal is to bring back a cultural landscape, a cultural ecosystem often guides management and monitoring as a reference. The mature food forests can be particularly useful for estimating how much maintenance, irrigation, fertilizer, and/or productivity changes over time, which may guide setting targets and measuring the progress.

Nevertheless, these reference ecosystems may not be replicas of what an individual food forest project tries to achieve; instead, they "provide a broad picture of likely ecosystems and inform the identification of key attributes and target ranges of desired outcomes" (Keenleyside et al. 2012). Selecting multiple reference sites is encouraged to include variations in the desired ecosystem attributes and outcomes (Ruiz-Jaen and Aide 2013). The GCA is interested in monitoring a similarly-aged regenerating forest where no management is taking place as a control site and an unmanaged mature forest ecosystem as a reference or target "natural" system against which to compare the food forest sites, by using most of the same ecological integrity indicators. The GCA's food forests will themselves be ongoing experiments, demonstrating how food forests in temperate climates may contribute to restoration while achieving social benefits and sustainability.

3.7 Conclusion

The generic C&I monitoring framework aims to be comprehensive and systematic. The four principles of restoration on which it is based (Suding et al. 2015) encompass a wide range of human values and address tensions between past and future and between ecological integrity and human benefits. Transparent linkages among the parameters of the hierarchy make it easy to select the criteria, indicators or measures that are related to the goals and objectives of a food forest project. We propose that the framework be applied and refined carefully and deliberately to achieve specific management objectives of a particular food forest project. Before determining monitoring indicators and measures, therefore, one needs to clearly examine the goals, objectives and scale of the projects and assess environmental, ecological and social landscape contexts. At the same time, a monitoring framework should not be static; it should be refined, complemented, or reorganized to reflect changes over time as a food forest project evolves.

Considering resources available for monitoring is important. Monitoring requires different skills, knowledge, equipment and time. Evaluating resources needed for employing a specific measure and the current capacity of an organization to employ measures will help to determine most efficient and effective measures in a particular circumstance. Learning from the GCA' case, we recommend including optional measures in a monitoring program, which can be employed in the future or through research collaboration as time and opportunities permit. Selecting evaluation measures out of over 100 possibilities can be challenging and may involve a series of conversations, modifications, and/or adaptations. We hope the generic C&I framework be tested and enhanced in the future.

3.8 Acknowledgements

We thank all interview participants and representatives from the Galiano Conservancy Association for their guidance, insight and support. We also thank the School of Environmental Studies at the University of Victoria, the Sara Spencer Foundation, and the Social Sciences and Humanities Research Council for financial support.

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Online Resource 3.10 A Generic C&I Monitoring Framework for Food Forestry: 4 principles, 14 criteria, 39 indicators and 109 measures. Measures in italics are those used more than once.

Principle 1 Ecological integrity		
Criterion (6)	Indicator (18)	Measure (53)
Integrity of the biotic community	Plant diversity (species and structure)	Species richness and its cover (%) of each structural layer (including invasive species)
		Native species richness and its cover
		Tree (10m+) density (number of stems per unit area)
		Abundance of invasive species in the neighbouring area
		What species people bring in and out from the site
		Tree and shrub species and cover
		Vegetation cover (%) in each structural layer (e.g. herbaceous, shrub, tree canopy)
		Dominant species and its cover of each structural layer
		Biomass distribution among different canopy layers
	Trophic structure (food web/chain) from decomposers, invertebrates to birds	Insect species diversity (especially, pollinators, *Scarabaeinae, Carabidae*) Amphibian diversity (e.g. frogs, salamanders) and behaviour (e.g. reproduction, migration, health) Bird diversity and behaviour (e.g. nesting)
	Regeneration and reproduction	Percentage & number of seedlings (DBH<5 cm) and saplings (5-10 cm)
Habitat quality	Habitat structural diversity	Volume of coarse woody debris, small woody debris, and snags Quantity of leaf litter
	Landscape connectivity	Area (% of site) of roads and footpath Abundance of invasive species in the neighbouring areas which escaped from the food forest
Ecological processes	Productivity	*Biomass (allometric equations: dbh and species)* *Basal area (tree growth rate)* *Tree survival rate*
	Carbon sequestration	*Biomass (allometric equations: dbh and species)*

		Soil organic carbon
	Succession	Repeat photography or video recording Tree diameter/age class Biomass and composition of dung beetles (*Scarabaeinae*) communities e.g. *Aphodius fossor* (*Linnaeus*) or old-growth forest species Percentage of stand in gaps of various sizes and ages
	Nutrient cycling	Presence of mycorrhizal mushrooms *Soil microbial biomass* Soil organic matter Annual rates of decay Nutrient loading in the landscape (closed-loop nutrient cycling)
Soil	Physical characteristics	Composition (% of sand, clay, silt, rock) Compaction (soil bulk density)
	Biological characteristics	Ratio of bacteria & fungi Signs of arbuscular mycorrhizae colonization *Soil microbial biomass* Species richness and quantity of mycorrhizal fungus Species richness and/or weight of earthworms Species richness and abundance of invertebrates Species richness and quantity of bacteria
	Chemical characteristics	Soil pH Indicator species Nutrient availability (e.g. nitrogen, phosphorous, calcium)
	Soil erosion	None or less than 5 % exposed soil including roads/paths (or more than 95 % vegetation cover)
Hydrology	Water storage and flow	Soil moisture (indicator species or a probe) Water recharge Signs of water logging Infiltration rate Water stress

	Water quality	Signs of eutrophication (e.g, algae)
Disturbance	Disease and pest	Use of organic spray for pest control *Areas disturbed by pest and disease (e.g. leaf damage, plant mortality) in neighbouring areas* *Areas disturbed by pest and disease (e.g. leaf damage, plant mortality) within a food forest*
	Environmental factors	*Frequency and intensity of drought, storm, flooding, fire*
	Herbivory	Frequency of most browse-sensitive species

Principle 2 Informed by past and future		
Criterion (2)	Indicator (3)	Measure (10)
Historical knowledge	Historical biological community or processes	Pollen cores Native species richness and its cover
	Traditional and/or local knowledge of the forest	Level of traditional and/or local knowledge for classification, identification, and use of plants (and for land management)
Anthropogenic changes	Weather patterns	Temperature Precipitation Wind Solar radiation Length of the growing season Frequency and intensity of drought, storm, flooding, fire Experiment to climate change: 80% for the current climate, 10% for colder and 10% for warmer or (drier, wetter)

Principle 3 Social benefits and engagement		
Criterion (3)	Indicator (10)	Measure (33)
Cultural values and social equity	Food security (high quality, reliable, affordable food for a community)	Destination of products and food produced (local or non-local) Nutrition value (visual scan of nutritional value) Absence of toxic chemicals
	Local community access to forest-related	Disabled access Number of people using resources for their livelihood

	livelihood opportunities	(including non-timber forest products) Number and volume of sales and permits awarded to local farms
	Cultural identity and spiritual values	Aboriginal participation Culturally important species used Area and percent of forests managed primarily to protect the range of cultural, social and spiritual values (e.g. space for local gathering and connecting groups)
	Life quality of a farmer and a family	Wage, income rates Satisfaction/enjoyment from work Farmer's health Farmer's participation in local activities Access to social services
Economic benefits	Yield	*Income from yield (e.g. food, value-added products) and other activities (e.g. workshop)* Total annual quantity (e.g. weight or volume of each crop) Number of visitors and what they ate Proportion of crop varieties in total production
	Employment	Number of jobs created Number of staff and wage Number of community residents employed by the project
	Local business (broader spin-off)	Local business created by the project (e.g. herbalists/honey production/mushrooms) Detailed listing of primary project partners Bed night (number of visitors staying due to your project)
	Contribution to the community	Amount or monetary value of yield donated to the community
Outreach, education and	Acquisition of knowledge and skills	Number of education and outreach events Number and demographics of visitors: age (*youth &

training		senior), locality, ethnic, level of knowledge, interest Number of hours invested in education, training, project implementation, monitoring for youth and locals Number of certification provided Feedbacks from participants What or how participants contribute to their community
	Research and science	Number of research/education and individuals studying the system (including nature of research) Investment ($) in research

Principle 4 Long-term sustainability		
Criterion (3)	Indicator (8)	Generic measure (17)
Resilience & stability	Prepared and resilient to extreme weather	Crop failure after extreme weather events (e.g. drought) Consistent mulching (no bare soil)
	Self-regulating (in the absence of maintenance)	Outbreaks of disease Areas disturbed by pest and disease (e.g. leaf damage, plant mortality) within a food forest
	Functional diversity	Evenness in abundance of nutrient-cycling microbs (fungi, nitrogen-fixing bacteria, ammonia-oxidizing bacteria)
Economic self-sufficiency	True yield (output-input)	Input and cost: labour hours and wage, volunteer hours, fertility input, seeds, imported plants, tools, fuel/oil, irrigation, any investment in infrastructure *Output: income from yield (e.g. food & value products) and other activities (e.g. workshop, consultation)* External fund (e.g. donation, in-kind contribution)
	Product energy/input energy ratio (EROI)	Labour hours, machinery, fuel/oil, electricity, irrigation, fertilizer (compost)
Governance	Collaborative participation	Number of collaborators involved in the project (e.g. networks, farmer's markets, community organizations, suppliers, outlets) Satisfaction with public involvement process
	Continuity in	Ownership/tenure

management	Monitoring Number of workers trained and type of training provided
Stewardship	Number of volunteers and volunteer hours Number of training hours What or how participants contribute to a project after partaking in educational programs

Chapter 4: Conclusion

4.1 Summary of Research Findings

Inspired by the Galiano Conservancy Association's food forest projects, this research was conceived for two reasons: first, to investigate how emerging food forestry may contribute to ecological restoration; and second, to develop monitoring indicators that help to assess how effectively a food forest contributes to ecological restoration. The four restoration principles—ecological integrity, informed by past and future, social benefits and engagement, and long-term sustainability (Suding et al. 2015)—were a valuable guiding tool in considering food forestry and monitoring in the context of ecological restoration.

The Chapter 2 has five key findings. First, both food forestry and ecological restoration aim to restore sustainable systems, by optimizing ecological processes that benefit people and other species. Second, differences may exist in prioritization on social benefits and native species, management intensity and continuity (including succession management) and habitat value. Yet, these differences are site-dependent and can be fuzzy. Third, urban food forestry may serve as an innovative restoration model to restore forest functions and improve biodiversity, the quality of human life, and human-nature connections in urban landscapes that are undergoing significant change. Fourth, the comprehensive restoration principles and resilience thinking can provide conceptual guidelines for restorative food forestry. Last, the findings require further examinations of relationships among food forests, urban resilience, and urban landscapes, followed by a thorough assessment and long-term monitoring of food forests.

The Chapter 3 has three key findings. First, it is important to clearly define goals, objectives and scale of a given project and to assess landscape contexts before building a monitoring program and/or determining reference sites and values. Second, the capacity and resources for monitoring within an organization are a determining factor, but limited resources can be overcome by seeking research collaboration. Last, we propose that the generic Criteria and Indicators framework be applied and refined carefully and deliberately to achieve specific management objectives of a food forest project, and the framework may change over time to reflect changes in management as a food forest evolves.

4.2 Overview

Needs for forest restoration and food security are two of pressing global challenges in the wake of climate change. In this context, whether food forestry can serve a tool for ecological restoration or not is a fascinating question. It invites flexible, integrated thinking in both ecological restoration and food production. At this point, I am cautious to confidently conclude emerging food forestry is a type of ecological restoration. Yet, answers will vary case by case. Food forests will continue to evolve as people design, redesign and adapt over time. Burgeoning food forests are living experiments, which allow us to explore how we might combing restoration efforts and agriculture and forestry and more broadly how we responsively design, interact and evolve with our landscapes.

Higgs (2003) wrote in Nature by Design: "ecological restoration as a design discipline demands attention to tradition and novel at the same time, searching creatively… for the best way to respect ecological and cultural integrity." Thinking of food forestry in the context of ecological restoration provided me with an invaluable opportunity to think how we might bridge tradition and novel, and ecological integrity and cultural integrity while moving toward a sustainable and resilient future.

4.3 Limitations of this Research

The Chapter 2 does not conclusively demonstrate contributions of emerging food forestry to ecological restoration. Instead, the findings suggest how and in what context food forestry may contribute to restoration. The in-depth, semi-structured interviews were found to be effective in deeply delving into the relationships between food forestry and restoration from various aspects based on empirical knowledge and experiences while allowing generous room for exploring and expanding topics that are important to individual informants. Yet, the findings should be tested by a systematic, quantitative assessment of multiple sites. I hope that other researchers and practitioners will draw on the study results for further research and experimentation.

A larger sample size for the interviews than the one I had may have helped to explore more diverse views and experiences in food forestry and ecological restoration. The food forests shared some commonalities; at the same time each food forest is unique in its objectives, ownership, primary users and landscape contexts. This is the same for ecological restoration projects. Fortunately, all food forestry experts that I interviewed also design, teach and practice consultation in other projects, and their views were well informed on the varying goals and types of food forests. The restoration informants also had local and international experiences in ecological restoration and a good knowledge of food forestry. Personally, other activities were very helpful for me to attain a first-hand appreciation of food forestry including: visits to the informants' food forests and others, informal conversations with volunteers and participation in food forest training, consultation meetings and work parties.

There are other techniques for selecting and evaluating monitoring indicators such as scoring, ranking and pair-wise comparison. Many studies employed quantitative methods or both quantitative and qualitative methods. I used a qualitative method (semi-structured interviews and content analysis) because of a lack of existing monitoring frameworks for food forestry in the context of ecological restoration. Content analysis allowed me to collect a wide range of indicators and measures that are related to food forestry and restoration both from literature resources and the interviews. The incorporation of quantitative methods could increase transparency and objectivity of the process of selection and could further refine the generic C&I monitoring framework.

In this work, the C&I monitoring frameworks are conceptually embedded within the restoration principles because my goal was to develop the framework that facilities an assessment of food forest projects in the context of ecological restoration. Yet, a restoration informant suggested it would be interesting to build a monitoring framework based on the food forest model that was developed from the first study (Chapter 2). I understand that, in some or many cases, the restoration principles may not be directly relevant to broader food forestry. Instead, the common goals and characteristics structuring the food forestry model may serve as a conceptual foundation that is more relevant and customized to food forestry. Yet, at this point, it is unknown how much difference this change would make in actual practices.

Writing the two articles as part of a thesis helped me to produce a tightly focused analysis. Yet, the compact nature of journal articles limited some of the context and background research that I could extensively report. They include different views among the informants on including native and non-native species among the informants (Appendix B) and other potential benefits (e.g. agricultural land) and challenges (e.g. shifting baseline syndrome, lack of data, restoration culture in North America) of incorporating food forestry into ecological restoration.

4.4 Suggestions for Future Research

Many research opportunities await, including: inventory of food forests in temperate-to-cold climates; systematic monitoring of their effects on ecological integrity (e.g. wildlife, biodiversity, soil microbiology, soil organic matter), ecosystem services (e.g. carbon sequestration, flood control), socioeconomic benefits (e.g. food security, diversity and productivity; income; education) and resilience (e.g. functional diversity in plant communities). Moreover, to meaningfully assess relationships of food forestry to restoration, the future research should employ quantitative comparisons of specific food forest projects and forest restoration projects in similar landscape contexts and at similar ages.

At the time of writing, information on emerging food forestry in the forms of unpublished documents, reports and anecdotal accounts was more prevalent and easily accessible than formal peer-reviewed papers, which was emanated from individual websites, blogs, and magazines. My experience in working with anecdotal information, perspectives, and knowledge that the interviewees generously shared with me, and my personal experience in different food forests raised a question: how can these different types of wisdom be best incorporated into academic or scholarly study? In other words, how do we bridge the gap between the realms of scholarly and practitioner knowledge? This question is being asked in many other contexts as well, from fisheries management to developing conserved and protected areas.

Last, my master's research project has left me fascinated with the intersection between food forestry and urban ecological restoration, inspiring me to explore urban food forestry as an integrated approach to enhancing social-ecological resilience of urban landscapes. I am hoping to carry on my journey with food forestry in a PhD program by asking: How effective is urban food forestry in enhancing the social resilience of urban communities in British Columbia?

Appendix A: Overview of the Participants' Food Forests

Participant	Name/Location/ year/size/type	Goals	Characteristics	Note
FF-1	Garden Cottage Coldstream, Scotland 1991/ 0.25 acre/ homegarden	Biodiversity	300 species Mixture of dense & open woodland	Recording invertebrates, fungi, plants, trees, and birds
		Yield production with less work	Produced 1.3 metric tons of food in 2014 Sold 5,000 plants incl. 500 trees Working average two days per week	
		Demonstration and education	Workshop, tour	
		Happiness	Food forestry is "leisure" rather work	
		Carbon sequestration	Little tillage and bare soil	
FF-2	Dartington, England 1994 /2.1 acre Commercial	Research, demonstration, and education	Research with a local university (e.g. bird and soil invertebrate surveys)	Higher richness and evenness of soil invertebrate taxa
		Diversity of species and structures	550 species (80 tree species, 100 shrub) 50% tree canopy cover	
		Carbon sequestration	Limited tests on soil organic matter: similar to one of a same-aged native forest	
		Supplementary income	Nursery, tour, workshop	
FF-3	Cottage Grove, U.S. 8 years/1 acre/ Homegarden	Food production	Extra yields for commercial sale and donation	Part of an edible, multifunctional landscape of 7.5 acres
		Demonstration and education		
		Beauty		
		Feeding wildlife		
FF-4	Cottonwood Community Garden	Ecological justice	Created from an illegal waste dump in a poor urban neighbourhood with high immigrant population	Voluntarily managed by (e.g. artists,

	Vancouver, Canada /1991/3 acres/ public Means of Production Vancouver, Canada/2002/ approximately 0.5 acres/ public	Active human-nature relationship Eco-cultural edges	Providing a green space including 150 garden plots for food production Growing food and *materials for paper, basketry, instrument, and medicinal plants, etc. (Means of Production Garden) Sharing cuisines and recipes of different cultures Habitat for species dependent on a mosaic of successional stages	neighbours, homeless) who use the garden
FF-5	Wheatstone House England 2011/ 2 acres/ homegarden for multiple households	Food production	Integrating different food production practices in a seven-acre land based on permaculture principles. Kitchen garden & semi-wild ones in the woodland and wetland An acre of orchards is slowly being diversified	Co-managed by three households
FF-6	Paradise Lot Holyoke, U.S. 2004/0.1 acre/ homegarden	Diverse food Maximum production season Supplementary income Carbon sequestration Demonstration	300 species May to December Workshops, tours, internship, writing, nursery Soil organic matter increased from 2.4% to 9% over 12 years 50% area for native species Resembling tropical homegarden incorporated with annual crops and chickens	Recording bird richness (e.g. migratory birds whose typical habitats are a forest are observed)
FF-7	Dragon's eye Grand Forks, Canada 1984/3 acre /homegarden	Biodiversity Soil building for future generations Beauty	Community genetic gene pool Resilient to severe weather events e.g. no crop failure of pear and apple for the 20 years For inspiration, health, collaboration	Allegedly first food forest in Canada

		Diverse, high quality food	Produced 80% of food consumed	
		Supplementary income	Medicinal herbs, consultation	
		Demonstration and education	Housing and community designs	
FF-8	Florida, U.S. 2010 / 3 acres / commercial/homegarden for residents	Diversity of food	For people living on the farm	
		Supplementary income	Food sales, Air B&B	
		Demonstration and education	Internship	
Galiano Conservancy Association	Galiano Community Food Forest Galiano Island, Canada 2015/ 0.2 acres/ commercial	Food production and food security	Feeding participants in their events Selling food locally Food donation	
		Community engagement and education	Workshop, research	
		Sustainable social enterprise model	Income	
		Ecological integrity	A secondary goal, integrated in the overall conservation planning	

Appendix B: Participants' Views on Native and Non-native Species

Participant views	Example summary	Examples
Functional, edible or cultural native species	Ecocultural restoration Riparian buffer	"Our native forage forest is like true ecocultural restoration…We are adding back in element of ongoing management of the site. And, we are gonna base it on traditional ecological management."(ER-2) "I also planted a food forest at the riparian buffer… and all species are native. That's really more of ecological restoration with a bit of food forestry rather than food forestry with a bit of ecological restoration." (FF-6)
Native only with limited exceptions	Native species are restoration target Limited acceptability of using non-natives Possible cumulative impact of introduced species, leading to total change of the system Climate change does not justify use of non-native species that is not sufficiently studied.	"I don't think that use of non-native is very often acceptable in restoration. I think it has got limited acceptability in terms of cover crops for initiating ecological processes." (ER-4) "It's not the process itself of introduction but the relative intensity and speed of introduction that is the problem. And also the number of species involved. It happens in such a rate, speed, and intensity, that the entire ecosystem can get changed totally." (ER-8) "I am certainly a native species advocate for any of restoration work that we do and we rather stick with native species… Obviously with climate change we are beginning to see shift in plant communities. I still think we don't know enough about that to gamble and begin to plant species that aren't in our range in certain areas until we know more." (ER-1) "One of the problems with assuming that non-native species are going to fill those roles is that we may be interfering with natural ability of native populations to make changes in terms of their gene pool, and they are probably still the

		best choice because they are from this area." (ER-7)
Native species first and non-native optional to fill the gap - and/or eventually reduce non-natives	Native species first and non-native optional to fill the gap and/or eventually reduce non-natives	"I am not a strictly purist native species person. When I am restoring, I look to ecological functions of particular plants… In restoration we need to think about those changes. That's why returning the site to a historical condition will be equally challenging because the historic conditions have a different climate. It's not gonna be the same. As well as have been influenced by invasive species over 150 years. We need to adapt to what is suitable for the site and perform the function required. Huge challenge." (ER-5) "I think there is room for both sides. Pull towards the middle. Let's not just dig into eucalyptus but on the other hand let's not talk about historical baseline…Let's start with the native species first and then just see if we need to plant other things. Would be idea that we eventually we may think about trying to reduce those [non-native]." (ER-6)
Functional native and edible non-native (non-invasive)	Native species good for native birds and pollinators and for humans Native plants may not be always tasty Use of functional, non-invasive edible plants for human and wildlife Benefits of using native species in a food forest: learning local ecology, site history, cultural history, local species	"You can use native edible trees. It's not a black and white situation with native plants. At least in Florida, most of native trees are useful. People have been using them forever." (FF-8) "They [native gardeners] are criticizing us for not having enough native stuff and we can criticize them for not producing food that we all have in common and useful native plants. It makes a lot of sense to start there… At home, half of species are native species. That's what I challenge people to do in a food forest. Planting native species. And certainly our native pollinators and birds are delighted at the habitat we provide in my garden." (FF-6) "It's a little artificial that way because if you accept the premise that people are part of ecosystems and people have always participated

		in bringing in species here and there. First Nations trade crops; the distance and intensity different from now. Degree and individual characteristics of introduced species matter." (ER-8) "My argument is that can we live only on native plants alone? No. Let's put in functional, non-invasive food plants for humans and wildlife in a restoration area. That is my interest, and it is a hard-sell to a lot of restoration because that's not how they were trained." (FF-3)
Diversity of all species	Distinction is in flux and nuanced Climate change Do not neglect native species Zoning or leaving a reservoir for native diversity or demonstration	"Distinction between native and non-native or useful or not useful is very much influx… What's native? A lot of things native now were not native thousands years ago. We need to be mindful of the bigger context of changes on the planet. We are about to experience extreme change in coming decades. What's going to be native? What if only best chances of keeping in front of that change is to plant things are not native at all but will be with the new conditions. We can't get stuck in the way things are." (FF-8) "This discussion of native versus exotic is more nuanced. We talked about how these systems are quite sustainable and not necessarily invasive but maybe there will be some plants from Europe, Asia, maybe combination of plants, animals and peoples." (FF-4) "Food forestry does not necessarily exclude native species. We can still have quiet a bit of native species in the food forest system… It does act as a gene reservoir." From my perspective, we need to both… I think part of difficulty with definition between native and non-native is it is extremely hard to define because species move either the help of other creatures or people. So what native may have been once becomes non-native. And non-native becomes native. I

		guess I will put it into what is useful." (FF-7) "All the time when I am teaching I try to get people stop thinking about plants being good or bad… It's not for us to decide… These things all have place in nature." (FF-1)

Appendix C: A Preliminary Criteria & Indicators Monitoring Framework (Response Instrument)

Principle 1	**Ecological integrity**				
Criterion	Biodiversity	Function	Stressor	Landscape	Soil
Indicator	Species richness and abundance	Functional diversity	Chemical contamination	Landscape connectivity	Soil physical conditions
Measure	Number of plant species and its cover	Evenness of the distribution of abundance in niche space	Water nutrient load and contamination (landscape)	Sediment or nutrient load to downstream	Water-holdin g capacity
	Number of native forest associated species	Presence of functional groups necessary for longterm stability	Topsoil heavy metal content	*Abundance of invasive species in neighbouring areas*	Top soil depth
	Abundance or behaviour (e.g. foraging or nesting) of bird species (incl. insectivorous)			*Saplings/Seedlin gs of Native Woody Species*	Soil bulk density (soil compaction)
Indicator	Habitat	Productivity	Herbivory	Landscape diversity	Infiltration rates
Measure	Amount/volume of coarse woody debris and snags	Biomass	Frequency of most browse-sensitiv e species	Forest patch size frequency distribution for each seral stage and community type and across all stages and types	Soil pH
	Quantity of leaf litter and SWD	*Basal area (Tree growth)*			
	Wild species indicator for habitat quality	Tree mortality (rate) or survival rate			
Indicator					**Soil fertility (nutrient**

					cycling)
Measure					Soil organic matter
					Nitrogen, phosphorous, potassium
					Signs of arbuscular mycorrhizae colonization
Indicator	Trophic structure (e.g. food web/chain)	Carbon sequestration &cycle	Disease and pest		Soil organic carbon
Measure	Invertebrate richness and abundance (e.g. pollinator and decomposers)	Avoided fossil fuel carbon emissions by using forest biomass for energy	Area forest disturbed by pest and disease		Earthworm species and count
	Abundance of nests of social bees	Soil organic carbon	Leaf greenness		Soil salinization
			Leaf damage		Ratio of bacteria & fungi
Indicator	Structural diversity	Regeneration and reproduction			Soil erosion
Measure	Vegetation cover of forest structural layer (e.g. herbaceous, shrub, tree)	Percentage & number of saplings and seedling			Percentage of ground covers
	Woody plant density (number of counting per unit area)	*Saplings/Seedlings of Native Woody Species*			Area and percent of forest land with significant

			soil degradation
	Vegetation type and structures similar to the historical condition and total forest area		Litter movement
	Basal area		Plant basal gap intercepts (runoff resistance)
			Signs of waterlogging
Indicator		**Succession**	
Measure		Insect indicators for succession e.g. dung beetles	
		Percentage of stand in gaps of various sizes and ages	
		Tree diameter/age class	
Indicator	Invasive species	Organic Matter Decomposition	
Measure	Abundance of invasive species	Annual rates of decay	

Principle 2	**Informed by past and future**	
Criterion	Historical Knowledge	Anthropogenic changes
Indicator	Use of (knowledge of) historic biological community and processes	Climate change

Measure	Use & recognition of traditional knowledge (the basis for local decision-making)	Temperature
	Abundance and richness of native species	Precipitation
		Length of the growing season
		Extreme weather events: drought, storm, flooding
Indicator	Traditional knowledge of the forest	Other anthropogenic activities
Measure	Level of knowledge of the classification, identification, usage and ecology of plants	

Principle 3	**Social benefits and engagement**			
Criterion	Cultural values and social equity	Economic and livelihood benefits	Outreach, Educ. and Training	Collaborative Participation
Indicator	Local community access to forest-related livelihood opportunities (incl. nontimber forest products)	Yield	Research and science	Stewardship
Measure	Equality in food and income distribution (and awareness of benefit sharing)	Total annual quantity (e.g. weight, volume) of certain species harvested	Interpretation, education, and research participation (e.g. number of contacts by type)	Number of volunteer days or volunteer hours
	Disabled access	Quality of food and raw materials (e.g. sugar contents)	Investment in research	Number of individuals involved in stewardship activities

	Number of people using resources	Monetary value of products		Number of training hours
	Number and volume of sales and permits awarded to local farms	Yield per hectare (appropriate area size)		Monitoring Donation, in-kind contributions
Indicator	Quality of farmer's life	Product diversity	Acquisition of knowledge and skills	Governance and community engagement
Measure	Wage, income rates	Proportion of crop varities in total production (for each crop)	Number of youth and number of hours spent in education, training, project implementation, monitoring	Satisfaction with public involvement process
	Access to social services	Number of crop varieties and livestock breeds	Number of workers trained and type of training provided	Number of collaborators involved in the project
	Farmer's health		Count of certification provided	Individuals and stakeholders involved/represented and what objectives are to be achieved by each stakeholder
	Farmer's participation in local activities		Numerical count of education programs/outreach events aimed at local leaders	
Indicator	Recreation	Employment		
Measure	Recreational	Wage, income rates,		

	opportunities created Number, type, and geographic distribution of visits attributed to recreation and tourism Aesthetic recovery and solitude Recreation visitor day Recreation user satisfaction	injury rates Number of community residents employed by project
Indicator	Cultural identity and spiritual values	Viability/profitability of the farm
Measure	Area and percent of forests managed primarily to protect the range of cultural, social and spiritual needs and values (i.e. space for local gathering and connecting groups) Culturally important species used Aboriginal participation and values	Net farm income Farm real estate values Benefit–cost ratio (BCR) of production
Indicator	Food security	Local business

Measure	Nutrition value of food crops	Number of Local business created by project
	Sugar contents	Detailed listing by primary project partners
		Identification of businesses related to project that have been created or helped and monetary benefit (profit) related to project.

Principle 4	**Long-term sustainability**	
Criterion	Resilience & stability	Self-sustainability
Indicator	Functional redundancy	Irrigation and groundwater
Measure	Presence of functional groups necessary for long-term stability	Depth of the ground water table
	Number of species within a given functional group	Water use economic efficiency (Yield per "kilolitre of irrigated water)
		Water use technical efficiency (Income per kilolitre of irrigated water)
		Water stress
Indicator	Genetic diversity	Product energy/input energy ratio (EROI)
Measure	Ecologically effective population sizes	Labour hours, machinery, fuel/oil, electricity, irrigation, fertilizer (compost), etc.
	Population levels of selected representative forest associated species to describe genetic	

	diversity Number and geographic distribution of forest associated species at risk of losing genetic variation and locally adapted genotypes	
Indicator		Financial self-sufficiency Ratio of Farmer's income and cost of off-farm or non-renewable inputs

Appendix D: List of Participants

Interview participants					
Code	**Name**	**Gender**	**Region**	**Affiliation**	**Date interviewed**
ER-1	Bowers, Keith	male	U.S.A	Biohabitats Inc.	10 February 2016
ER-2	Erickson, Keith	male	Canada	Galiano Conservancy Association	13 January 2016
ER-3	Hebda, Richard	male	Canada	Royal BC Museum	15 January 2016
ER-4	Higgs, Eric	male	Canada	University of Victoria	26 November 2015
ER-5	Munson, Thomas	male	Canada	City of Victoria	4 December 2015/ 19 December 2015
ER-6	Anonymous	female	Canada	University of British Columbia	10 February 2016
ER-7	Schaefer, Valentin	male	Canada	University of Victoria	10 December 2015
ER-8	Turner, Nancy	female	Canada	University of Victoria	5 January 2016
FF-1	Bell, Graham	male	Scotland	Garden Cottage	7 December 2015
FF-2	Crawford, Martin	male	England	Agroforestry Research Trust	30 August 2015/ 4 January 2016
FF-3	Hobbs, Jude	female	U.S.A	Cottage Grove; Permaculture Institute (USA)	8 January 2016
FF-4	Kellhammer, Oliver	male	Canada	Parsons School of	11 December 2015/ 7 June 2016

				Design	
FF-5	Remiarz, Tomas	male	England	Green Land Services	22 December 2015
FF-6	Toensmeier, Eric	male	U.S.A	Perennial Solutions	21 December 2015
FF-7	Walker, Richard	male	Canada	Silvermoon Food Forest	2 December 2015
FF-8	Yanez, Mario	male	U.S.A	Earth Learning	7 December 2015/ 29 December 2015

Galiano Monitoring Workshop participants

Name	Gender	Affiliation	Date
Bourne, Cedana	female	Galiano Conservancy Association (GCA)	26 February 2016
Erickson, Keith	male	GCA	26 February 2016
Higgs, Eric	male	University of Victoria	26 February 2016
Hoffman, Terry	male	GCA	26 February 2016
Kramer, Moritz	male	GCA	26 February 2016
Jacobson, Eric	male	GCA	26 February 2016
Jarvis, David	male	GCA	26 February 2016

Appendix E: Sample Interview Questions

Article #1: Exploring the potential of food forestry to assist in ecological restoration	
Questions for the food forestry experts	
Ice-breaker	a. Would you like to tell me how you get involved in food forestry and about your food forest (or forest garden)? b. How long have you been involved in food forestry? c. What do you find so valuable in your food forestry?
Main questions	a. What are goal and key characteristics of your food forests? b. The food forestry diagram is designed to articulate pivotal goals and characteristics of food forestry, which distinguish food forestry from other land management practice and highlight the benefits of food forestry. This model will help restoration ecologists and other scientists to understand what is food forestry in general. Based on your experience in food forestry, how well do you think the model represents food forestry? What is missing? How would you improve this model? c. What are similarities and differences between restoring a forest and creating a food forest? d. In your experience in food forestry, do you think food forestry restores a social or ecological system? Do you consider your practice as a type of restoration? e. What are the potential benefits and risks when restoration integrates with food forestry? f. In what ways do you think restoration approaches and knowledge might contribute to food forestry?
Emerging questions	a. How do food forestry and restoration mutually benefit each other? b. A food forest can be relatively similar to a natural forest system in terms of its structures and functions but compositions can be very different. Here we can talk about using native & non-native species. What is your view? c. How do you distinguish a food forest, forest garden and alley-cropping system?
Questions for the ecological restoration experts	
Ice	a. You have been involved in restoration for a while. Could you tell me about your

-breaker	work and what motivated you to get involved in restoration? How long? b. Have you been involved in or heard of restoration projects that aim to restore or enhance food production? Have you heard or seen a food forest (or forest garden)?
Main questions	a. The model #1 is designed to articulate overarching goals and characteristics of food forestry that distinguish its practice from other land management practices. My hope is that this model helps restoration ecologists and scientists to understand what food forestry aims to achieve in general. How does the food forestry model #1 help you to understand food forestry? b. What are the similarities and differences between food forestry and restoration? c. In your experience in restoration, have you seen any food production practices like food forestry that has restored an ecological and social system? What's your thought on integrating food forestry in restoration? d. What are the potential benefits and risks when restoration integrates with food forestry? e. In what ways can restoration approaches and knowledge contribute to food forestry?
Emerging questions	A food forest can have relatively similar structures and functions to its neighbor natural forest. But compositions can be very different. Meanwhile, climate change is challenging our traditional ways of restoration and conservation focused on certain species composition. Here we can talk about using native & non-native species. What is your view?
Article #2: A Criteria and Indicators (C&I) Monitoring Framework for Food Forestry Embedded in the Principles of Ecological Restoration	
Questions for the food forestry experts	
Main questions	a. What do you measure to assure that your goals are met? b. If anyone is willing to monitor your food forest for you, what will you want to know over time? c. When a food forest is housed in an ecologically important forest landscape where people value native species and traditional culture, what criteria and indicators do you think are most important, and what are most effective and practical measures for

	a food forest. What do you recommend to measure for the Conservancy?
Emerging questions	How do you know if your food forest is resilient?
Questions for the ecological restoration experts	
Main questions	What are important monitoring indicators and criteria for the Conservancy to consider?

Appendix F: Certificate of Approval

University of Victoria | Office of Research Services | Human Research Ethics Board
Administrative Services Building Rm B202 PO Box 1700 STN CSC Victoria BC V8W 2Y2 Canada
T 250-472-4545 | F 250-721-8960 | uvic.ca/research | ethics@uvic.ca

Certificate of Approval

PRINCIPAL INVESTIGATOR:	**Hyeone Park**	**ETHICS PROTOCOL NUMBER** Minimal Risk Review - Delegated	**15-233**
UVic STATUS:	**Master's Student**	ORIGINAL APPROVAL DATE:	11-Aug-15
UVic DEPARTMENT:	**ENVI**	APPROVED ON:	11-Aug-15
SUPERVISOR:	**Dr. Eric Higgs**	APPROVAL EXPIRY DATE:	10-Aug-16

PROJECT TITLE **Food forests on Galiano Island as a restorative approach: How can we assess food forests?**

RESEARCH TEAM MEMBER None

DECLARED PROJECT FUNDING: **SSHRC CGS Masters; Sara Spencer Foundation Research Award**

CONDITIONS OF APPROVAL

This Certificate of Approval is valid for the above term provided there is no change in the protocol.

Modifications
To make any changes to the approved research procedures in your study, please submit a "Request for Modification" form. You must receive ethics approval before proceeding with your modified protocol.

Renewals
Your ethics approval must be current for the period during which you are recruiting participants or collecting data. To renew your protocol, please submit a "Request for Renewal" form before the expiry date on your certificate. You will be sent an emailed reminder prompting you to renew your protocol about six weeks before your expiry date.

Project Closures
When you have completed all data collection activities and will have no further contact with participants, please notify the Human Research Ethics Board by submitting a "Notice of Project Completion" form.

Certification

This certifies that the UVic Human Research Ethics Board has examined this research protocol and concluded that, in all respects, the proposed research meets the appropriate standards of ethics as outlined by the University of Victoria Research Regulations Involving Human Participants.

Rachael Scarth

Dr. Rachael Scarth
Associate Vice-President Research Operations

Certificate Issued On: 12-Aug-15

15-233 Park, Hyeone

Appendix G: Modification of an Approved Proposal

University of Victoria | Office of Research Services | Human Research Ethics Board
Administrative Services Building Rm B202 PO Box 1700 STN CSC Victoria BC V8W 2Y2 Canada
T 250-472-4545 | F 250-721-8960 | uvic.ca/research | ethics@uvic.ca

Modification of an Approved Protocol

PRINCIPAL INVESTIGATOR:	**Hyeone Park**	**ETHICS PROTOCOL NUMBER** Minimal Risk Review - Delegated	**15-233**
UVic STATUS:	**Master's Student**	ORIGINAL APPROVAL DATE:	11-Aug-15
UVic DEPARTMENT:	**ENVI**	MODIFIED ON:	24-Nov-15
SUPERVISOR:	**Dr. Eric Higgs**	APPROVAL EXPIRY DATE:	10-Aug-16

PROJECT TITLE **Food forests on Galiano Island as a restorative approach: How can we assess food forests?**

RESEARCH TEAM MEMBER None

DECLARED PROJECT FUNDING: **SSHRC CGS Masters; Sara Spencer Foundation Research Award; Kennedy Award (2015); UVic President Scholarship (2015)**

CONDITIONS OF APPROVAL

This Certificate of Approval is valid for the above term provided there is no change in the protocol.

Modifications
To make any changes to the approved research procedures in your study, please submit a "Request for Modification" form. You must receive ethics approval before proceeding with your modified protocol.

Renewals
Your ethics approval must be current for the period during which you are recruiting participants or collecting data. To renew your protocol, please submit a "Request for Renewal" form before the expiry date on your certificate. You will be sent an emailed reminder prompting you to renew your protocol about six weeks before your expiry date.

Project Closures
When you have completed all data collection activities and will have no further contact with participants, please notify the Human Research Ethics Board by submitting a "Notice of Project Completion" form.

Certification

This certifies that the UVic Human Research Ethics Board has examined this research protocol and concluded that, in all respects, the proposed research meets the appropriate standards of ethics as outlined by the University of Victoria Research Regulations Involving Human Participants.

Rachael Scarth

Dr. Rachael Scarth
Associate Vice-President Research Operations

Certificate Issued On: 25-Nov-15

15-233 Park, Hyeone

Appendix H: Participant Consent Form: Interview

University of Victoria	***Participant Consent Form***

Food forestry model and monitoring in the context of ecological restoration: How do food forestry and restoration mutually benefit each other?

You are invited to participate in a study entitled *Food forestry model and monitoring in the context of ecological restoration: How do food forestry and restoration mutually benefit each other?* that is being conducted by Hyeone Park. I am a graduate student in the department of Environmental Studies at the University of Victoria and you may contact me if you have further questions by e-mail sulgi99@uvic.ca or by telephone +1 778 677 0136.

As a graduate student, I am required to conduct research as part of the requirements for a degree in Environmental Studies. It is being conducted under the supervision of Dr. Eric Higgs. You may contact my supervisor at 250-514-9961.

This research is being funded by the Social Science and Humanities Research Council, Kennedy Award, UVic President's Scholarship and the Sara Spencer Foundation Research Award.

Purpose and Objectives

This multi-disciplinary research project draws together expertise and experience from ecological restoration, permaculture and other related fields, and it explores how food forestry (or forest gardening) and restoration might mutually benefit each other and how to monitor a food forest in the context of its contribution to restoring social and ecological systems. My research objectives are twofold: 1) to develop a food forestry model and compare with restoration models; and 2) to provide in-depth analysis of the social, ecological and cultural dimensions of a local food forest project of the Galiano Conservancy Association (GCA), Galiano Island and create a monitoring framework for their food forests.

Importance of this Research

This research is one of the first studies to examine food forestry in the context of ecological restoration and systematically develop a holistic framework of criteria and indicators (C&I) for assessing food forests. The study will mobilize expertise of food foresters and help restoration ecologists to understand food forestry practices and encourage further scientific research. The research will shed light on the social, cultural and ecological dimensions of the local food forest project of the GCA, which is strongly committed to their goals of conservation, education and sustainability. By working closely with the Conservancy, this study will produce a C&I framework that will guide the development of a monitoring program for GCA's food forests. More broadly, the study will contribute to scholarly and on-the-ground discussion on how we can restore and manage the lands while improving sustainability, food security and the human-nature connection.

Participants Selection

You are being asked to participate in this study because you have more than 5 years of experience or training in ecological restoration or food forestry (incl. agroforestry); you are an employee or a board member of the Galiano Conservancy Association; or you have participated in activities for GCA's food forest project. You may have been recommended by one of the research participants as a good candidate for this research.

What is involved

If you agree to voluntarily participate in this research, your participation will include interviews. Conversations will be about food forests, restoration, and monitoring. To enhance the interview process, you will be provided with response instrument materials of working food forestry models and the list of potential monitoring criteria and indictors. You will review the materials before the interview and provide recommendations and suggestions on the models and monitoring list during the interview._The interview is expected to take 30 minutes to an hour, depending on your availability/time. The interview can take place at any location or any means where is convenient for you (e.g. Skype, email, participant's office, public, or telephone). I may follow up with you after the first interview to clarify your answers or to inquire further expertise if you are willing. You will be invited to join a voluntary group discussion on Galiano Island where we will examine the results from the interview and develop monitoring criteria and indicators specifically for the food forest project of the Galiano Conservancy Association for two hours. I will send an invitation and transportation information when details are confirmed if you are willing.

Inconvenience

Participation in this study may cause some inconvenience to you in the form of time. You will review the response instrument materials before the interview, but you can decide your level of involvement and the time that you want to commit and a communication method (telephone, in-person, Skpye or email). If you choose to participate in the group discussion, you may travel to Galiano Island on your own. Transportation information will be provided.

Risks

There is no known or anticipated risk to you by participating in this research. Any information disclosed in interviews and group discussions that could impact your job security in any way will be systematically disclosed in the writing of the research results.

Benefits

The potential benefits of your participation in this research include: a means by which you will contribute to scholarly and on-the-ground efforts in restoring social and ecological systems and developing a monitoring framework for food forests. Your empirical knowledge and experience will benefit adaptive management of food forest projects and better understanding of ecological and social contributions of food forests.

Voluntary Participation

Your participation in this research must be completely voluntary. If you decide to participate, you may withdraw at any time without any consequences or any explanation. If you withdraw from the study, your data will be used only if you agree.

On-going Consent

To make sure that you continue to consent to participate in this research, I will discuss your participation if you are willing to participate in interviews and wish to be contacted for the group discussion on Galiano Island. If you are unwilling or unable to continue, withdrawal from the project at any time is possible. You will have the right to take any information given during the interview process with you upon withdrawal from the project. However, when your data is linked to group data (group discussions), it will be summarised form with no identifying information.

Anonymity

I will do my best to ensure anonymity; but there is a chance, given the snowball sampling recruitment employed in the research and a small community of Galiano Island, that some information may be recognizable by others. Your personal names will not be published in the dissemination of results, unless you wish to be recognized by name or by photograph by indicating so on this consent form. If you choose to remain fully anonymous, I will endeavour to make you as anonymous as possible in the dissemination of my results.

Confidentiality

Due to the small size of the community, the recruitment method, and the targeted nature of my research, there can be no guarantees of confidentiality. After your interview is summarised, you will have the opportunity to review the summary and make any alterations prior to data being made final. Until then, data will be stored on an encrypted computer password-protected.

Dissemination of Results

As stated, the data will be used as research for my M.A. thesis. It is anticipated that the results of this study will be used as data for participation in academic or non-academic talks, conferences (e.g. International Permaculture Conference) and potential publications as academic papers. Also, the results of the study will be used and shared with other researcher for the purpose of development of food forest monitoring programme and other related research. The digital data will be password protected and contain no participant's name. They will be archived by myself and are available upon request.

Disposal of Data

Digital data from this study will be password protected and stored on the researcher's encrypted laptop and hard drive and stored by the University of Victoria for the future research. Additional material that is generated from this research, such as journals and photos, will be stored at the University of Victoria as long as relevant research in the region is being pursued, and may be used for future research. I will anonymize the data to ensure that it will not be used in a way that compromises the integrity of participants. I cannot ensure your complete anonymity as stated above. Given the small community of Galiano Island, the nature of the research project and the recruitment method it may be possible for some to recognize you.

Contacts

Individuals that may be contacted regarding this study include Dr. Eric Higgs or myself at the phone number at the beginning of this consent form. In addition, you may verify the ethical approval of this study, or raise any concerns you might have, by contacting the Human Research Ethics Office at the University of Victoria (250-472-4545 or ethics@uvic.ca).

Your signature below indicates that you understand the above conditions of participation in this study, that you have had the opportunity to have your questions answered by the researchers, and that you consent to participate in this research project.

Name of Participant		*Signature*		*Date*

Visually Recorded Images/Data Participant provide initials, *only if you consent*:

- Analysis _______ Dissemination* ________

*Even if no names are used, you may be recognizable if visual images are shown in the results.

PLEASE SELECT STATEMENT only if you consent:

I consent to be identified by name / credited in the results of the study: ______________ (Partici pant to provide initials)

I consent to have my responses attributed to me by name in the results: ______________ (Parti cipant to provide initials)

I consent to be contacted for followup interviews and for the group discussion on Galiano Island:

______________ (Participant to provide initials)

Future Use of Data

I consent to the use of my data in future research: ______________ (Participant to provide initi als)

I consent to be contacted in the event my data is requested for future research: ______________ (Participant to provide initials)

A copy of this consent will be left with you, and a copy will be taken by the researcher.

Appendix I: Participant Consent Form: Workshop

University of Victoria	***Participant Consent Form***

Food forests on Galiano Island as a restorative approach: How can we monitor food forests?

You are invited to participate in a study entitled Food forests on Galiano Island as a restorative approach: How can we monitor food forests? that is being conducted by Hyeone Park. I am a graduate student in the department of Environmental Studies at the University of Victoria and you may contact me if you have further questions by e-mail sulgi99@uvic.ca or by telephone +1 778 677 0136.

As a graduate student, I am required to conduct research as part of the requirements for a degree in Environmental Studies. It is being conducted under the supervision of Dr. Eric Higgs. You may contact my supervisor at 250-514-9961.

This research is being funded by the Social Science and Humanities Research Council and the Sara Spencer Foundation Research Award.

Purpose and Objectives

This multi-disciplinary research project draws together expertise and experience from ecological restoration, permaculture, and other related fields and explores how to monitor a food forest in the context of its contribution to restoring social and ecological systems. My research objectives are twofold: 1) to develop criteria and indicators for monitoring the attributes of food forests that may contribute, or not, to ecological restoration; and 2) as a case study, to provide in-depth analysis of the social, ecological and cultural dimensions of a local food forest project of the Galiano Conservancy, Galiano Island and create a monitoring framework for their food forests.

Importance of this Research

Research of this type is important because public interests in food forests are increasing; yet food forests have received little scholarly attention to date, especially about monitoring indicators. This research is one of the first studies to systematically develop a framework of criteria and indicators (C&I) for assessing food forests in the context of ecological restoration. The local case study will shed light on the social, cultural and ecological dimensions of GC's food forest project, which is strongly committed to pursuing conservation, education and sustainability. By working closely with the Conservancy, this study will produce a C&I framework that will guide the development of a monitoring program for GC's food forest project. More broadly, the study will mobilise empirical knowledge of experts in food forests and in restoration and will contribute to scholarly and on-the-ground discussion on how we can restore and manage the lands while improving sustainability, food security and the human-nature connection.

Participants Selection

You are being asked to participate in this study because you have more than 5 years of experience or training in ecological restoration or food forestry (incl. agroforestry); you are an employee or a board member of the Galiano Conservancy Association; or you have participated in activities for a food forest project of the Conservancy. You may have been recommended by one of the research participants as a good candidate for this research.

What is involved

If you agree to voluntarily participate in this research, your participation will include group discussions on February 26th, 2016. Conversations will be about the food forest project on Galiano Island, restoration, monitoring indicators, and reference ecosystems. To enhance the interview process, participants will be provided with a list of potential monitoring criteria, indicators, and measures that we will assess against the local context and the objectives of GCA's food forest project during the discussion in advance. The group discussion will take place for three hours. You may be invited to a follow-up interview or group discussion, if requested by GCA or the researcher. I will send an invitation and transportation information when details are confirmed.

Inconvenience

Participation in this study may cause some inconvenience to you in the form of time. You will have to review the list of potential monitoring criteria, indicators and measures before the group discussion. Also, you will arrange your own transportation to travel to Galiano Island.

Risks

There is no known or anticipated risk to you by participating in this research. Any information disclosed in interviews and group discussions that could impact your job security in any way will be systematically disclosed in the writing of the research results.

Benefits

The potential benefits of your participation in this research include: a means by which you will contribute to scholarly and practical efforts in exploring ways to restore social and ecological systems and developing a monitoring framework for food forests. Your empirical knowledge and experience will benefit adaptive management of food forest projects and better understanding of ecological and social contributions of food forests.

Compensation

As a way to compensate you for any inconvenience related to your participation, your travel cost will be reimbursed if you travel from outside of Galiano Island upto CAD 100 (cash) upon the presentation of the receipt regarding travel and upon the completion of the group discussion. In case you decide to withdraw from the research after the discussion, the compensation will return to the researcher. It may be given to a participant who attends the next group discussion if it takes place. If you consent to participate in this study, this form of compensation to you must not be coercive. It is unethical to provide undue compensation or inducements to research participants. If you would not participate if the compensation was not offered, then you should decline.

Voluntary Participation

Your participation in this research must be completely voluntary. If you decide to participate, you may withdraw at any time without any consequences or any explanation. If you withdraw from the study, your data will be used only if you agree.

On-going Consent

To make sure that you continue to consent to participate in this research, I will discuss your participation If you are willing to participate in group discussions and a follow-up interview. If you are unwilling or unable to continue, withdrawal from the project at any time is possible. You will have the right to take any information given during the interview process with you upon withdrawal from the project. However, when your data is linked to group data (group discussions), it will be summarised form with no identifying information.

Anonymity

I will do my best to ensure anonymity; but there is a chance, given the snowball sampling recruitment employed in the research and the nature of the group discussion, that some information may be recognizable by others. Your personal names will not be published in the dissemination of results, unless you wish to be recognized by name or by photograph by indicating so on this consent form. If you choose to remain fully anonymous, I will endeavour to make you as anonymous as possible in the dissemination of my results.

Confidentiality

Due to the small size of the community, the recruitment method, and the targeted nature of my research, there can be no guarantees of confidentiality. After the group discussion data are summarised, you will have the opportunity to review the summary and make any alterations prior to data being made final. Until then, data will be stored on an encrypted computer password-protected.

Dissemination of Results

As stated, the data will be used as research for my M.A. thesis. It is anticipated that the results of this study will be used as data for participation in academic or non-academic talks, conferences (e.g. International Permaculture Conference) and potential publications as academic papers. Also, the results of the study will be used and shared with other researcher for the purpose of development of food forest monitoring programme and other related research. The digital data will be password protected and contain no participant's name. They will be archived by myself and are available upon request.

Disposal of Data

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Your signature below indicates that you understand the above conditions of participation in this study, that you have had the opportunity to have your questions answered by the researchers, and that you consent to participate in this research project.

Name of Participant		*Signature*		*Date*

Visually Recorded Images/Data Participant provide initials, *only if you consent*:

- Analysis _______ Dissemination* ________

*Even if no names are used, you may be recognizable if visual images are shown in the results.

PLEASE SELECT STATEMENT only if you consent:

I consent to be identified by name / credited in the results of the study: ______________ (Participant to provide initials)

I consent to have my responses attributed to me by name in the results: ______________ (Participant to provide initials)

I consent to be contacted for follow-up interviews and/or for follow-up group discussions on Gal iano Island:

______________ (Participant to provide initials)

Future Use of Data

I consent to the use of my data in future research: ______________ (Participant to provide initi als)

I consent to be contacted in the event my data is requested for future research: ______________ (Participant to provide initials)

A copy of this consent will be left with you, and a copy will be taken by the researcher.