# Professional papers

# Is there a role for food forests in New Zealand forestry?

Lania Holt, Karen Bayne, Oscar Montes de Oca, Richard Yao and Andrew Pugh

## Food Forest Products

**Food examples:**

Fruit, vegetables, nuts, seeds

Meats, mushrooms,

Honey, herbs

Processed products – e.g. flour, butter

Medicines

**Resource examples:**

Fibre, building material

Fuels, oils, rubber

Animal fodder

## Food Forest Benefits

**Environment benefit examples:**

Increasing biodiversity

Carbon sequestration

Purifying air and water

Improving the hydrological cycle

Reversing climate change

Moderating local climate

Building soil

Stopping soil erosion

Restoring fertility

**Human benefit examples:**

Food security

Self-reliance



Figure 1: This illustration of a food forest lists examples of forest food products (e.g. fruit and nuts), and other products (e.g. animal fodder), and environment benefits (e.g. increasing biodiversity) and human benefits (e.g. self-reliance) from these forests

## Abstract

Over the past couple of years there has been renewed interest in agroforestry research, primarily driven by the unrealised potential of the role of food forests in New Zealand. A workshop with leading research institutes brought together a multi-discipline group of scientists across forestry, agriculture, horticulture, land care, food research and academia, to take a deep dive into the potential of food forests. This was followed by an online workshop with a range of practitioners that included foresters, farmers, Māori landowners, lifestyle block owners, and applied researchers and policy people.

The position from these two workshops was that a cooperative system of food forests, in all their eventualities, would add resilience to national food security, and be potentially transformative to the forestry sector, lending itself to new silvi-agricultural methods, new local market possibilities, and new community relationships. With this insight came a call from workshop participants about the need for definitions.

In a targeted iterative exercise, a forestry research focus group has formulated a definition of food forests to apply in forestry in New Zealand. In this paper we put forward this definition of food forests, outline the perceived benefits to the forestry sector to develop a food forest system, and provide a food forests lexicon with terms used in this paper. The aim is to support communication across the different disciplines and scales to foster the development of food forests in New Zealand.

## Introduction to food forests

The general understanding globally is that food forests are a multifunctional and biodiverse agroforestry system incorporating trees, shrubs and groundcover (Albrecht & Wiek, 2021). They are a model of Continuous Cover Forestry (CCF) focused on producing non-timber forest products (NTFPs). Some examples of NTFPs from a food forest are shown in Figure 1. Here diverse products would generate more frequent and earlier cashflow than timber, as well as provide standing forest values, particularly of long-lived forests.

NTFPs have been hailed as a 'silver bullet' that can provide economic incentives to conserve standing forests while contributing to local livelihoods (Sunderland, 2011). When harvesting NTFPs the forest canopy and forest functions are largely retained, hence the analogy to CCF. Consequently, the harvest of NTFPs is seen as less ecologically destructive than timber harvesting, and therefore a sounder basis for sustainable forest management. Many would consider most forests to inherently be food forests because of the wild food that grows naturally within them. However, a distinguishing feature of food forests is the forest and agriculture practices that are intentionally integrated to function as a single management system over a period of time, to primarily produce food.

Food forests were thus envisaged in the form of silvopastoral or silvoagricultural systems:

- Silvopastoral systems would be on farms or orchards, with trees incorporated in mutually beneficial ways with foraging and the grazing of animals. Examples of silvopastoral systems globally are alley cropping, with Figure 2 being a New Zealand example of inter-cropping using multipurpose radiata pine trees planted in land that has been over-sown with lotus.

- Silvi-agriculture, however, is less well-known. In silvoagricultural systems, the forest constitutes the main component and crops and/or animals are integrated within it. Examples of silvoagricultural systems globally are taungya approaches in the early years of establishing the forest and shifting cultivation. In New Zealand there are examples of the precision placement of companion crops (see the Chilean hazelnut example shown in Figure 3), and of under-cropping with shade tolerant crops such as *Panax ginseng* (see Figure 4).

In New Zealand, and arguably globally, it is gardens, sometimes called forest gardens, that predominantly identify as food forests. These types of food forests are usually located close to a house and they are typically less than a few hectares in size. Sustainable farming practices such as permaculture are often associated with these food forests, and they can be in the form of either a silvopasture or silvoagriculture system.

The wide range of food forest descriptions occurs because no exact definition of food forests exists in the literature that prescribes details such as size, the extent and height of the tree canopy, the number of forest canopy layers, the species and number of trees, the type and amount of food produced, and so on (Gent, 2019). Thus, various forms are called food forests largely because of some common, general features such as:

- A forest-like system with a tree canopy and vertical layers. For an overview of the layers that can be in a food forest (see Figure 5)

- Being man-made for the purpose of producing food in ways that mimic ecosystems and patterns found in a forest

- Having a high diversity of perennial and/or woody species, biennial and annual seasonal crops, gathered through natural or cultivated means, which could include or exclude animals

- Having a lower input system than industrial agriculture/horticulture, often using practices that have evolved around the world since the latter part of the 21st century, like permaculture (Australia), syntropic agriculture (South America) and analog forestry (Southeast Asia).

Regarding Figure 3, the first trials of gevuina in New Zealand were carried out by tree croppers, largely in the South Island, with disappointing results. Ten years ago, a Māori forest owner chose to explore



Figure 2: A silvopastural grazing scheme, Cpt 383, Kaingaroa, November 1987. Cattle grazing over-sown lotus that is growing amongst the radiata pine trees

this native Chilean species with Mapuche landowners in Chile. This study has resulted in a selection process being undertaken and a provenance trial growing at Scion that has seen some of these trees start to produce nut crops at five years.

Fundamental knowledge required in food forests is to understand the different roles in the forest food chain, and the overarching role of a forest in providing habitat and in maintaining the suitable conditions for life. The species composition of forest food is broad from the ungulates (such as deer, pig and goat), to the aquatic animals (such as fish and koura), to the bees that produce honey, to the fungi, to the more recognised plants (such as blackberry, puha, herbs, etc), to less well recognised plants and insects.

The food chain involves predators (hunters), consumers (herbivores, carnivores, omnivores), producers (plants that make their own food and organisms that can transform inorganic into organic compounds), and decomposers (organisms and microorganisms that breakdown organic matter into soil such as worms, fungi, bacteria). Associated with this are matters of forest access, pest management, knowing when food is safe, the level of agriculture or horticulture integration, and managing recreational and commercial catches sustainably. A distinguishing feature of forest food is their indirect value of being part of a forest ecosystem that serves to support human well-being (King et al., 2013).

## The New Zealand food forests opportunity

### Workshop findings

Feedback from the workshops identified four cases for why a food forest system should be developed in New Zealand: 1) enhancing national



Figure 3: *Gevuina avellana* (known as the Chilean hazelnut) trees, age 17 months (January 2023), have been planted and left to grow along the road edge in front of pine trees on Mangamingi farm north of Taupo



Figure 4: A plot of simulated wild Asian ginseng (*Panax ginseng*) under pest control cover, under radiata pine at Pureora, Central North Island, February 2019

food security; 2) unlocking the economic potential and multiple benefits of NTFPs; 3) creating new knowledge of sustainable food systems and social licence in forestry; and 4) creating a CCF option with substantive environmental benefits.

## 1. Enhancing national food security

Food forests were seen as being a backstop to our arable lands. This land has been under pressure from encroaching urban sprawl, and the demands from producing enough high-quality food for the 40 million people that New Zealand-grown food presently reaches (Mcilraith, 2023). Furthermore, despite being a significant food producer, our country has some serious nutritional concerns with increasing trends in obesity and undernourishment, especially in Māori and Pacifica communities (Coad & Pedley, 2020).

With the right design, food forests could be aimed at helping reduce these concerns. For example, they could be grown for local consumption, targeting specific foods such as nuts, where the dietary intake is below the recommended target (see Figure 6). Furthermore, spin-off benefits are anticipated where research in food forests could be transferable to existing forests, thereby giving knowledge and confidence in the sustainability of the wild foods that we currently hunt and forage.

## 2. Unlocking the economic potential and multiple benefits of NTFPs

Wild foods make an important contribution to the livelihood of the New Zealand households and communities who hunt, gather and consume them. The freedom to harvest wild food from the forests is a tradition and considered as a basic right in this country. Hence there are operations, rules and regulations associated with hunting, fishing and gathering that exist for safety and sustainability reasons, such as pest management, controls on access, catch limits and trading restrictions. To uphold the wild food culture in New Zealand it is crucial that opportunities to forage and hunt food naturally are sustainably managed.

Vegetables, fruits, nuts, fish, game and livestock were once wild. It is not anticipated that wild or simulated wild food from a food forest will match the commercial value of the more efficient single output monocrops of industrial agriculture and horticulture. However, food forests can be profitable and generate flows of cash and value over timeframes shorter than for timber and carbon forestry.

A New Zealand food forest system will create a resource potential for research and technologies to unlock unknown commercial and industrial benefits. This could include positioning forest food as an



**Layers of a Food Forest**

Canopy overstorey or tall tree layer (large fruit and nut trees)

Sub-canopy, understorey or low tree – large shrub layer (dwarf fruit trees)

Vertical layer (climbers and vines)

Shrub layer (berries)

Wetland – aquatic layer (watercress)

Mycelial – fungal layer (mushrooms)

Ground layer (strawberries)

Herbaceous layer (herbs)

Root layer (root vegetables)

Figure 5: The different layers of a food forest with examples of food crops (shown in brackets, excludes animals) that can occur at each layer, where consideration is given to the air space inhabited so that enough light filters through to lower layers
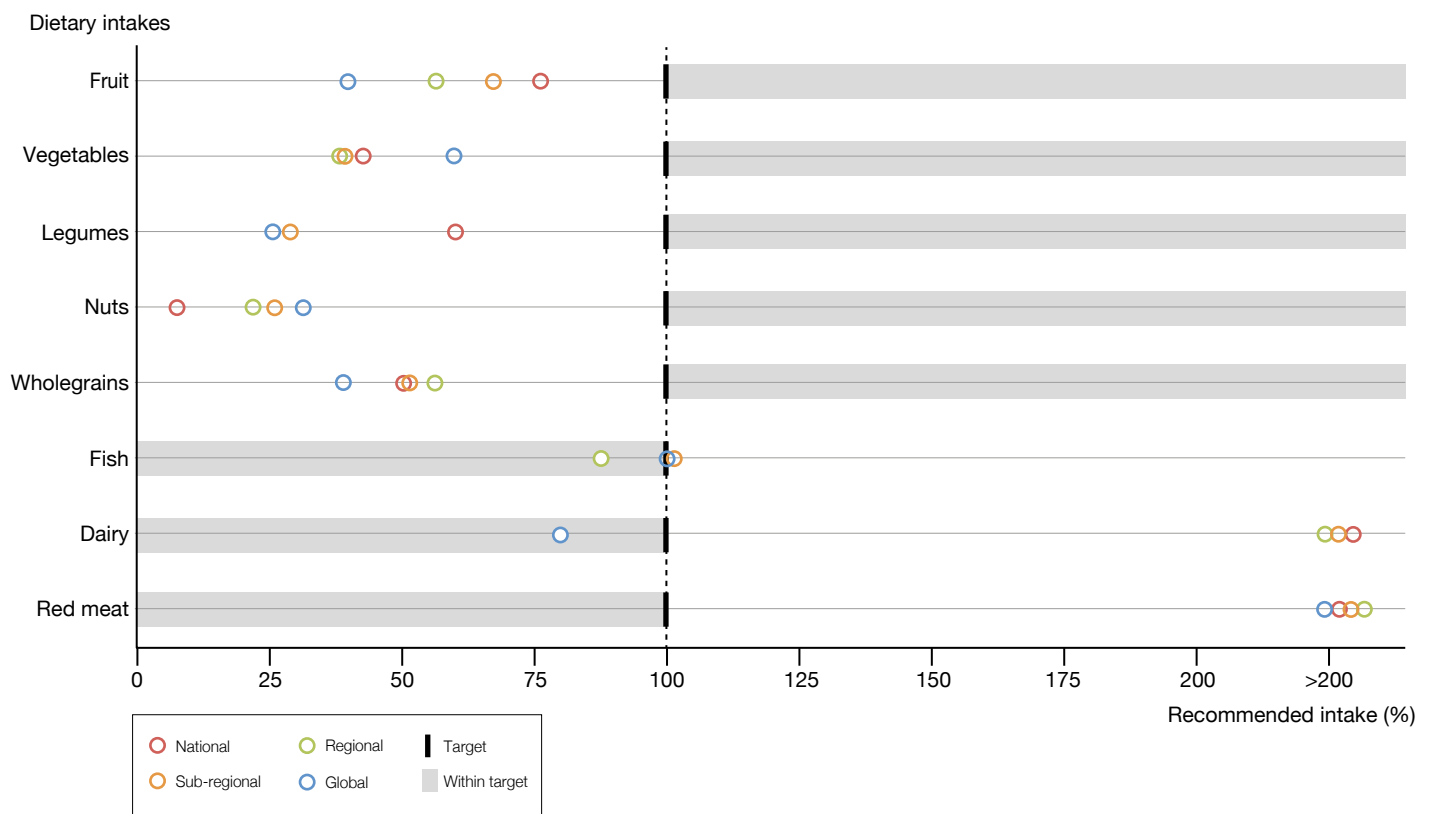
Figure 6: Dietary intakes of key foods and nutrients in adults aged 20 years and over compared against minimum and maximum targets for New Zealand (National), Australia and New Zealand (Sub-regional), Oceania (Regional) and Global (Independent Expert Group, 2022)

alternative to lab-grown future food that assumes to reduce the environmental impact of agriculture, but with added forest values such as carbon sequestration. To do this, policies and legislation will need to be adapted to include food forests in schemes such as the Emission Trading Scheme (ETS), allowing the accounting of carbon within fruit and nut tree species.

Forests provide a range of direct and indirect benefits to society, that are generally known as forest ecosystem services (Grebner et al., 2022). These include timber, understorey crops, carbon sequestration, avoided erosion and recreational hunting. While timber and understorey crops are material benefits with market prices, services such as avoided erosion and recreational hunting are not directly sold in the market. However, the latter can be financially quantified to enable their inclusion in decision-making.

Evaluating both financial and non-market economic benefits of ecosystem services clarifies their true value to hunters, gatherers and forest users, while also highlighting the diverse contributions of standing forests. For example, a case study of Wenita Forest Estate showed that although timber was the primary reason for growing forest trees, the non-timber benefits (e.g. recreational pig hunting and environmental conservation such as carbon sequestration and erosion control) exceeded the value of the profits from log sales at the time of the study (Yao et al., 2017).

Another example is simulated wild ginseng (*Panax ginseng*), a high-value food crop that was grown in two forest blocks in radiata pine forests under a pruned regime in the Central North Island region. Financial analysis indicates that the profit from growing this crop, valued at $4,000 per kilogram of ginseng products at the time of the study, was more than twice the profit from the sale of pine logs (Yao et al., 2013).

The profitability indices are given in Figure 7, where Cases 1 and 2 both show that wild-simulated ginseng understorey cropping contributes to more than double the profit of a hectare of pruned radiata pine forest. The high-value ginseng crop is also relatively labour-intensive and has provided employment opportunities for the local community.

## 3. Creating new knowledge of sustainable food systems and social licence in forestry

The products from food forests span both wild and domesticated food options. These foods can speak to a clean green image and to niche markets that seek natural, healthy and sustainable products, such as those that use organic and fair-trade labels. There will also be quantities of food products from activities that will provide recreational, aesthetic, educational and spiritual benefits.

While harvesting these foods is often for non-commercial purposes, some wild species stocks can
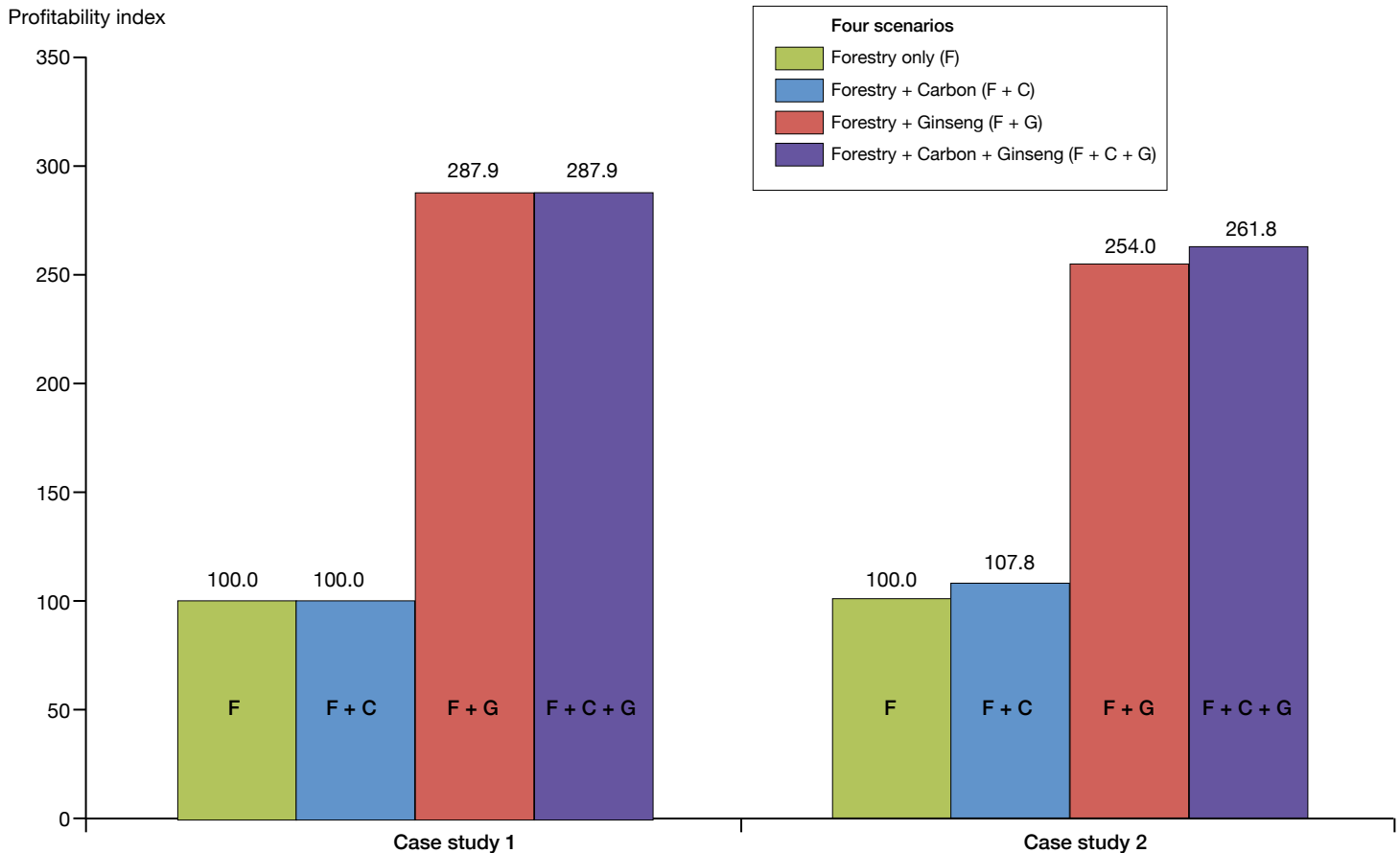
Profitability index



Figure 7: Profitability indices for the two Central North Island case study forests across the four scenarios from Yao et al. (2013)

be traded for sale by a certified hunter, and harvesting can also be part of commercial tourism ventures (e.g. fishing, hunting). Thus, food forests have the potential to add to New Zealand's foodscape's tourism menu alongside vineyards, and to events such as the Hokitika Wildfood Festival and Mamakan's Art of Foraging, to supplement food already being sourced from existing forests and forest gardens.

## 4. Creating another CCF option with substantive environmental benefits

There are regions in New Zealand where natural capital is being lost in massive amounts. A case in point is Tairawhiti, where soils are being washed away due to more frequent and extraordinary weather events. A recognised solution for this is to have CCF, which is exemplified in New Zealand by a diverse range of CCF models focused on biodiversity and/or speciality timber, such as Woodside Forest, Forever Beech, the Totara Industry Pilot and the Redwood CCF Model.

A review of CCF business models claims that CCF should expand in New Zealand, with the transition (transition forestry) of existing high erosion-risk exotic plantations. This encourages CCF in regenerating native stands on-farm, as well as the establishment of new planted forests of selected exotic and native species also on farmland (MPI, 2022). These forms

of CCF come with uncertainty and cost challenges, and ways to transition are associated with a widely recognised need for more underpinning research (Jones et al., 2023).

Food forests would in theory be suitable for a range of CCF situations but a key factor here is scale, especially for realising significant environmentally beneficial impacts with CCF, such as avoided erosion and temperature control. A high-level analysis identified the potential of circa 2 million ha in CCF by 2050, with support in three key areas being highlighted to attract this scale (MPI, 2023):

- **Market development:** Develop the voluntary carbon, compliance and biodiversity credits, and payments for ecosystem services (PES); develop timber markets for non-radiata pine and timber products; and use CCF plant-based products, such as wild food/simulated wild food products and nutraceuticals.

- **Societal momentum for change:** Integrating cultural, conservation, recreation and production value.

- **Business model enablers:** Develop long-term policy direction and regulatory changes, including changes to the ETS and Part 3A of the Forest Act 1949; people capability; silvicultural

management; harvesting systems; and science and data.

## A food forests definition for New Zealand forestry

Synthesising the knowledge from the workshops and accompanying research, a forestry research focus group did a targeted iterative exercise to formulate and evaluate a definition of food forests for a forest system in New Zealand. This food forest definition is:

*"An area of forest being intentionally managed for commercial, recreational/customary use food production, with at least one complimentary tree species, and with at least one food crop produced in at least two forest layers, with a minimum extent of 5 hectares which at maturity will contain at least 10% tall tree, 20% non-tall tree, and 20% ground cover in each hectare."*

This definition is proposed as a starting place to fine-tune the prescriptive technical and policy aspects of a food forests system in New Zealand. The key criteria underpinning this definition are management purpose, scale and species diversity, layer complexity and use of the NTFPs, particularly general vs private use. The approach taken to formulate this definition is stepped through in Figure 8.

1. Purpose criteria – food is not just a by-product of the forest, but comes from an intentionally managed area with a primary purpose of producing food. The forest can also have other purposes, such as standing values like carbon and biodiversity, as well as for timber. However, in the case of timber, any harvest of trees will be selective and aligned with the other criteria outlined. A key assumption is that food forests can be included in the ETS and biodiversity schemes. These details, including the case to certify food forests such as with the Forest Stewardship Council (FSC), need to be worked through.

2. In the scale and species diversity criteria the forest needs to be at least 5 ha and have at least one food crop and one complementing tree species, and at least two forest layers being managed for food. The aim is to create energy efficiently from having a mixed species of trees with multiple food types being grown together, using lower inputs than those in agricultural/horticultural systems. There is a vision to have a national estate of 300,000 ha of food forests. At this scale, it is estimated that at maturity this would produce enough carbohydrates/protein for 1.5 million people (based on Nytofte & Henriksen, 2019). The feasibility of national and regional scales, and the identification of crops and complementary species and the value chains suitable in these locations, need to be investigated.

3. Layer complexity criteria is about managing horizontal layers and light. The forest must be able to contain at least 10% of tree canopy cover (in the form of shrub and trees) with a minimum height of 5 m at maturity, 20% canopy cover of non-tall trees and 20% ground cover in

| 1. Purpose criteria: Is the forest area being intentionally managed with a primary purpose of producing food? | |
|---|---|
| Yes – go to next step | No – not a food forest, it may be a floral garden or forest |

| 2. Scale and diversity criteria: Is there at least five hectares with at least one food crop and one complementary species, and at lease two forest layers producing food? | |
|---|---|
| Yes – go to next step | No – not a food forest, it may be a small garden or orchard/farm or forest |

| 3. Complexity criteria: Will there be at least 10% tall tree canopy cover, 20% non-tall tree canopy cover, and 20% ground cover in each hectare, at maturity? | |
|---|---|
| Yes – go to next step | No – not a food forest, it may be a garden or orchard/farm or forest |

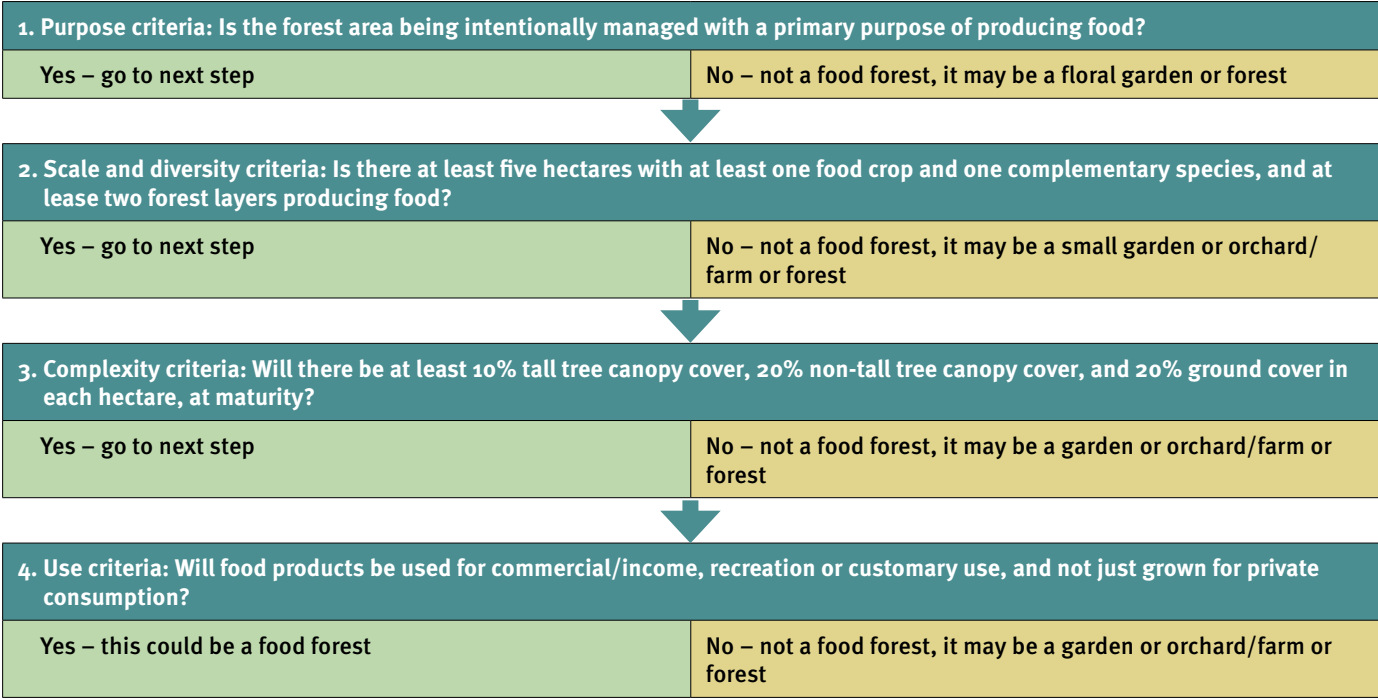| 4. Use criteria: Will food products be used for commercial/income, recreation or customary use, and not just grown for private consumption? | |
|---|---|
| Yes – this could be a food forest | No – not a food forest, it may be a garden or orchard/farm or forest |

Figure 8: This approach for defining food forests for New Zealand forestry is based on four criteria of purpose, scale and species diversity, layer complexity and the use of the products

Table 1: Perceived value (L=low, M=medium, H=high, or U=unsure/No data) of a food garden, timber production forest, silvopastoral farm system and food forest using an ecosystem services lens across the three main groups of services: provisioning (the material benefits), regulating (the environmental benefits) and cultural (the non-material benefits)

| Ecosystem service | Food garden | Production forest (Whakarewarewa) area › 5,000 ha | Silvopastoral | Food forest |
|---|---|---|---|---|
| **Provisioning (material)** | | | | |
| 1. Food/forage | H | L | M | H |
| 2. Timber | L | H | M | M |
| 3. Firewood | L | M–H | H | M |
| 4. Fibre | L | M–H | H | M |
| **Regulating (enviro conservation)** | | | | |
| 1. Carbon sequestration | L | H | M | M–H |
| 2. Avoided erosion | L | H | M | M–H |
| 3. Improved water quality | L | H | M | M–H |
| 4. Habitats for native species | L | H | M | M–H |
| **Cultural (non-material)** | | | | |
| 1. Recreational hunting of animals | L | L–M | L | L–M |
| 2. Aesthetics | U | L | M | M |
| 3. Tourism | U | H | M | M |

each hectare. It is assumed that species of fruit and nut trees, fungi and livestock are allowed, if they can feasibly be grown and managed in the forest. We assume that a range of trials would be set up, and that this would fast-track knowledge of forest management details such as stocking, interactions and harvest systems between the main food crops and supporting tree species.

4. Use criteria is about the products from the forest being used for commercial/income, recreation or customary or all these uses, and that they are not just being grown for private consumption.

To evaluate the criteria approach the focus group compared the perceived values of a garden, timber production forest, silvopastoral farm system and food forest using an ecosystem services lens (see Table 1). The purpose criterion is a provisioning service (food/forage) and here food forests align most with food gardens. However, the scale and diversity, and layer complexity criteria, are regulating services, with the use criteria in the cultural services. In these instances, the perceived values of a food forest align best with the timber production forest and silvopastoral system as opposed to a food garden, which makes sense with greater value being placed on the function of the forest structure.

## Summary

Emerging from this agroforestry exploration is verification that food forests are in the domain of forestry. Despite the current prevalence of garden-scale types, creating a system of food forests is an opportunity for New Zealand that could also expand the social licence of forestry in New Zealand (Yao et al., 2021). Thus, developing a food forest system should be driven by the forest sector, perhaps by a new branch of farm forestry. Developing new valuation methods using an ecosystem services approach would be highly relevant to apply to food forestry due to the significant levels of both private and public benefits. That said, the full value of ecosystem services will be difficult to measure, especially when considering the non-market benefits.

One of the first hurdles is to figure out if food forests should be studied further, what the priority of this is to the forestry sector, and how to go about getting started. In this paper we have given general examples of the types of food forests that exist globally, outlined reasons to develop a system of food forests in New Zealand, put forward a definition of food forests, and provide an agroforestry lexicon (Table 2) describing terms that are linked to food forestry. If anyone is interested in this topic, and has thoughts on progressing food forests (or not) within forestry in New Zealand, please contact the authors.

Table 2: A lexicon of agroforestry terms linked to food forests

| Term | Description |
|------|-------------|
| **Agroecology** | An interdisciplinary approach to sustainable agriculture that integrates ecological concepts and principles into agricultural practices and systems. Agroecology goes beyond production techniques by encompassing a wide range of practices, research methods and social movements aimed at transforming food systems to be more equitable and sustainable. |
| **Agroforestry** | A land management practice that integrates trees, shrubs, or other wood perennials with crops or livestock in a single system. This can (or not) involve agroecology. |
| **Alley cropping and inter-cropping** | An agroforestry practice of planting rows of trees or shrubs between or alongside crops to provide shade, shelter and separation. |
| **Analog forestry** | A system that mimics the structure and function of natural forests while integrating agricultural production. This is based on traditional forest gardens being human-created analogs of the natural forest to serve needs such as food, fibre, timber, medicine and water. |
| **Companion crops** | These are plants used in companion planting or mixed cropping, with an agricultural technique where two or more plant species are grown together in a proximity to benefit one another. Leveraging mutually beneficial plant relationships based on the natural properties of a plant, the aim is for growth, pest control and overall yield to be enhanced. |
| **Continuous Cover Forestry (CCF)** | A sustainable forest management approach that focuses on preserving forest structure, ecological resilience and biodiversity by always maintaining a forest canopy and avoiding large-scale clearfelling. Trees are harvested while retaining and maintaining a high level of canopy cover. |
| **Food forest** | A sustainable agricultural system modelled after forest ecosystems designed to produce food and other resources for human use. |
| **Food security** | Refers to a state in which all people have consistent physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. Food security is a complex and crucial aspect of sustainable development. |
| **Forest ecosystem services** | Refers to the wide range of benefits that forests provide directly and indirectly to humans and the environment. The flow of goods and services from the forest fall into three main groups of: provisioning or material benefits (e.g. timber, NTFPs), regulating or the environmental benefits (e.g. carbon sequestration, avoided erosion) and cultural or the non-material benefits (e.g. recreation, aesthetics). |
| **Forest food chain** | This is a complex and dynamic system of interactions involving various trophic flows, often depicted as a series of feeding relationships where energy and nutrients flow between organisms in a chain governed by natural processes such as predation, herbivory and decomposition. The chain plays a crucial role in ecosystem balance and function. |
| **Non-timber forest products (NTFPs)** | Refers to the wide variety of goods that can be obtained from forests, excluding timber. |
| **Permaculture** | This is a design system for sustainable land use that seeks to create self-sufficient and regenerative ecosystems. It integrates ecological principles with practical design strategies, to create systems that mimic natural ecosystems while meeting human needs for food, water, shelter and energy. |
| **Shifting cultivation** | Also known as slash-and-burn agriculture, this is where a plot of land is cleared by cutting down and burning vegetation, and then crops are grown for a few years until soil fertility declines and the land is abandoned. |
| **Silvoagricultural systems** | A type of agroforestry practice that focuses on the benefits of integrating tree cultivation with agricultural crops. Shade-grown coffee in Latin America, and ginseng growing under pine in New Zealand (as in Figure 4), are notable examples. |
| **Silvopastoral/ pastoral system** | A type of agroforestry practice that draws on the benefits of integrating trees, shrubs and forage with livestock grazing on the same piece of land. |
| **Sustainable forest management** | An approach to managing forests that balances environmental, social and economic objectives, to ensure that forests provide goods and services for present and future generations. |
| **Syntropic agriculture** | Integrating principles of agroforestry, permaculture and ecological restoration, this system involves planting a mix of plants in diverse layers, with a focus on the natural succession of plant growth and the regeneration of ecosystems. |

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| Term (continued) | Description |
|---|---|
| Taungya | An agroforestry system that combines agricultural crops with tree planting in the early years when trees are planted, so that crops can be harvested before the trees become established and overtop them. |
| Transition forestry | Refers to forestry management practices aimed at shifting existing forest systems toward more resilient and sustainable ecosystems. |
| Under-cropping | An agricultural practice where crops are grown beneath the canopy of taller trees or crops. The under-crop typically consists of plants that thrive in the shaded or semi-shaded conditions created by the taller trees/crops, optimising the available space and light while providing additional yield. |
| Wild food | Refers to edible plants, animals, fungi and other organisms harvested from natural ecosystems such as forests, grasslands, wetlands and marine environments. These foods are not cultivated or domesticated but grow and thrive in the wild. |
| Wild food culture | Refers to the traditions, practices and knowledge surrounding foraging, harvesting, preparation and the consumption of edible plants, mushrooms, fruits and wildlife that are found in natural ecosystems rather than being cultivated on farms. Practices are deeply embedded in rural and indigenous communities where hunting and foraging has been an essential part of daily life, and traditions are intimately tied to ecological knowledge, sustainability and community resilience. |

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*Lania Holt is a Forestry Management Scientist in the Te Ao Maori Team in Rotorua, Karen Bayne is a Senior Scientist in Forest Products Marketing in Christchurch, Oscar Montes de Oca is a Senior Scientist in Sustainable Value Chains in Wellington, Richard Yao is a Senior Research Economist in the Economics and Society Team in Rotorua and Andrew Pugh is Team Lead for Entomology and is an Ecological Entomologist in Rotorua, in Scion. Corresponding author: lania.holt@scionresearch.com*