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Bachelor Thesis

Ecological Principles of Permaculture

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ZADÁNÍ BAKALÁŘSKÉ PRÁCE

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Téma práce:	**Ekologické principy permakultury**
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Zásady pro vypracování

Permakultura je udržitelný způsob zemědělského hospodaření, jehož design vychází mimo jiné ze znalostí fungování přirozených ekosystémů. Kromě obecně ekologických zákonitostí využívá prvky ekologického zemědělství, ale též zahrnuje aspekty kulturní a morální.

Cílem práce je kritické zhodnocení prvků permakultury z ekologického hlediska na podkladě současné vědecké literatury. Práce bude zahrnovat tato témata:

1. Vymezení termínu permakultura
2. Přehled prvků permakultury a jejich hodnota pro fungování ekosystému
3. Porovnání permakultury a ekologického zemědělství
4. Formulace kontroverzí a otázek k dalšímu výzkumu.

Rozsah pracovní zprávy:	**25 normovaných stran**
Rozsah grafických prací:	**dle potřeby**
Forma zpracování bakalářské práce:	**tištěná**

Seznam doporučené literatury:

Ferguson, R. S., & Lovell, S. T. (2014). Permaculture for agroecology: design, movement, practice, and worldview. A review. Agronomy for sustainable development, 34(2), 251-274.

Krebs, J., & Bach, S. (2018). Permaculture-Scientific evidence of principles for the agroecological design of farming systems. Sustainability, 10(9), 3218.

McLennon, E., Dari, B., Jha, G., Sihi, D., & Kankarla, V. (2021). Regenerative agriculture and integrative permaculture for sustainable and technology driven global food production and security. Agronomy Journal, 113(6), 4541-4559.

Vedoucí bakalářské práce:	**prof. RNDr. Hana Čížková, CSc.** Katedra biologických disciplin

Declaration

I declare that I am the author of this graduation thesis and that I used only sources and literature displayed in the list of references in its preparation.

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Abstrakt

Tato práce se snaží ověřit, zda zemědělské zásady permakultury jsou vědecky podložené. K tomuto účelu byl použit dotazník používaný Českou permakulturní asociací (Permakultura ČS) pro hodnocení permakulturních projektů. Postupy, metody a struktury doporučené v dotazníku byly porovnány s informacemi ve vědeckých pracích indexovaných databází na Web of Science. Podařilo se nalézt několik publikací potvrzujících vhodnost doporučených postupů. Na druhou stranu nalezené vědecké publikace dokumentují, že bezorebné hospodaření a aplikace průmyslových hnojiv, kterým se permakultura vyhýbá, mohou mít příznivý dopad, pokud jsou správně použity. Vyhodnocení dotazníku dále ukazuje, že permakultura není sama o sobě zemědělským hnutím, ale její zaměření je širší. Klade si za cíl hledání udržitelných řešení ve většině aspektů života, včetně bydlení, získávání energie a vody, a také v socioekonomických aspektech života místních a regionálních komunit.

Klíčová slova: permakultura, agroekologie, udržitelnost, vědecká potvrzení

Abstract

This paper seeks to verify whether the agricultural practices recommended by permaculture have a scientific foundation. For this purpose, the questionnaire used by the Czech Permaculture Association (Permaculture CS) for the evaluation of permaculture projects was used. The procedures, methods and structures recommended in the questionnaire were compared with information in scientific papers indexed in the Web of Science database. Several publications were identified confirming the suitability of the recommended procedures from an agricultural and ecological point of view. On the other hand, other publications show that tillage and the application of industrial fertilizers, which permaculture avoids, can have a positive impact if used correctly. The evaluation of the questionnaire further shows that permaculture is not an agricultural movement per se, but its focus is broader. It aims at finding sustainable solutions in most aspects of life, including housing, energy generation and water management, as well as in the socio-economic aspects of local and regional communities.

Keywords: Permaculture, agroecology, sustainability, scientific evidence

Acknowledgment

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Content

1 Introduction

Permaculture raised my interest when searching the Internet for possibilities to set up a newly acquired piece of land. The intent was to create a garden with some elements of self-sufficiency, such as poultry, fruits, and berries, as well as some vegetables, and later maybe more.

According to the initial Internet sources found, permaculture promised little effort, high yields, an integral ecological approach, as well as scalable solutions and high flexibility in terms of time to be dedicated to the project.

We are now moving into the 4^{th} year of this project, and these expectations were not met. Doubts about the seriousness of the sources from the Internet lead to the decision to return to school, learn the business the old way, and finalising the education by investigating, whether permaculture has a solid scientific foundation.

This thesis aims at reviewing the scientific literature regarding the individual agricultural practices performed by most permaculture projects. To identify these practices, we analyse a questionnaire (Czech version - appendix 1 and English version - appendix 2) used by Permakultura (CS) (*Permakultura (CS)*, 2023), until 2020 to classify Permaculture projects as "permaculture project" or as "Project with elements of permaculture). The new questionnaire (appendix 3) has been significantly shortened (from 5 to 1 page), which is why the older version is used.

Permakultura (CS) agreed in writing (email as of November 10, 2021) that the questionnaire can be used for the purposes of this thesis.

2 Permaculture – Definition

2.1 Short History of Permaculture

Permaculture originates from an idea of Bill Mollison (the original copyright holder of the term permaculture) (Mollison, 1988) referring to an agroecosystem which would – through mimicking the ecosystem of the Tasmanian rain forest, be as resilient and productive as an untouched rain forest ecosystem, however its prevailing composition of food crops would enable mankind to produce enough food for the entire world population, and – at the same time – be climate neutral or better, prevent soil erosion, be resilient to droughts and floods, as well as other natural catastrophes which currently threaten health, food security, and maybe even the survival of mankind on our planet.

Permaculture has developed into a movement which nowadays covers not only agriculture and gardening, but believes that its principles can be applied universally, e.g., in architecture, management of corporations, socio-political issues, etc., to the benefit of all individuals involved in the respective projects. The term should now be understood as "permanent culture", where culture refers not merely to agriculture, but also to continuous education, ethical and social behaviour, etc. (Ferguson & Lovell, 2014)

It is relatively difficult to define permaculture, as it is applied to several disciplines (see previous paragraph) and at the same time relies on a series of principles (see Table 1: Permaculture principles by Bill Mollison, David Holmgren, and Toby Hemenway) which can be interpreted in different ways, depending on the context.

Central to the agricultural side of permaculture is the attempt of self-sufficiency not only in terms of production (outputs), but also in terms of resources needed (inputs). A big focus is therefore put on water management, e.g., by collecting rainwater, building swales and other structures to reduce water drainage and allow water penetration into the soil. Similarly, mulching is recommended as a measure to protect the soil from overheating and water evaporation, as well as for weed control by keeping weed seeds in the dark.

Permaculture gardens typically contain seminatural or artificial structures to allow animals such as insects, birds, reptiles, and others to settle. In the long term this should lead to a natural balance with reduced pest and disease pressure on edible crops grown, eliminating the need for pesticides and fungicides. For example, the installation of small structures of carton (e.g., cartons folded to tubular structures with several layers) on trees or shrubs may support the settlement of earwigs (*Forficula auricularia*), which will decimate the population of aphids (*Aphidoideae*), and thus prevent the various fruit trees and shrubs to be infested by these aphids. Earwigs are however harmful for pome fruit trees (e.g., *Malus domestica, Pyrus communis*). – By installing such structures on pome fruit trees, the earwigs can be easily collected with these structures and placed on trees and shrubs affected by aphids. This protects the pome fruit trees from earwigs and other trees and shrubs (e.g., *Prunus avium, Ribes rubrum)* from aphids.

Permaculture often emphasises the term food forest– the food forest is a structure of trees, shrubs, and herbs producing edible fruits and herbs. This structure serves not only for food production, but it shall also allow the garden / farm to work as an ecosystem, by introducing perennials and allowing for an artificial succession, stabilising the (agro-)ecosystem and supporting biodiversity.

Another important agricultural principle of permaculture consists in having soil always covered, through the entire year, to prevent erosion, support water retention, and contribute to weed control. This can be achieved by mulching, e.g., with straw, wood chips and similar materials, or by cover crops, including pre-crops, catch crops, intercropping (e.g., three sister principle – maize supports beans growing vertically, and pumpkins grow around maize and beans and cover the soil with their huge leaves – other combinations are possible), or winter vegetables (e.g., leaf cabbage *(Brassica oleracea* var. *sabellica*).

In Europe and Northern America, permaculture is mostly practiced on small-scale homesteads, or by hobby gardeners. Businesses built on permaculture are either very specific, e.g. specialised in the production of sustainable vegetable seeds (*Permasemínka*, n.d.), or they are prevalently consulting businesses, conducting courses about food self-sufficiency, as well as PDC courses (see 5.3 Permaseminka).

However, there are a few farms also in Europe, best known are probably Sepp Holzer's Krameterhof (*Krameterhof*, 2021), or "La Ferme biologique du Bec Hellouin" (*La ferme biologique du Bec Hellouin*, 2023) created by Charles and Perrine Hervé-Gruyer. Both are self-sustaining family farming businesses and declare to follow permaculture principles. La Ferme du Bec-Hellouin raised considerable interest in Normandie (France), and several studies and analyses were performed by various scientific and public institutions (*La recherche*, 2023) in cooperation with the farm, including economic analyses.

In Northern America another model, "Regenerative Agriculture" is being adopted by bigger agricultural enterprises – this model encompasses some practices promoted by permaculture (care for soil, biodiversity, no or reduced tillage, etc.), however without any direct reference to Permaculture itself. The best known practitioner and pioneer of Regenerative

Agriculture is Gabe Brown (Brown's Ranch, Bismarck, ND, United States) (*Brown's Ranch*, 2023), whose project is being followed by the Center for Regenerative Agriculture and Resilient Systems at the California State University Chico (*Center for Regenerative Agriculture and Resilient Systems*, 2023).

In less developed countries several families manage their plots according to permaculture principles – partially as governmental programs or projects from non-governmental organisations (Gambiza & Didarali, 2019),

In some cases, e.g., in Cuba, permaculture is also perceived as a possibility to practice (religious) faith which had been suppressed by the communistic government (Caraway, 2020). In other regions, e.g., in South America, it is perceived by some as "yet another colonialist development of well-meaning Northerners" (Conz, 2018).

2.2 Permaculture Principles

Permaculture is based on a series of principles, which come in three more or less similar variations (see Appendix 2):

1. The principles deducted from Mollison's and Slay's work, "Introduction to Permaculture" (Mollison & Slay, 1991), where a total of 11 principles, including attitudinal principles, are deducted in the various chapters.
2. The 15 principles described in detail by David Holmgren in his work "Permaculture" (Holmgren, 2002) including 3 ethical principles which are the most often mentioned principles.
3. The 14 principles proposed by Toby Hemenway in his work "Gaia's Garden" (Hemenway, 2009).

Table 1: Permaculture principles by Bill Mollison, David Holmgren, and Toby Hemenway

	Mollison	Holmgren	Hemenway
1	Relative location	Observe and interact	Observe
2	Each element performs many functions	Catch and store energy	Connect
3	Each important function is supported by many elements	Obtain a yield	Catch and store energy and materials
4	Efficient energy planning	Apply self-regulation and accept feedback	Each element performs multiple functions
5	Using biological resources	Use and value renewable resources and services	Each function is supported by multiple elements
6	Energy cycling	Produce no waste	Make the least change for the greatest effect
7	Small-Scale Intensive Systems	Design from patterns to detail	Use small-scale, intensive systems
8	Accelerating succession and evolution	Integrate rather than segregate	Optimize edge
9	Diversity	Use small and slow solutions	Collaborate with succession
10	Edge effects	Use and value diversity	Use biological and renewable resources
11	Attitudinal principles	Use edges and value the marginal	Turn problems into solutions
12		Creatively use and respond to change	Get a yield
13		Care for Earth	The biggest limit to abundance is creativity
14		Care for people	Mistakes are tools for learning
15		Limit consumption and production, and redistribute surplus	

These principles are very general, and only marginally refer to agricultural methodologies. They rather serve as design principles, and when training to obtain the Permaculture Design Certificate (PDC), course participants are to apply these principles for each element added to the project, and to re-iterate this practice with every newly added element not only for the new element, but for all so far existing elements as well, to warrant maximum efficiency of the respective project. For example, the principle "edge effect" applies to all physical structures included in the project – with each new element, edge effects with already present elements will have to be considered.

Several activists claim that permaculture gardening and farming not only warrants rich yields, but also that it requires much less resources, including labour. Svoboda, for example, claims that setting up a vegetable bed the right way from the beginning will ensure that no further maintenance of the soil is needed, labour associated with pest and weed control will be minimal (Svoboda, 2009). He also claims that there's no need to prune fruit trees – fruits may get smaller, but this would be balanced by a higher number of fruits. Other practitioners though contradict these claims (Strouts, 2016).

2.3 Organisation and Practice of Permaculture

2.3.1 Organisational aspects

Permaculture is a global movement which started in Australia and is organised on a national or regional basis. Based on their website (*Permakultura (CS)*, 2023), social network activity and newsletters, the activity of the Czech institution, Permakultura (CS) is described in the following paragraphs as a representative example.

Permakultura CS provides educational activities, publications, and encourages networking of various individuals and companies practicing permaculture, or affine to it.

Courses offered through the platform Akademie Permakultury (*Akademie permakultury*, 2023) encompass courses of permaculture design, at various levels, courses of specific aspects of gardening (not farming), such as (rain and sewage) water management, food forests, edible weeds, soil, herbs and their therapeutic use, production of seeds, scything, canning, and preserving food products.

Permakultura (CS) also publishes a biyearly edition of handbooks, focussing on these same topics, compiled by various authors and specialists. These publications go far beyond the gardening scope, covering topics concerning sustainability, such as house technology and architecture, various sustainable technologies, self-sufficiency, minimalistic lifestyle, alternative economic systems, and others.

Permakultura (CS) furthermore organises a series of events, such as seed and seedling exchange fair, conventions, and it promotes activities like KomPot (*KomPot*, 2023), a communal gardening centre, where for a membership fee individuals cooperate, under professional guidance, to grow vegetables and fruit and divide the harvest amongst them.

2.3.2 **Practice of Permaculture in the Czech Republic**

Permaculture is put in praxis at various levels, from gardeners who'd like to change their traditional garden into an ecological space, or a step further, strive for self-sufficiency at various levels, up to complete independence from the current societal system (no public supply of water, energy, waste disposal, etc.), or leading a professional life using permaculture. Most of these businesses, in particular those with a gardening or farming activity, also offer various educational courses, as those mentioned above. Such farms are mostly small, with a cultivated area of 1–10 ha, as they avoid engine powered mechanisation, if possible. They often rely on volunteers, who work at the farm for a limited period in exchange for housing, food and training or experience.

Some businesses distribute, partially under the tag "Permaculture" or even with the help of permaculture organisations, various tools or materials for gardens and farms. Some hot topics are, e.g., silicate rock powder, "Terra Preta", biochar, "essential microorganisms", etc. Other distributers sell for example ecological sewage plants, pond biotopes (korenovky.cz), gardening tools (KlubOZ), and others.

2.4 Permaculture and Scientific Evidence

Many authors note that permaculture failed to meet Academia (Ferguson & Lovell, 2014), (Krebs & Bach, 2018) (McLennon et al., 2021) and, in consequence, there aren't many publications studying permaculture's claims and methods in a scientific way.

When evaluating permaculture practices, authors mostly review Permaculture principles. A systematic review of Holmgren's 12 principles (Holmgren, 2002) was performed by Krebs and Bach (2018). These principles, however, are rather design, ethical, and attitudinal principles, and no agricultural methods based on scientific evidence, which leads to a certain level of inconsistency of their practical application. The authors draw terminological analogies for the respective principle and list examples for which they sought evidence in the scientific literature. For example, for the principle "Observe and Interact" the terminological analogy was "design process management", and the example for which they listed publications as scientific evidence was "Adaptive management". A publication about "the investigation and improvement of the effectiveness of agro-environmental schemes in protecting the corn bunting" was referred to as scientific evidence for this principle (Krebs & Bach, 2018).

Permaculture associations and activists build their claims on case studies rather than on scientific evidence. Though some case studies are impressive (see chapter 4, Case Studies), this bears two important disadvantages for making judgements on the validity of these claims:

1. These case studies are reviewed without comparator.
2. A bias is introduced by considering successful case studies only, while unsuccessful ones remain unmentioned.

3 Support of Permaculture Practices in the Scientific Literature

3.1 Overview

To evaluate the reflection of permaculture agricultural methods in the scientific literature, a search was conducted in the Web of Science (WoS) database using the components of permaculture design as search topics (based on the items of the Permakultura CS questionnaire (see Appendices Appendix 1 – Qualification Questionnaire from Permakultura (CS)and Appendix 2 – Qualification Questionnaire from Permakultura (CS) –English version).

The literature search yielded from none or very few to several thousand results per topic (Table 2).

Table 2: No. of publications identified on Web of Science by questionnaire item. Only topics with more than one result are included. The key publications related to these topics are introduced in the sections indicated

Section	Questionnaire item	No. of publications
4.2.2	Well-conceived coenoses, mixed cultures, polycultures	10 206
4.2.4	Melliferous, repellent, disinfectant, and soil cover crops	20 503
4.2.5	Food forest	59 796
4.2.7.2	Garden pond, swimming pond with biotope	660
4.2,7,3	Greenhouse, heated greenhouse, hotbed	192 138
4.2.7.5	Swales and other structures to retain water	82 632
4.2.7.6	Trellises	1
4.2.7.8	Raised beds	15 433
4.2.7.9	Natural, flowery meadows	33 270
4.3.1	Natural methods, without chemicals/pesticides, herbicides, fungicides, industrial fertilisers	52 960
4.3.2	Use of organic fertilizers /compost, solid and liquid manures	8 326
4.3.3	Peat – not allowed	23
4.3.4	Purposeful soil improvement/green fertiliser, compost, soil organisms	616
4.3.5	Placement of birdhouses, structures for bats, bumblebees, snakes, and other small animals	191
4.3.9	Cultivation of mushrooms – outside/inside/mycorrhiza	416
4.3.10	No heavy mechanical tools	23

Section	Questionnaire item	No. of publications
4.3.14	Coppicing, wood production	4 387
4.3.15	No-till cultivation of cereals, minimalization of digging	856
4.3.16	Crop rotation	524
4.3.17	Green manure, catch crops, mulching	683
4.3.20	Hedges	575
4.3.18	Animal breeding	83

Krebs and Bach (Krebs & Bach, 2018) reviewed scientific publications supporting permaculture principles as listed by Holmgren (Holmgren, 2002). As already outlined in section 2.4 (Permaculture and Scientific Evidence) they listed examples of permaculture agricultural practices for each principle. Some of these examples match or at least overlap with items of Permakultura questionnaire evaluated in this thesis (Table 3).

Table 3: Examples of agricultural methods derived by Krebs and Bach (2018) from Holmgren's principles and related items on the Permakultura CS questionnaire

Principle (Holmgren)	Example listed by Krebs and Bach	Permakultura CS questionnaire item
Catch and store energy	Organic mulch application	Underseeding, catch crops, mulching (VI.17)
	Rainwater harvesting measures	Swales and other structures to retain water (V.b.5)
Apply Self-Regulating and Accept Feedback	Natural habitats in agricultural landscapes	Installation of boundaries and shelter shrubs and trees (VI.18)
	Wildflower strips	Natural, flowery meadows (V.b.9)
Use and Value Renewable Resources and Services	Legumes and animal manure as nutrient source	Use of organic fertilizers / compost, solid and liquid manure (VI.2)
	Mycorrhizal fungi	Cultivation of mushrooms – outdoors/indoors/mycorrhiza (VI.9)
Produce no Waste	Animal manure	Use of organic fertilizers / compost, solid and liquid manure (VI.2)
Design from Patterns to detail	Structurally complex agroforests in tropical climates	Food forest (V.1.5)
Integrate rather than segregate	Polyculture (crops)	Well-conceived coenoses, mixed cultures, polycultures (V.a.2)
Use Small and Slow Solutions	Agroforestry systems	Food forest (V.1.5)
		Guild / Underplanting of fruit trees with crops and lower shrubs (V.a.6)
Use and Value Diversity	Pollinator diversity	Hedges/edible fruits for people or birds, nesting, insects (V.b.8)
	Habitat diversity	Placement of birdhouses, structures for bats, bumblebees, snakes, and other small animals (VI.5)
		Natural, flowery meadows (V.b.9)
		Installation of boundaries and shelter shrubs and trees (VI.18)
Use edges and Value the Marginal	Field margins	Hedges (VI.20)

3.2 Questionnaire items not included in the literature search

The questionnaire (Appendix 1) lists a total of 127 items, 52 of which concern agriculture or ecology, whilst the rest are either of administrative nature (20 questions), concerning buildings on premises (37 questions), self-sufficiency, or social engagement / alternative economic initiatives, as well as educational background and teaching activity.

Sections I–III of the questionnaire are of administrative or informational nature and are therefore not subject to a literature search. Sections VII ("House"), VIII ("self-sufficiency"), X ("Community"), and XI ("Permaculture background and teaching activity") are not of an agricultural nature and were thus also not subject of the literature search.

Section IV concerns permaculture design practices, but the design items are either specific to the permaculture concept (e.g., "consideration of sectors"), or too general ("design considers potential crisis events"). Again, either no literature search was performed, or – if attempts were made (e.g., zoning) – no relevant hits were generated. Also, several of the items from sections V. and VI. were too general for a literature search:

V.a1	Cultivation of edible crops, herbs, and fruit trees
V.a6	Guild / underplanting of fruit trees with crops and lower shrubs
V.a7	Plant layers
V.b1	Stone structures for sun affine herbs (e.g., mound, spiral, etc.)
V.b3	Greenhouse, heated greenhouse, hotbed
V.b4	Sun trap
V.b6	Trellises
V.b8	Hedges/edible fruits for people or birds, nesting, insects
VI.3	Peat not allowed
VI.5	Placement of birdhouses, structures for bats, bumblebees, snakes, and other small animals
VI.6	Sedges, basket willows
VI.7	Offer of seedlings
VI.8	Seed production
VI.9	Cultivation of mushrooms – outside/inside/mycorrhiza
VI.11	Organic farming, "Bio" certification
VI.12	Cultivation of crops for energy production
VI.13	Cultivation of native species / varieties / perennial vegetables
VI.14	Coppicing, wood production
VI.18	Installation of boundaries and shelter shrubs and trees

VI.19 Windbreakers

VI.20 Hedges

Also, section VI, subsection "Animal breeding" was considered to be too general for conducting a meaningful literature search – it queries whether animals are kept in accordance with their natural needs and in an ethical manner, and the respective types of animals bred are to be indicated.

Items V.3, "Crops with reciprocal positive influence" relates directly to item V.2 "Well conceived coenoses, mixed cultures, polycultures", as does VI.17, "Underseeding, catch crop, mulching". All these topics were therefore merged with V.2, except for mulching, for which a separate literature search was performed. Item VI.10, "No heavy mechanical tools" was assessed together with item VI.15, "No-tillage cultivation of cereals, minimalization of digging.

Section VI, subsection "handicrafts" was considered not to be an agricultural topic.

3.3 Garden

3.3.1 Well-conceived coenoses, mixed cultures, polycultures

As De Liedekerke de Pailhe (2014) writes in his thesis, intercropping is being used by some farms, amongst them "La ferme biologique du Bec Hellouin" (see the respective case study: chapter 4.1) for an intensive organic vegetable production. According to this paper, intercropping at this farm is done with the aim to:

1. Increase productivity per square meter
2. Increase time and energy efficiency
3. To mimic the natural ecosystem
4. To increase production stability
5. To increase aesthetics of the cultivated plots
6. To decrease pert, disease and weed pressure
7. To attract pollinators

De Liedekerke de Pailhe (2014) concludes that intercropping makes sense when farmers "seek for ecological intensification". Using associated cover crops, intercropping may result in lower interspecific competition and a higher efficiency of resources (as compared to sole cropping), resulting in higher yields., The benefits intercropping can provide range from "lower production costs, higher production stability", to "reinforcement of the ecosystem services resulting in a decrease in pest, disease and weed pressure, higher pollination rates, and a better soil structure and water availability" (De Liedekerke de Pailhe, 2014).

Gitari et al. (2020) confirm that intercropping is an interesting alternative, in particular for small farmers – whilst the yield of intercropping (potatoes – dolichos, or potatoes – beans) slightly decreased with respect to the respective monocultures, intercropping resulted in an economic advantage for the farmers. This advantage grew with the respective concentration of legumes.

3.3.2 Melliferous, repellent, disinfectant, and soil cover crops

Garibaldi et al. (2011) applied a mathematical model to show that a decrease or high variability of pollinators have a negative impact on yield mean and stability. Krebs and Bach (Krebs & Bach, 2018) conclude that this result implies that a higher biodiversity in terms of pollinators, which is proportional to the biodiversity of melliferous plants and the diversity of pollinator habitats (which relates to questionnaire item VI.5 "Placement of birdhouses, structures for bats, bumblebees, snakes and other small animals"), will contribute to stabilise the pollinator population.

Gaffke et al. (2021) describe several examples of plants attracting insects being natural enemies of determined weeds, and there use to control these weeds as part of an integrated weed control. In 2012, Parolin et al. (2012) described various categories of plants which through different mechanisms function as pest control plants and illustrates why such systems are rarely adapted.

Unger and Vigil (1998) studied the impact of cover crops on soil properties and concluded that cover crops are beneficial as long as they are well-managed – the main negative effect of cover crops is competition for water with the primary crop, however in humid climates this is generally not an issue. In arid and semiarid conditions cover crops should be replaced by mulch.

Ward et al. (2012) came to a similar conclusion after investigating the effect of cover crops in an Australian region with a semiarid climate – the cover crops had little to no influence on evapotranspiration as well as on deep drainage of the subsequent crops as compared to the conventional technique.

3.3.3 Food forest

Permaculture food forests – with their 7 layers of edible plants, and potential integration of livestock – are relatively complex agroecosystems and represent a key ambition of many permaculture projects.

Existing food forests focus not only on food production, but also socio-cultural, educational, regenerative and sustainability services, as results from a paper of Albrecht and Wiek (2021). They conclude that the more than 200 food forests analysed (most of which are in Northern America and Europe) perform well in terms of "socio-cultural and environmental criteria by building capacity, providing food, enhancing biodiversity, and regenerating soil, among others", however they would not perform well enough in economic terms, which limits the spreading potential of food forests as a business model.

3.3.4 Garden pond, swimming pond with biotope

The literature search yielded no publications discussing garden ponds in the context of agroecology or farming activities. However, some publications studied garden ponds and their impact on biodiversity, e.g., Gaston et al. (2005), who found that rather small garden ponds with a volume of 28 litres will attract invertebrates and can maintain a population of *Daphnia* introduced to these ponds over the study period of nearly two years. They assume that bigger ponds may attract more species, including amphibians.

Hill and Wood (2014) found that the biodiversity in urban garden ponds is lower than in field ponds. On the other hand, because they are often managed by their owners (sediment dredging, macrophyte removal, installation of artificial fountains), they attracted a few taxa which would normally not be seen in field ponds e.g., caddisfly larvae (*Hydropsyche angustipennis*, *Limnephilus lunatus,)*. They conclude that garden ponds may therefore play an important role in conserving urban-macroinvertebrate biodiversity. These findings are confirmed in another paper of Hill et al. (2021), in which they also underline the importance to issue clear guidance for pond-owners on how to manage these ponds to achieve best results.

3.3.5 Swales and other structures to retain water

Yuen et al. make the case for water harvesting techniques, including swales, in underdeveloped areas, where the water needs of remote settlements cannot be met by potable water supply. Harvested rainwater – although not potable – can help safe the more precious sources of potable water, and thus reduce the water shortage of such settlements (Yuen et al., 2001).

The same principle became central to successful water management by small communities in dry areas of India, promoted by the Watershed Organization Trust (WOTR; https://wotr.org).

3.3.6 Raised beds

Govaerts et al. (2007) studied chemical and physical soil properties in raised bed cultivations of maize and wheat in the Mexican highlands. They conclude that this system comes at reduced costs (no tillage) and preserves soil quality if crop residues are left on the surface.

Alagöz et al. (2020) compared tomato yield in raised versus flat beds and found that crops cultivated in raised beds not only contained significantly ($p < 0.01$) more chlorophyll – also the yield per plant was significantly higher than in the flat bed. Also soil microbial biomass carbon, soil CO_2 production, and soil compaction was negatively correlated with yield.

3.4 Gardening and Farming Methods

3.4.1 Natural methods, without chemicals/pesticides, herbicides, fungicides, industrial fertilisers, …

Boydston (2010) investigated weed pressure in potato cropping systems and concluded that weeds can be effectively suppressed by a well-planned crop-rotation, by planting cover crops, and by sanitation practices (perennial weeds often spread from equipment or tubers).

However, as several other authors (Lewis et al., 2020) he is prone to integrate non-specific organic herbicides into the weed control system.

Other publications however also suggest that inorganic fertilizers, when correctly dosed and when combined with organic fertilizers – may actually increase soil microbial activity as well as maximise yield or crops, such as wheat and maize (Salehi et al., 2017) (Singh, 2018).

Muneret et al. (2018) investigated biological pest control in vineyards. The authors concluded that organic farming was beneficial in stabilising ecosystem services of biological pest control, but seminatural habitats in the landscape would reduce these services. This applied to moth egg removal rates, larval removal rates as well as weed seed removal rates, which were always higher in organic fields than in conventional fields. The author also emphasised that the use of pesticides tends to reduce the biological pest control potential.

3.4.2 **Use of organic fertilizers /compost, solid and liquid manures**

De Tombeur et al. (2018) conducted a study at the Ferme biologique du Bec Hellouin to investigate the effect of permaculture practices on soil physical properties, comparing soils in permaculture farming implemented for 7 years with soil under pasture and soil under similar geological and climatic conditions which was managed conventionally. Permaculture practices consisted of the exclusion of pesticides and the use of 225–330 tons of horse manure per hectare (wet weight). The concentrations of organic carbon and nitrogen were higher in permaculture soils, which was attributed to the high inputs of manure and compost, which led to higher concentrations of bio-available nutrients Ca, Mg, K, and P. The level of macroaggregation was similar to soil under pasture, however well above that under conventional practice. Organic carbon concentrations were higher in the bigger aggregates, however not in the smallest fraction when compared to soil under pasture. The authors conclude that the practices investigated considerably increase nutrient bioavailability as well as soil organic carbon.

3.4.3 Purposeful soil improvement/green fertiliser, compost, soil organisms …

Green fertilizers and compost are confirmed to be effective by the authors cited in paragraphs section “3.3.3 Raised Beds” with Govaerts concluding that cover crop residues must remain on raised beds for effectivity reasons (Govaerts et al., 2007), and in section “3.4.2 Use of organic fertilizers /compost, solid and liquid manures”, with de Tembeur finding that the use of significant amounts of horse manure and compost and the exclusion of pesticides improve nutrient bioavailability as well as soil organic carbon content, as compared to soil under pasture or conventionally managed agricultural soil.

Piotrowska and Boruszko (2023) studied the impact of a liquid microbial preparation offered under the trademark Effective Microorganisms® (EM) (Higa, 1991) ("Effective Microorganism", 2023) on plant production. They concluded that the preparation had beneficial effects especially on the uptake of microelements. They ascribe this result to the role of microorganisms in the mineralization of organic carbon which improves the bioavailability of nutrients.

A positive effect of Effective Microorganisms was reported also by Hu and Qi, who found that after the application of effective microorganisms together with compost on wheat fields, the total nematode population in the month May was 43,21% higher than in plots fertilised with compost alone, with wheat grain yield being correlated with soil free-living nematodes during the jointing stage of wheat growth (Hu & Qi, 2013).

On the other hand, Mayer et al. (Mayer et al., 2010) did not find any positive effect of the Effective Microorganisms on crop yields and soil microbial parameters when the possible effect of the microbial medium was filtered out in a 4-year long field experiment. Although there is no doubt on the beneficial effects of balanced microbial communities on soil health and plant mineral nutrition, it seems that application of a particular mixture of microorganisms to a field culture may not always have reproducible results.

3.4.4 No-till cultivation of cereals, minimalization of digging

Many agricultural studies document the advantages of the no-till cultivation systems. Spargo et al. (2008) found that no-till cultivation has the potential to increase soil N retention. This was documented by experimental data comparing no-till systems on three soil types, over the duration of 0-14 years, with a crop rotation of corn (*Zea mays)*, wheat (*Triticum aestivum)* or barley (*Hordeum vulgare)* and double-crop soybean (*Glycine max)*.

Another paper covers similar studies conducted in Eastern Canada, which however confirmed that the success of no-till systems varies over years, which is one of the reasons why many organic farmers in this region hesitate to adopt this system (Halde et al., 2017).

It was also confirmed that soil compaction due to heave machine traffic or tillage negatively affects the soil nitrogen economy, nutrient transformation and uptake by plants, and demonstrates adverse effects on root growth and configuration (Lipiec & Stępniewski, 1995).

At the 27th International Symposium on Agricultural Engineering, Zimmer et al. (1999) presented data demonstrating an inferior corn yield obtained by non-tillage systems. However, the decreased production costs and the reduced soil compaction due to less machine passes made up for the inferior yield. Furthermore, the data showed that the upper soil layer had 34% more cellulolytic microorganisms, which contributed to a faster and better decomposition of harvesting residues.

3.4.5 Crop rotation

Crop rotation is a time-tested agronomic practice, which is nevertheless frequently abandoned in modern agriculture for economic reasons. There are numerous scientific studies demonstrating its positive effects. For instance, Mukhametov et al. (2021) found that crop rotation increases water resistance of soil aggregates, the amount of detritus in the soil as well as the amount of soil aggregates (Mukhametov et al., 2021).

In a literature review, Liebmann and Dyck came to the conclusion that crop rotation can effectively contribute to suppressing weed densities, which, as they believe, results from varying patterns of resource competition, allelopathic interference, soil disturbance as well as mechanical damage to specific weeds (Liebman & Dyck, 1993).

3.5 "House, Self-Sufficiency, Permaculture Background and Teaching Activity

As permaculture developed, from an agricultural farming and gardening method, to a movement for sustainable life and social fairness, more attention was devoted to other aspects of daily life, e.g., buildings, social aspects, and – finally – education and teaching. These topics are not agricultural methods and were thus not subject of the literature search. Nevertheless, they will be briefly introduced because of their relevance to sustainability.

3.5.1 House

The questionnaire investigates the projects' ways to sustainably use water (grey water recycling, reducing consumption of groundwater, collecting rainwater, etc.), energy, use of the house or parts thereof as a productive element of the project (winter garden, garden balcony or terrace, green roof, etc.), as well as to the building materials and methods themselves.

3.5.2 Self-Sufficiency

Although current permaculture practitioners are mostly gardeners aiming at some degree of self-sufficiency, this section is devoted rather to the social embedding of the project, asking for cooperation with local or international organisations fostering regional distribution, fair trade, support of permaculture community projects (e.g., community gardens), etc.

3.5.3 Permaculture Background and Teaching Activity

The global permaculture movement is organised through several national and some international non-profit organisations, which are independent from each other. They unite around permaculture educational activities, culminating in the so-called PDC courses – Permaculture design certificate courses. Individual members offer additional courses on specific topics, which may vary from cutting meadows with the scythe to preserving fruits and vegetables, building greenhouses, collecting, and storing seeds, etc. Furthermore, so-called project networks are maintained on a national level, which list the respective permaculture project – the questionnaire used for this paper is indeed the tool used in Czech Republic to qualify such projects as eligible or not eligible and classify eligible projects as "projects with permaculture elements", "permaculture showcase project", or "regional centre of permaculture".

4 Case Studies

4.1 La Ferme biologique Bec-Hellouin

La Ferme biologique du Bec Hellouin is a small farm of approximately 20 hectares, claiming to have created an edible landscape by following the principles of permaculture.

La Ferme biologique du Bec Hellouin is a permaculture showcase study, and is – as far as we were able to find out – the only similar project to be under continuous scrutiny of Universities and research institutes which analyse their performance in terms of soil quality (de Tombeur et al., 2018), (Bourguignon & Bourguignon, 2018), intercropping performance (De Liedekerke de Pailhe, 2014), economic viability (Morel et al., 2016), as well as yearly economic performance reports by Institut Sylva, a research institution closely associated with the farm itself.

The project was described in detail in an article published in Agroecology and Sustainable Food Systems (Morel & Léger, 2016). It includes a whole series of elements listed in the analysed questionnaire, which are connected in a logical way.

The project also runs a permaculture school and attracts volunteers who work at the farm to gather experience.

This project is particularly interesting because it seems to demonstrate the agricultural as well as economic viability of a small organic farm using which follows sustainable principles to an extraordinary extent.

4.2 Sepp Holzer's Krameterhof

Sepp Holzer is a well-known figure in permaculture, and his book "Sepp Holzer's Permaculture – A Practical Guide to Small-Scale Framing and Gardening" is considered a must-read in the permaculture community.

The farm was operated conventionally by his father, and Holzer claims, that when he took over, he realised the need to dramatically change the way the farm was managed, towards a healthy and ecologically management of its natural resources.

He also claims that he heard and read about permaculture only in 1995 and realised that his way of managing his farm was in line with its principles. Indeed, it is not rare that prominent permaculture figures state that permaculture is about following common sense rather than adhering to a series of dogmas.

The Krameterhof is a relatively small farm with 45 hectares, located in the Salzburg region on the southern slope of a mountain, 1.000 – 1.500 meters above sea level.

Holzer's book gives several examples of intelligent solutions for successfully managing a farm in a non-favourable climate, the most well-known one being his use of pigs for ploughing up the ground of areas on which he intends to grow crops – the pigs can express their natural behaviour and find fodder, the soil is prepared for growing cash crops, with little labour and at no cost for mechanisation or fossil fuels.

The project was not scientifically or otherwise analysed, only Holzer's own reports / books are available.

Holzer is running projects all over the world (see www.seppholzer.at) and is lecturing at various Universities.

4.3 Permaseminka

Permaseminka is a business located in the Czech Republic.

The core business is the production and sale of seeds for ecological gardening.

The vision of the owner, according to his website, is to progressively create, grow and maintain a collection of non-hybrid, old, regional, and other non-industrial or forgotten species, which are suitable for cultivation without chemicals in normal gardens, and which can be further used for seed production. Much time is devoted to identifying rare or hardly available species from local gardeners, ecological breeders, related seed organisations or gene banks. New species are tested, reproduced, and those which proofed suitability are made publicly available.

In addition to the sales of seeds, the owner of the business also organises permaculture design courses. In former years courses about seed production and nutrition safety in context with self-sufficiency were offered as well, however these are apparently not offered anymore as of 2017.

Permaseminka operates a total of 3 websites, www.permaseminka.cz, www.permazahrada.cz, and www.potravinovezahrady.cz with overlapping content. Of interest for the purpose of this thesis may be Kvapil’s view on permaculture – according to Kvapil, permaculture is not recommending any particular gardening or farming techniques, but rather outlining a series of possibilities from which one can choose, and which have to be verified on site, relating also to the myth, that the result of setting up a permaculture garden is effortless growing of crops, with labour limited to their harvest.

This case study is an example of a business under the “flag” of permaculture, though it could limit itself to organic farming, with the same range of offers. The link to permaculture may be due to a personal bond of the owner, or there could be marketing reasons.

Permaseminka has been active since 2012, i.e., for more than 10 years. Despite no official numbers are available, this duration suggests that the business is profitable.

Permaseminka is not a permaculture project on the list of Permakultura (CS), it is however under the surveillance of the responsible Czech authority (ÚKZÚZ) and certified as an organic farmer by Biokont.

5 Discussion

The purpose of the questionnaire analysed in this thesis aims to qualify mainly projects of gardeners or farmers as "permaculture showcase project" or "project with permaculture elements", according to a list of items, which are considered characteristic for permaculture. We considered this questionnaire an interesting tool to investigate whether permaculture – as characterised by Permakultura CS through this questionnaire – is based on solid scientific background.

Permaculture as described by its godfathers Mollison and Holmgren (Holmgren, 2002), (Mollison & Slay, 1991), relies mainly on empirical knowledge, and attempts to mimic natural ecosystems. By banning inorganic substances, in particular herbicides, pesticides and fertilisers, permaculture relies on cultivation techniques from former times, and calls for each practitioner to refine them based on the results obtained in the respective location and its environmental and climatic conditions, which need to be profoundly analysed during the design process.

The questionnaire, as detailed as it is, indeed reveals that permaculture is more about the design process than about specific techniques or methods. These were rather developed and shared as best practices over time, and every practitioner may use them, modify them, or neglect them, according to his best assessment of the situation in loco.

5.1 Non-Agricultural Aspects

Although this thesis concerns mainly the agricultural aspects of permaculture, it is interesting to notice the interest given to the buildings on premises, obviously assuming that this is a house where the project owner and his family / community lives, and its independence from big suppliers, energy suppliers foremost. Other key areas permaculture organisations world-wide focus on are self-sufficiency, local or regional social involvement, and permaculture education as well as teaching and promoting permaculture ideas and practices.

5.2 Agricultural Aspects of Permaculture

The literature searches conducted yielded evidence for agricultural permaculture practices as listed in the questionnaire, in particular for:

1. Well-conceived coenoses, including intercropping, crops attracting pollinators, pest- and weed-repellent crops, where the potential of such coenoses was confirmed (De Liedekerke de Pailhe, 2014), (Garibaldi et al., 2011), (Gaffke et al., 2021), (Gitari et al., 2020), (Parolin et al., 2012). Some authors however found that cover crops may not be as useful as propagated, in particular in semiarid and arid climates (Unger & Vigil, 1998), (Ward et al., 2012).
2. Food forest systems, which's functionality even beyond the mere food production were described and confirmed. Food forests however do not appear to currently yield sufficient profit to make them attractive from a commercial point of view, which limits a broader application (Albrecht & Wiek, 2021).
3. Ponds appear to contribute to biodiversity, which – although not an agricultural method per se – attracts macroinvertebrates and amphibia (Gaston et al., 2005) which may contribute to pest control, and increases biodiversity (Hill et al., 2021) and might thus contribute to the resilience of the agroecosystem.
4. Swales and other structures to retain water safe precious potable water resources in arid climatic regions (Yuen et al., 2001). Although most permaculture projects are located in regions with sufficient rainfall, climate change and the accompanying changes in water circulation (longer drought periods, fewer nut more intense rainfalls) such structures may well serve the purpose also in these regions.
5. Raised beds reduce costs (Govaerts et al., 2007) and may increase the yield of crops, such as tomatoes (Alagöz et al., 2020), what makes them interesting for small farmers and gardeners.
6. Weed and pest control without chemicals, pesticides or herbicides appears to be feasible, e.g., crop rotation (Boydston, 2010), or making use of the pest control ecosystem service as investigated by Muneret et al. on organic vineyards (Muneret et al., 2018). However, several publications suggest that these measures should be integrated with organic herbicides for better efficacy.
7. Organic fertilizers (e.g., horse manure and compost) and the avoidance of pesticides are effective in improving soil quality (nutrient bioavailability as well as soil organic carbon content of soil aggregates), as shown on the permaculture farm La Ferme biologique du Bec Hellouin (de Tombeur et al., 2018). The case studied used 225 – 330 t of horse manure per hectare, which corresponds to approximately 80–120 kg of nitrogen, assuming a nitrogen content of 0,36% (*Managing and composting horse manure*, 2023), which is in line with the average amounts of industrial nitrogen fertilisers (112,63 kg) used in Czech Republic in 2020 (*Nutrient nitrogen N (total) - Use per area of cropland (kilograms per hectare)*, 2023).

The use of effective microorganisms may a topic of further research, as it may be called at least controversial (Piotrowska & Boruszko, 2023), (Mayer et al., 2010).

Several questionnaire items were not subject of the literature search or yielded no hits, however it may be worth discussing these briefly as well.

1. The design principles (items V.1 – IV.7) are a core aspect of permaculture (Mollison & Slay, 1991), and it may be interesting to compare the permaculture concept of designing an agricultural project with a conventional way of designing it, and to identify possibilities to integrate the strengths of both.
2. Several items relate to using space as efficiently as possible (underplanting fruit trees, plant layers including climbers, trellises), and partially relate to "urban permaculture", where – among others - balconies and roofs are used to grow edible crops.
3. Other items relate to structures which may have a positive impact on plants grown, e.g., suntraps which store thermal energy and radiate it back after sunset, benefitting thermophilic plants, such as peach trees *(Prunus persica)* or apricot trees (*Prunus armeniaca).* Herb spirals allow to plant various herbs, according to their preferences, on a more sunlit or rather shadowy side of the spiral, and still grow all herbs in the same spot.
4. Several structures or methods aim at increasing the biodiversity – hedges, birdhouses, structures for bats, bumblebees, snakes, and other small animals, installation of boundaries and shelter shrubs and trees, cultivation of native species / varieties / perennial vegetables.
5. Coppicing, wood production, sedges, basket willows, cultivation of crops for energy production shall increase self-sufficiency in terms of energy and materials.

6 Conclusions

The interest of the public and scientific community in permaculture has steadily increased over the last years. The focus of scientific publications has been either on agricultural aspects of permaculture (Ferguson & Lovell, 2014), (Krebs & Bach, 2018), (McLennon et al., 2021), social or religious aspects (Caraway, 2020), (Gambiza & Didarali, 2019), (Massicotte & Kelly-Bisson, 2019) or using the design process as an educational tool. (Martins et al., 2021).

Permaculture has also been a topic of some theses, which typically focus on specific projects (Gajdušková, 2010), (Susanin, 2015), but there have also been analyses of agricultural practices used in permaculture projects (De Liedekerke de Pailhe, 2014).

The conditions to be fulfilled for qualifying as a showcase permaculture project by Permakultura CS suggest that the standard project is a food producing family farm, aiming either at self-sufficiency, or at local distribution of food products, striving for highest standards of sustainability.

Rather than analysing agricultural practices recommended by permaculture, in future it may be more interesting to compare permaculture design practices with the way conventional or organic farms are designed and realised, perform the respective SWOT analyses, and try to identify solutions to combining the respective advantages.

According to a contribution on Permakultura CS' Facebook channel, Bill Mollison stated that the biggest change manhood needs to implement is to convert from consumers to producers – if only 10% would do that, there would be enough for everybody. Although this number of 10% may seem low, it's much higher than the number of people dreaming of being a full-time farmer, and willing to take on the burden of cultivating an organic food-producing garden. The socioeconomic ramifications may not find everybody's approval, which could be a reason for rejecting the entire movement.

On the other hand, permaculture is an interesting, intelligent, and creative way of looking to agricultural production. It's a source of ideas Although it may not seem like an attractive full-time occupation to many, the ideas and practices of permaculture are often used by hobby gardeners who do not rely on the produce for their living, but enjoy the variety of structures, crops, products, and activities in their spare time.

7 Appendices

7.1 Appendix 1 – Qualification Questionnaire from Permakultura (CS)

Dotazník k vyhodnocení projektu pro zařazení do Sítě permakulturních projektů

v případě 1 hodnotitele je uveden důvod

Jména hodnotitelů :		
Datum hodnocení:		
I. Prohlášení:		
Souhlasím se zveřejněním informací o projektu včetně kontaktu. Souhlasím s možností návštěv po předchozí domluvě.		
II. Základní údaje		
1) **A)** název projektu		
B) jméno majitele/ realizátora, případně kontaktní osoby		
2) kontaktní údaje: e-mail		
telefon		
webové stránky, FB, aj.		
3) poštovní adresa:		
PSČ:		
4) rok založení, začátek práce na projektu		
5) výměra pozemku / zastavěná plocha		
6) krátká charakteristika projektu pro zveřejnění na internetu:		
III. Návštěva a spolupráce		
1) mám/máme zájem o pomoc při realizaci projektu A) dobrovolníci	ano	ne
B) placení brigádníci	ano	ne
2) mám/máme vlastní den otevřených dveří	ano	ne
Pokud Ano, kdy?		
3) jsem ochotný/á poskytnout bezplatnou konzultaci	ano	ne
5) jsem ochotný/á poskytnout placenou konzultaci, případně návrh designu	ano	ne
6) pravidelná otevírací doba	ano	ne
Pokud Ano, kdy?		
7) pravidelné akce pro veřejnost	ano	ne
Pokud Ano, jaké a kdy?		
POZN.:		
IV. Permakulturní design projektu		
1) využití principu zónování /zaškrtněte: 0, 1, 2, 3, 4, 5/	**ano**	**ne**
2) propojování prvků	**ano**	**ne**
3) kout divočiny /zóna 5/	**ano**	**ne**
4) důležité funkce jsou zajišťovány 2 a více prvky	**ano**	**ne**
5) zohlednění sektorů /S, J, V, Z, větry, vodní toky, rušivé výhledy atd./	ano	ne
6) zohlednění relativního umístění jednotlivých prvků v rámci celého projektu	ano	ne
7) design s ohledem na krizové události (vítr, oheň, povodně, sucho)	ano	ne
POZN.:		
V. Zahrada		
a) rostliny		
1) pěstování rostlin ke konzumaci, bylin, ovocných stromů.	**ano**	**ne**
2) promyšlená společenstva rostlin, smíšené kultury, polykultury	**ano**	**ne**
3) vzájemně prospěšné rostliny	ano	ne

1

4) medonosné, repelentní rostliny, dezinfekční, půdokryvné	ano	ne
5) jedlá lesní zahrada	ano	ne
6) guild /**podsadba ovocného stromu rostlinami a nižšími keři/**	ano	ne
7) rostlinná patra	ano	ne
POZN.:		
b) struktury - ***projekt musí mít alespoň 2 struktury***		
1) kamenné struktury pro sluncemilné bylinky (např. kopeček, spirála, aj.)	ano	ne
2) zahradní jezírko, koupací jezírko s biotopem	ano	ne
3) skleník, vytápěný skleník, pařeniště	ano	ne
4) sluneční past	ano	ne
5) svejly a další struktury k zadržování vody	ano	ne
6) treláže	ano	ne
7) vyvýšené záhony	ano	ne
8) živé ploty/**jedlé plody pro lidi, ptáky, hnízdění, hmyz**	ano	ne
9) přírodní/květnaté louky		
10) jiné struktury, napište:	ano	ne
POZN.:		
VI. Způsob hospodaření:		
1) přírodní hospodaření bez chemikálií /pesticidy, herbicidy, fungicidy, průmyslová hnojiva …/	**ano**	**ne**
2) použití organických hnojiv /kompost, hnůj, jíchy/	**ano**	**ne**
3) rašelina - NEsmí používat	**ano**	**ne**
4) cílené zúrodňování půdy /zelené hnojení, kompost, **půdní organismy…/**	ano	ne
5) umisťování ptačích budek, netopýrníků, čmelníků, hadníků a jiných breberníků	ano	ne
6) prutníky, košíkářské vrby	ano	ne
7) nabídka sazenic	ano	ne
8) osivaření	ano	ne
9) pěstování hub - venku/uvnitř/mykorhizní	ano	ne
10) hospodaření **bez použití těžké mechanizace**	ano	ne
11) ekozemědělství - certifikace „bio"/přechodné období	ano	ne
12) pěstování rostlin k energetickým účelům	ano	ne
13) pěstování původních druhů, odrůd/vytrvalé zeleniny	ano	ne
14) kopicování/pěstování dřeva	ano	ne
15) bezorebné pěstování obilí, minimalizace rytí	ano	ne
16) pestré osevní postupy	ano	ne
17) podsevy, meziplodiny, mulč	ano	ne
18) budování mezí a remízků	ano	ne
19) větrolamy	ano	ne
20) živé ploty	ano	ne
POZN.:		
Chov zvířat		
1) zvířata jsou chována v souladu se svými přirozenými potřebami, eticky	**ano**	**ne**
2) chov včel	ano	ne
3) drobné zvířectvo (drůbež, králíci, atd.)	ano	ne
4) větší zvířata (ovce, kozy, atd.)	ano	ne
5) dobytek (krávy, koně, lamy…)	ano	ne
6) chov ryb	ano	ne
7) ohrazené pastviny	ano	ne
8) pastevní přístřešky	ano	ne
POZN.: původní plemena?		
Řemesla - provozuje?	**ano**	**ne**
1) hlavní řemeslo – jaké	ano	ne
2) další řemesla – jaká	ano	ne

POZN.:		
VII. Dům		
a) počet obyvatel a převažující materiál konstrukce		
1) počet obyvatel /napište/		
2) materiál hlavní konstrukce (i kombinace):		
cihla/nepálená hlína/dřevo/sláma/kámen/jiný, jaký:		
POZN.:		
b) zajímavé prvky		
1) zimní zahrada	ano	ne
2) tepelná akumulace	ano	ne
3) zahrada na balkoně/terase	ano	ne
4) zahrada na střeše/zelená střecha	ano	ne
5) použití odpadů v designu (pneumatiky, staré koberce, kameny z jiné stavby)	ano	ne
6) použití lokálních materiálů/k přírodě šetrných materiálů	ano	ne
7) jiné	ano	ne
POZN.:		
c) vytápění		
1) pasivní, nízkoenergetický dům	ano	ne
2) dřevo	ano	ne
3) peletky, dřevěné brikety, štěpka	ano	ne
4) plyn	ano	ne
5) elektřina	ano	ne
6) tepelné čerpadlo	ano	ne
7) solární vytápění	ano	ne
8) jiné:	ano	ne
POZN.:		
d) zdroje vody		
1) zachytávání/uskladnění a využití dešťové vody	**ano**	**ne**
2) zachytávání povrchové vody (rybníky, jezírka)	ano	ne
3) využití podzemní vody (studna, vrt), **vyjádřete v procentech**	ano	ne
4) využití povrchové vody (zavlažování, užitková voda), **vyjádřete v procentech**	ano	ne
5) využití pitné vody z obecního vodovodu, **vyjádřete v procentech**	ano	ne
POZN.:		
e) hospodaření s odpady		
1) kompostování	**ano**	**ne**
2) recyklace (jaká)	**ano**	**ne**
3) využívání šedé vody	ano	ne
4) kompostovací/separační toaleta	ano	ne
6) reusace – znovu využití za jiným účelem, skladování nevyužitého odpadu na pozemku	ano	ne
POZN.:		
f) zdroje energie		
1) využití solárních kolektorů (vytápění nebo příprava TUV)	ano	me
2) využití fotovoltaických panelů k produkci elektřiny	ano	ne
3) využití energie větru (výroba elektřiny, čerpání vody, atd.)	ano	ne
4) využití energie vody (výroba elektřiny, hnací síla, atd.)	ano	ne
5) využití energie biomasy k výrobě tepla	ano	ne
6) využití energie biomasy k výrobě elektřiny nebo hnací síly	ano	ne
7) připojení k el. síti či plynu – odběr od veřejného poskytovatele	ano	ne
8) využití plynových bomb	ano	ne
9) ostrovní systém	ano	ne
POZN.:		

trvale neobvdlen

IX. Soběstačnost		
1) potravinová: vyjádřete v procentech	ano	ne
2) vytápění, ohřev vody: vyjádřete v procentech	ano	ne
3) elektřina: vyjádřete v procentech	ano	ne
POZN.:		
X. Komunita /musí být členem alespoň 1 typu /		
1) komunita v místě projektu (např.: cohousing)	ano	ne
2) komunita v rámci blízkého okolí (obec, nad rámec běžných sousedských vztahů)	ano	ne
3) rozprostřená komunita (v rámci regionu, ČR)	ano	ne
4) provozování LET systému nebo zapojení do něj	ano	ne
5) lokální fair trade a podobné sítě	ano	ne
6) investiční fond, družstvo	ano	ne
7) komunitní zahrada	ano	ne
8) lesní mateřská školka	ano	ne
9) KPZ	ano	ne
10) je členem Permakultury (CS)	ano	ne
11) WWOOF	ano	ne
POZN.:		
XI. Permakulturní vzdělání a vzdělávání		
1) realizátor projektu má úvodní kurz permakulturního designu	ano	ne
2) realizátor projektu má úplný kurz permakulturního designu PDC	ano	ne
3) realizátor projektu je diplomovaný permakulturní designer DPD	ano	ne
4) v místě je výukové centrum - kurzy, workshopy aj.	ano	ne
5) realizátor pořádá kurzy, workshopy aj. v jiných místech	ano	ne
POZN.: //vypište vzdělání/ účast na kurzech//		
Zpracováno v roce 2010.		
Upraveno v roce 2015, 2016 pro účely SUPP kolektivem hodnotitelů, upraveno v roce 2020.		

Kritéria pro zařazení do Sítě ukázkových permakulturních projektů

Projekt splňuje základní (vytučněná) kritéria v dotazníku a zároveň:

1) Projekt se řídí etickými permakulturními principy, v rámci projektu realizuje permakulturní design.

2) Majitelé/realizátoři projektu jsou ochotni sdílet informace o svém projektu s veřejností, po předchozí dohodě poskytovat prohlídky návštěvníkům, souhlasí se zařazením projektu do mapy ukázkových permakulturních projektů na webu www.permakulturacs.cz

3) Součástí projektu je aspekt pěstování potravy.

4) Hospodaření je bez chemie – ekologické, šetrné zacházení s půdou, vodou, krajinou, etické zacházení se zvířaty s respektem k jejich přirozeným potřebám.

5) Projekt má potenciál inspirovat návštěvníky, být pro ně vzorem, alespoň po některých stránkách.

V..dne...................................

Realizátor/ka　　　　　　　　　　　　Hodnotitelé za Permakultura CS

PRO HODNOTITELE

Stupeň A "Projekt s permakulturními prvky"

4

1) realizátor umí vysvětlit základy PK
2) velmi dobře vytvořené 2 struktury dle PK principů
3) alespoň 3 zóny /0, 1, 5/, zona 0 nemusí být
4) shaha o propojování stuktur a cyklů

Stupeň B „Ukázkový permakulturní projekt"

1) realizátor umí vysvětlit permakulturní principy a zásady
2) vzdělání v oblasti, nejlépe PDC, podobné kurzy, event. relevantní literatura
3) vytvoření jasných zón, zohlednění sektorů
4) vytvořené základní struktury
5) důsledné propojování struktur, zón – projekt je „vyzrálý" a již funguje
6) aspekty pěstování, soběstačnosti a udržitelného designu se doplňují se sociálními aspekty
7) všechno vyzařuje tři zásady permakulturní etiky – jsou patrné i bez vysvětlování

Stupeň C „Regionální permakulturní centrum":

1) majitel/realizátor projektu absolvoval Úplný kurz permakulturního designu (PDC)
2) projekt přijímá dobrovolníky, kteří zde mohou pracovat a učit se
3) projekt má výzkumný program (volitelné)
4) je zde vzdělávací a výcvikové centrum permakultury a příbuzných dovedností – alespoň jeden kurz nebo jiná akce pro veřejnost ročně
5) spolupráce s organizací Permakultura (CS), Akademií permakultury a s mezinárodní sítí permakultury (volitelné)

7.2 Appendix 2 – Qualification Questionnaire from Permakultura (CS) – English version

Name of evaluators:		
Date of evaluation		
I. Declaration:		
I consent to the publication of information about the project including contact details. I consent with the possibility of visits after former agreement		
II. Basic details		
1) **A)** Project name		
B) Owner's / executor's name, if applicable: contact person		
2) Contact details: email		
Phone		
website, FB, etc.		
3) Postal address**:**		
ZIP code:		
4) Founding year, year project started		
5) Size of project area Building area		
6) Short project characterisation to be published on the Internet:		
III. Visits and cooperation		
1) I am / we are interested in help with the realization of the project A) volunteers	yes	no
B) paid workers	yes	no
2) Specific open doors day	yes	no
If yes, when?		
3) I'm available to provide consulting without remuneration	yes	no
5) I'm available to provide consulting, including project design, for a remuneration	yes	no
6) Regular opening hours	yes	no
If yes, what time?		
7) Regular actions for public	yes	no
If yes, which and when?		
Notes.:		
IV. Permaculture design of the project		
1) Use of principle zones / cross out: 0, 1, 2, 3, 4, 5	**yes**	**no**
2) Connections between various elements	**yes**	**no**
3) Presence of a wilderness zone (zone 5)	**yes**	**no**
4) Important functions are covered by two or more elements	**yes**	**no**
5) Consideration of sectors / S, N, W, E as well as wind, water flow, foreseeable disturbances, etc.	yes	no
6) The individual project elements are well-positioned with respect to each other	yes	no
7) Design considers potential crisis events (wind, fire, flood, drought)	yes	no
Notes:		
V. Garden		
a) Plants		
1) Cultivation of edible crops, herbs, and fruit trees	**yes**	**no**
2) Well conceived coenoses, mixed cultures, polycultures	**yes**	**no**
3) Crops with reciprocal positive influence	yes	no
4) Melliferous, repellent, disinfectant, and soil cover crops	yes	no
5) Food forest	yes	no
6) Guild / Underplanting of fruit trees with crops and lower shrubs	yes	no

7) Plant layers	yes	no
Notes		
b) Structures – the project must have at least 2 structures		
1) Stone structures for sun-affine herbs (e.g., mound, spiral, etc.)	yes	no
2) Garden pond, swimming pond with biotope	yes	no
3) Greenhouse, heated greenhouse, hotbed	yes	no
4) Sun trap	yes	no
5) Swales and other structures to retain water	yes	no
6) Trellises	yes	no
7) Raised beds	yes	no
8) Hedges/edible fruits for people or birds, nesting, insects	yes	no
9) Natural, flowery meadows	yes	no
10) Other structures, describe:	yes	no
Notes:		
VI. Gardening/farming methods:		
1) Natural methods, without chemicals/pesticides, herbicides, fungicides, industrial fertilisers, …	**yes**	**no**
2) Use of organic fertilizers /compost, solid and liquid manure	**yes**	**no**
3) Peat – not allowed	**yes**	**no**
4) Purposeful soil improvement/green fertiliser, compost, soil organisms …	yes	no
5) Placement of birdhouses, structures for bats, bumblebees, snakes, and other small animals	yes	no
6) Sedges, basket willows	yes	no
7) Offer seedlings	yes	no
8) Seed production	yes	no
9) Cultivation of mushrooms - outside/inside/mycorrhiza	yes	no
10) No heavy mechanical tools	yes	no
11) Organic farming, certification “Bio”	yes	no
12) Cultivation of crops for energy production	yes	no
13) Cultivation of native species / varieties / persistent vegetables	yes	no
14) Coppicing, wood production	yes	no
15) No-tillage cultivation of cereals, minimalization of digging	yes	no
16) Crop rotation	yes	no
17) Underseeding, catch crops, mulching	yes	no
18) Installation of boundaries and shelter shrubs and trees	yes	no
19) Windbreaker	yes	no
20) Hedges	yes	no
Notes:		
Animal breeding		
1) Animals are kept in line with their natural needs, ethically	**yes**	**no**
2) Breeding of bees	yes	no
3) Breeding of small animals (poultry, rabbits, etc.)	yes	no
4) Bigger animals (sheep, goats, etc.)	yes	no
5) Cattle (beef, horses, lamas, …)	yes	no
6) Breeding of fish	yes	no
7) Fenced pastures	yes	no
8) Pastures with shelters	yes	no
Notes: local breeds?		
Handicraft – operating?	**yes**	**no**

1) main handicraft – which?	yes	no
2) further handicrafts – which?	yes	no
Notes:		
VII. House		
a) Number of inhabitants and main construction material		
1) Number of inhabitants		
2) Main construction material (or combination):		
brick/unburnt clay/wood/straw/stone/other, which:		
Notes:		
b) Interesting elements		
1) Winter garden	yes	no
2) Heat accumulation	yes	no
3) Garden on balcony/terrace	yes	no
4) Roof garden / green roof	yes	no
5) Use of waste (pneumatics, old carpets, stones from other buildings)	yes	no
6) Use of local materials / sustainable materials	yes	no
7) Other	yes	no
Notes:		
c) Heating		
1) Passive, low-energy house	yes	no
2) Wood	yes	no
3) Pellets, wood briquettes, wood chips	yes	no
4) Gas	yes	no
5) Electricity	yes	no
6) Heat pump	yes	no
7) Solar heating	yes	no
8) Other:	yes	no
Notes:		
d) Water sources		
1) Capture / storage and use of rainwater	**yes**	**no**
2) Capture of surface water (fishponds, ponds)	yes	no
3) Groundwater (well), indicate percentage	yes	no
4) Use of surface water (irrigation, utility water), indicate percentage	yes	no
5) Use of drinking water from municipal water supply, indicate percentage	yes	no
Notes:		
e) Waste management		
1) Composting	**yes**	**no**
2) Recycling (how)	**yes**	**no**
3) Use of grey water	yes	no
4) compost/separation toilets	yes	no
6) Re-use– re-using things for other than original purposes, on premise storage of unused waste	yes	no
Notes:		
f) Energy sources		

1) Solar collectors (heating or hot water)	yes	no
2) Photovoltaic panels for electricity	yes	no
3) Wind energy (electricity, water pump, etc.)	yes	no
4) use of water energy (electricity, kinetic energy, etc.)	yes	no
5) Biomass to produce warmth	yes	no
6) Biomass energy (electricity, kinetic energy, etc.)	yes	no
7) Connection to electricity or gas network by public provider	yes	no
8) Gas bottles	yes	no
9) Insula system	yes	no
Notes:		
IX. Self sufficiency		
1) Victuals: express in percent		
2) Heating, warm water: express in percent		
3) electric energy: express in percent		
X. Community (must be member of at least1 in kind)		
1) Community on project premises (e.g.: cohousing)	yes	no
2) Community in the proximity (municipality, above average relationship with neighbours)	yes	no
3) Spread-out community (within region, Czech Republic)	yes	no
4) Operation of LET system or linkage to it	yes	no
5) Local fair trade or similar network	yes	no
6) Investment fund of cooperative	yes	no
7) Communal garden	yes	no
8) Forest kinder garden	yes	no
9) KPZ	yes	no
10) Member of Permakultura (CS)	yes	no
11) WWOOF	yes	no
Notes:		
XI. Permaculture background and teaching activity		
1) Project realizer has absolved basic course of permaculture design	yes	no
2) Project realizer has absolved complete course of permaculture design	yes	no
3) Project realizer has a certification of permaculture design	yes	no
4) There's a course centre on premises – courses, workshops, etc.	yes	no
5) Project realizer conducts workshops etc. in other places	yes	no
Notes: //describe background / courses covered //		

Created 2010
Redacted 2015, 2016 for the purposes of SUPP collective of evaluators, redacted 2020

7.3 Appendix 3 – New Qualification Questionnaire from Permakultura (CS)

PŘIHLÁŠKA k hodnocení projektu do Sítě permakulturních projektů
PERMAKULTURA (CS), z.s. pro rok ....

Název místa / permakulturního ukázkového projektu / projektu s permakulturními prvky:
Jméno majitele / realizátora / kontaktní osoby:
Kontaktní údaje Adresa:
Tel:
E-mail:
Web, Fb:

Lokalita: *např. Vysočina, 555 m.n.m.*	
Rozloha v m2/ha:	
Počet trvale bydlících osob (dospělí/děti):	
Založeno / první výsadba / nastěhování:	

ANO/NE, stručně uveďte jaké:

Permakulturní design projektu: ANO/NE	
Zahrada–Rostliny ke konzumaci: ANO/NE	
Zahrada – Struktury: ANO/NE	
Způsob hospodaření přírodní: ANO/NE	
Chov zvířat: ANO/NE	
Provozování řemesel: ANO/NE	
Dům na pozemku: ANO/NE	
Zdroje vody: ANO/NE	
Hospodaření s odpady: ANO/NE	
Zdroje energie: ANO/NE	
Soběstačnost: ANO/NE	
Komunita: ANO/NE	
Vaše permakulturní vzdělání: ANO/NE	
Jiné:	

Datum: .... Jméno: ....

7.4 Appendix 4 – Permaculture Principles

1. Bill Mollison (1988)

    a. Relative location
    b. Each element performs many functions
    c. Each important function is supported by many elements
    d. Efficient energy planning
    e. Using biological resources
    f. Energy cycling
    g. Small-Scale Intensive Systems
    h. Accelerating succession and evolution
    i. Diversity
    j. Edge effects
    k. Attitudinal principles

2. David Holmgren (2002)

   Design principles:

    a. Observe and interact
    b. Catch and store energy
    c. Obtain a yield
    d. Apply self-regulation and accept feedback
    e. Use and value renewable resources and services
    f. Produce no waste
    g. Design from patterns to detail
    h. Integrate rather than segregate
    i. Use small and slow solutions
    j. Use and value diversity
    k. Use edges and value the marginal
    l. Creatively use and respond to change

   Holmgren furthermore formulated three ethical principles:

    a. Care for Earth
    b. Care for people
    c. Limit consumption and production, and redistribute surplus

3. Toby Hemenway (2009)

Core principles for ecological design:

a. Observe
b. Connect
c. Catch and store energy and materials
d. Each element performs multiple functions
e. Each function is supported by multiple elements
f. Make the least change for the greatest effect
g. Use small-scale, intensive systems
h. Optimize edge
i. Collaborate with succession
j. Use biological and renewable resources

Principles based on attitude

k. Turn problems into solutions
l. Get a yield
m. The biggest limit to abundance is creativity
n. Mistakes are tools for learning

8 References

Akademie permakultury (n.d.). [online] (cit. 29 April 2023] Available at https://www.akademiepermakultury.cz/

Alagöz, G. et al. (2020). Raised bed planting and green manuring increased tomato yields through improved soil microbial activity in an organic production system, *Biological Agriculture & Horticulture,* 36(3), 187-199.

Albrecht, S., & Wiek, A. (2021). Food forests: Their services and sustainability. *Journal of Agriculture, Food Systems, and Community Development,* 10(3) 1-15.

Bourguignon, C. and Bourguignon, L. (2018). Analyses des sols de la Ferme biologique du Bec Hellouin. *Sol et Fertilité.*

Boydston, R. (2010). Managing Weeds in Potato Rotations Without Herbicides. *American Journal of Potato Research*, 87(5), 420-427.

Brown's Ranch: *Regenrating Landscapes for a Sustainable Future* (2023). [online] [cit. 31.3.2023]. Available at brownsranch.us

Caraway, R. (2020). Deep Green and Social Permaculture: Spirituality, and Society in Cuba. *Nova Religio: Journal of Alternative and Emergent Religions*, 24(2), 5-31

Caraway, R. (2020). Deep Green and Social Permaculture: Spirituality, and Society in Cuba. Nova Religio: JOURNAL OF ALTERNATIVE AND EMERGENT RELIGIONS, 24(2), 5-31.

Center for Regenerative Agriculture and Resilient Systems. (2023). [online] cit. 16.4.2023. Available at www.csuchico.edu/regenerativeagriculture/

Ciupek, B. and Gołoś, K. (2020). Concentration of Nitrogen Oxides when Burning Wood Pellets of Various Origins. *Journal of Ecological Engineering*, 21(5), 229-233.

Conz, B. (2018). Permaculture demonstration sites in Central America: Contributions to agroecological transition and implications for educators. *Revista Geográfica de América Central*, 3(61), 111-124.

De Liedekerke de Pailhe, A. (2014*). Designing Intercropping in Vegetables*, *Scope for Improvements: A case study implemented at Bec-Hellouin Farm, Normandy, France,* Master Thesis, Wageningen University, ISARA-Lyon, Faculty of Organic Agriculture & Agroecology.

de Tombeur, F. et al. (2018). Effects of Permaculture Practices on Soil Physicochemical Properties and Organic Matter Distribution in Aggregates: A Case Study of the Bec-Hellouin Farm (France). *Frontiers in Environmental Science,* 6.

Wikipedia: the free encyclopedia (2023). *Effective Microorganism.* [online] [cit. 31 March 2023]. Available at: https://en.wikipedia.org/wiki/Effective_microorganism

Ferguson, R., and Lovell, S. (2014). Permaculture for agroecology: design, movement, practice and worldview. A review. *Agronomy for Sustainable Development,* 34(2)*, 251-274.*

Gaffke, A., Alborn, H., Dudley, T., & Bean, D. (2021). Using Chemical Ecology to Enhance Weed Biological Control. *Insects*, *12*(8).

Gajdušková, A. (2010). *Možnosti aplikace permakulturního systému hospodaření na rodinné farmě.* Bachelor Thesis, University of South Bohemia, Faculty of Agriculture.

Gambiza, J. and Didarali, Z. (2019). Permaculture: Challenges and benefits in improving rural livelihoods in South Africa and Zimbabwe. *Sustainability,* 11(8), 19.

Garibaldi, L. et al. (2011). Global growth and stability of agricultural yield decrease with pollinator dependence. *Proceedings of the National Academy of Sciences*, *108*(14), 5909-5914.

Gaston, K. et al. (2005). Urban domestic gardens (II): experimental tests of methods for increasing biodiversity. *Biodiversity and Conservation*, *14*(2), 395-413.

Gitari, H., Nyawade, S., Kamau, S., Karanja, N., Gachene, C., Raza, M., Maitra, S., & Schulte-Geldermann, E. (2020). Revisiting intercropping indices with respect to potato-legume intercropping systems. *Field Crops Research*, *258*.

Govaerts, B. et al. (2007). Influence of permanent raised bed planting and residue management on physical and chemical soil quality in rain fed maize/wheat systems. *Plant and Soil*, *291*(1-2), 39-54.

Halde, C. et al. (2017). Organic No-Till Systems in Eastern Canada: A Review. *Agriculture*, *7*(4).

Hemenway, T. (2009). *Gaia's Garden: A Guide to Home-Scale Permaculture* (2nd ed.). Chelsea Green Publishing: White River Junction. 1-60358-029-8

Hemenway, T. (2009). *Gaia's Garden: A Guide to Home-Scale Permaculture* (2nd ed.). Chelsea Green Publishing: White River Junction. 1-60358-029-8.

Hill, M. and Wood, P. (2014). The macroinvertebrate biodiversity and conservation value of garden and field ponds along a rural-urban gradient. *Fundamental and Applied Limnology,* 185(1), 107-119.

Hill, M. et al. (2021). Garden pond diversity: Opportunities for urban freshwater conservation. Basic and Applied Ecology, 57, 28-40.

Holmgren, D. (2002). *Permaculture: Principles & Pathways Beyond Sustainability*. Holmgren Design Services.

Hu, C., & Qi, Y. (2013). Effective microorganisms and compost favor nematodes in wheat crops. *Agronomy for Sustainable Development*, 33(3), 573-579.

KomPot (2023). [online] [cit. 29 4. 2023]. Available at https://kom-pot.cz/

Krameterhof (2021). [online] [cit. 31.3.2023]. Available at krameterhof.at

Krebs, J. and Bach, *S*. (2018). Permaculture—Scientific Evidence of Principles for the Agroecological Design of Farming Systems. *Sustainability*, 10(9).

La ferme biologique du Bec Hellouin (2023). [online] [cit. 31.3.2023]. Available at www.fermedubec.com.

La ferme biologique du Bec Hellouin (2023). *La recherche.* [online] [cit. 31 March 2023], Available at https://www.fermedubec.com/la-ferme/la-recherche/.

Lewis, D. et al. (2020). Better Together? Combining Cover Crop Mulches, Organic Herbicides, and Weed Seed Biological Control in Reduced-Tillage Systems. *Environmental Entomology*, *49*(6), 1327-1334.

Liebman, M., & Dyck, E. (1993). Crop Rotation and Intercropping Strategies for Weed Management. *Ecological Applications*, *3*(1), 92-122.

Lipiec, J., & Stępniewski, W. (1995). Effects of soil compaction and tillage systems on uptake and losses of nutrients. *Soil and Tillage Research*, *35*(1-2), 37-52.

Martins, P. et al. (2021). Educação ambiental escolar a partir da agroecologia e da permacultura*:* a experiência do projeto Escola Permacultural. *Desenvolvimento e Meio Ambiente*, 58.

Massicotte, M. and Kelly-Bisson, C. (2019). What's wrong with permaculture design courses?: Brazilian lessons for agroecological movement-building in Canada permaculture as a transdisciplinary methodology in applied resilience research. *Agriculture and Human Values*, 36(3), 581-594.

Mayer, J.et al. (2010). How effective are 'Effective microorganisms® (EM)'? Results from a field study in temperate climate. *Applied Soil Ecology*, 46(2), 230-239.

McLennon, E. et al. (2021). Regenerative agriculture and integrative permaculture for sustainable and technology driven global food production and security*. Agronomy Journal*, 113(6), 4541-4559.

Mollison, B. (1988). *Permaculture: A Designer's Manual* (Second edition). Tagari Publications: Sister's Creek, Tasmania: ISBN 0 908228 01 5.

Mollison, B., & Slay, R. (1991). *Introduction to Permaculture.* Tagari Publications: Sister's Creek, Tasmania: ISBN 0 908228 08 2.

Morel, K. and Léger, F. (2016). A conceptual framework for alternative farmers' strategic choices: the case of French organic market gardening microfarms. *Agroecology and Sustainable Food Systems,* 40(5*),* 466-492.

Morel, K. et al (2016). Can an organic market garden based on holistic thinking be viable without motorization? The case of a permaculture farm. *Acta Horticulturae*, *2016*(1137), 343-346.

Mukhametov, A. et al. (2021). The Impact of Growing Legume Plants under Conditions of Biologization and Soil Cultivation on Chernozem Fertility and Productivity of Rotation Crops. *Legume Research – An International Journal*, 44(10), 1219-1225.

Muneret, L., Auriol, A., Thiéry, D., & Rusch, A. (2018). Organic farming at local and landscape scales fosters biological pest control in vineyards. *Ecological Applications*, *29*(1).

Nutrient nitrogen N (total) - Use per area of cropland (kilograms per hectare). (2023). Our World in Data. Retrieved 2023-04-25, from https://ourworldindata.org/grapher/nitrogen-fertilizer-application-per-hectare-of-cropland?tab=table

Permakultura (CS) (2023). [online] [cit. 15.4.2023]. Available at www.permakulturacs.cz

Permasemínka (2023). [online] [cit. 31 March 2023]. Available at www.permaseminka.cz

Piotrowska, A. and Boruszko, D. (2023). Analysis of the potential of effective microorganisms in plant production. *Ekonomia i Środowisko – Economics and Environment*, *83*(4), 180-195.

Salehi, A. et al. (2017). Organic and inorganic fertilizer effect on soil CO2 flux, microbial biomass, and growth of Nigella sativa L. *International Agrophysics*, 31(1), 103-116.

Singh, B. (2018). Are Nitrogen Fertilizers Deleterious to Soil Health? *Agronomy*, 8(4).

Spargo, J., Alley, M., Follett, R., & Wallace, J. (2008). Soil nitrogen conservation with continuous no-till management. *Nutrient Cycling in Agroecosystems*, *82*(3), 283-297.

Strouts, G. (2016). Permaculture and the Edible Forest Garden: a Critical Analysis. [online] [cit. 22 April 2022] Available at theculturalwilderness.wordpress.com/2016/03/26/permaculture-and-the-edible-forest-garden-a-critical-analysis/

Susanin, P. (2015). *Tvorba a funkce permakulturní zahrady.* Bachelor Thesis, University of South Bohemia, Faculty of Agriculture

Svoboda, J. (2009). *Kompletní návod k vytvoření ekozahrady a rodového statku*. Smart Press: Praha, ISBN: 978-8087049-28-0.

Unger, P. W. and Vigil, M. F. (1998). Cover crop effects on soil water relationships. Journal of Soil and Water Conservation, 53(3), 200-207.

University of Minnesota Extension (2023). *Managing and composting horse manure*. [online] [cit. 25.4.2023]. Available at extension.umn.edu/horse-care-and-management/managing-and-composting-horse-manure

Ward, P. et al. (2012). Soil water balance with cover crops and conservation agriculture in a Mediterranean climate. *Field Crops Research*, *132*, 33-39.

Yuen, E., Anda, M., Mathew, K., & Ho, G. (2001). Water harvesting techniques for small communities in arid areas. *Water Science and Technology*, *44*(6), 189-195.

Zimmer, R., Milkakovic, Z., Milos, B., & Krzek, Z. (1999). No-till corn production and residues deterioration. *Actual Tasks on Agricultural Engineering, Proceedings*, 27, 127-134.

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